

Theoretical and Practical Research in Economic Fields

Quarterly

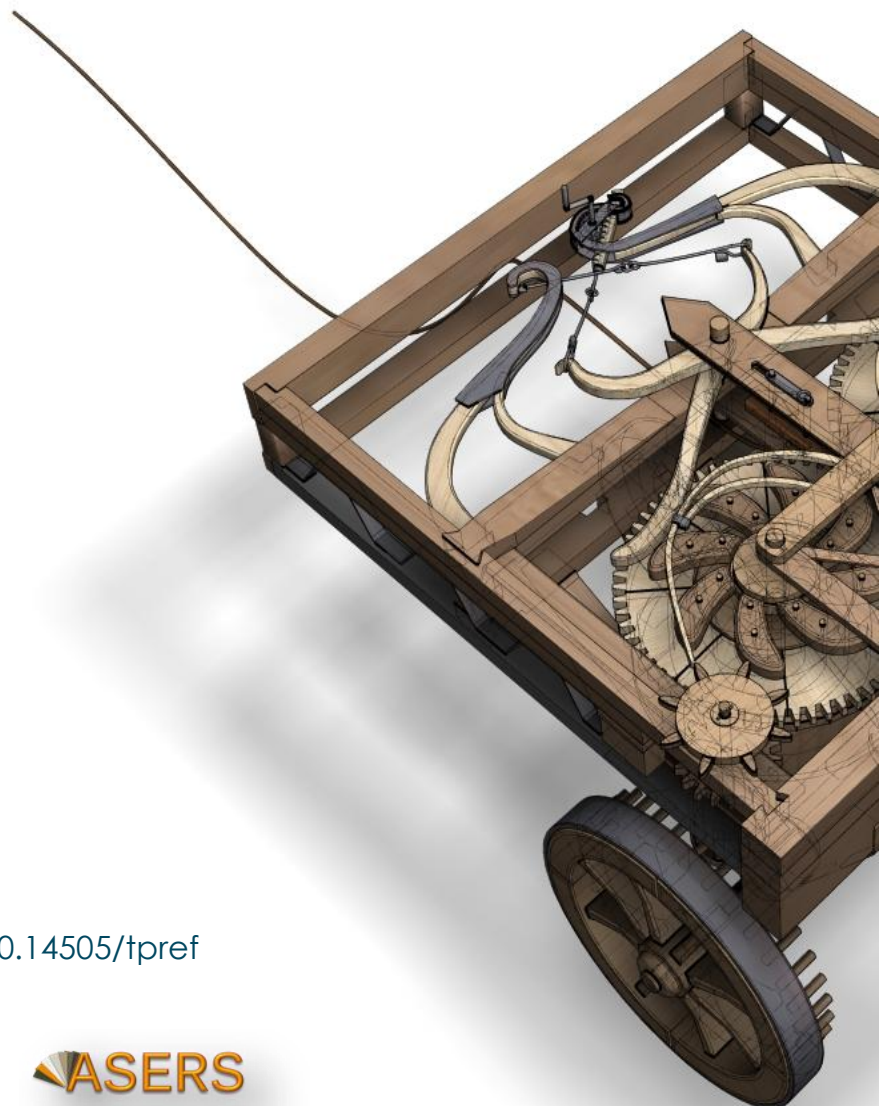
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An Application of the Generalized Method of Moments on the Mankiw-Romer-Weil Model

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Abstract: This paper develops an algorithm for the restricted Generalized Method of Moments (RGMM) to re-evaluate the empirical findings of Mankiw, Romer, and Weil (1992), who emphasized the critical role of human capital accumulation in explaining cross-country income differences. Despite the influence of their results, subsequent literature has raised concerns about potential endogeneity arising from omitted variable bias. To address these concerns, we employ a novel instrumental variable strategy - using the algorithm of the restricted Generalized Method of Moments (RGMM). Using the restricted GMM, we find that the original Mankiw, Romer, and Weil (1992) results are robust for the method of estimation and survive the endogeneity criticisms that are present in the literature.

Keywords: omitted variable bias; restricted GMM; endogeneity; instrumental variables.

JEL Classification: O24; C26; E24.

Introduction

Income disparity across countries continues to be an intriguing research question. In this context, the paper by Mankiw, Romer, and Weil (1992) henceforth MRW, where they augmented the Solow growth model with human capital, is an oft-cited work in the empirical growth literature. Employing the least square and the restricted least square estimation method, they showed that the combined contribution of technology and investment in physical capital and human capital, can explain over three-fourths of the variation in long-run per-capita income across countries, and the implied model-based factor shares are consistent with the national accounts data.

However, Acemoglu (2009) pointed out that the MRW estimates could be biased due to potential endogeneity arising from the correlation between technology and investment in physical and human capital. Such correlation arises because countries with better institutions (a potential omitted variable) have better technology, and they also invest more in physical and human capital accumulation. Romer, while reviewing the work of Bernanke and Gürkaynak (2001), had also identified the same and suggested an instrumental variable estimation.

In this backdrop, we re-estimate the MRW model through GMM by using the future-time reference (FTR) of languages as an instrument for investment in physical capital (savings rate); and the proportion of the Protestant missionaries in 1923, and the national primary school enrollment in 1900, as instruments for human capital. Our findings indicate that the original MRW results are robust to the method of estimation, as well as for alternate datasets of human capital.

Our paper has two important contributions: 1. We develop an algorithm of restricted GMM and employ it to estimate the MRW model¹. 2. We address the endogeneity issue in MRW by employing potential instruments for physical and human capital accumulation based on the extant literature.

1. Data

The period considered in our study is from 1970 to 2019. To keep the data consistent with that of MRW, we obtain the real GDP and the private investment data from the Penn World Table 10.0. For a country j , the average per capita income is y_j and the average investment to GDP ratio is s_{kj} . We use the average of the mean years of schooling (for the population aged at least 25 years) from UNESCO as a measure for human capital. We use it to construct the measure of human capital s_{hj} . Moreover, we also calculate the population growth rate n_j respectively using the Penn World Table 10.0 data. Additionally, following MRW, we set the sum of the average technology growth rate and depreciation of capital, i.e. $(g + \delta)$, equal to 5%.

For robustness check, we have also obtained alternate data for human capital. We have obtained the data of the mean years of schooling (secondary) from Barro and Lee (2013). The dataset considers the total population aged 15 and above for the period 1970-2010.

1.1 Instrument for Physical Capital Accumulation

We utilize the future-time reference (FTR) characteristic of languages as an instrument to account for physical capital accumulation. In languages classified as strong-FTR - such as English and French - the grammatical structure mandates a clear distinction between present and future tense. Unlike speakers of weak-FTR languages, who are not required to make this separation, strong-FTR language users must explicitly mark temporal differences. Since Chen (2013) initiated the discourse, numerous studies have consistently drawn connections between the FTR structure of languages and various economic behaviors. Chen's (2013) findings revealed that countries with weak-FTR languages tend to exhibit greater future-oriented behavior - manifested through elevated saving patterns - both at individual and national levels. While some critiques targeted Chen's (2013) assumption of linguistic independence, Roberts *et al.* (2015) addressed this limitation by incorporating linguistic interdependence, ultimately affirming the robustness of Chen's (2013) original conclusions. Building on this linguistic framework, we interpret the FTR's correlation with saving behavior as a theoretical foundation for treating it as a valid instrument. Given that FTR has a well-established relationship with intertemporal decision-making and lacks any empirically supported connection to technology, we argue that it serves as a credible instrument for capturing variation in physical capital accumulation.

Data for FTR of languages is from Chen (2013). Specifically, we use an instrument $z_{kj} = ftr_j - \ln(n_j + g + \delta)$ for $x_{kj} = \ln(s_{kj}) - \ln(n_j + g + \delta)$; where, $ftr_j = 1$ if the official language of country j has weak FTR, and 0 otherwise.

1.2 Instruments for Human Capital Accumulation

Acemoglu *et al.* (2014), along with the references² therein, posited that: (i) Protestant missionaries' activities, partly motivated by encouraging readings of the scriptures, played an important role in setting up schools in different countries, thereby leading to a lasting impact on the evolution of human capital, (ii) Country-wise variation of the Protestant missionaries' activities, after controlling for variations in continent dummies, the identity of the colonial power, and institutions, have largely been determined by idiosyncratic factors and need not be correlated with potential future economic prosperity of a country.

¹ It produces consistent, and efficient parameter estimates that matches the data, and it can be applied on any data in the future.

² Please see Benavot and Riddle (1988) for the data on the secondary enrollment rate of the 1900s. Also, please refer to Nunn (2014), Becker and Woessmann (2009), and Woodberry (2004, 2012) for the data on Protestant missionary activities.

Following Acemoglu *et al.* (2014), we use the share of Protestant missionaries in 1923 per 10,000 population (pm_j), and the national primary enrollment in 1900 ($enrol_j$) for country j as instruments for human capital. Specifically, we use the vector³,

$$z_{hj} = [pm_j - \ln(n_j + g + \delta), \ln(enrol_j) - \ln(n_j + g + \delta)]$$

as an instrument for $x_{hj} = \ln(s_{hj}) - \ln(n_j + g + \delta)$

2. Methodology

Starting with the benchmark Solow model and assuming s_{kj} and s_{hj} as the fraction of income saved by the households to accumulate physical and human capital respectively by country j , MRW (1992) derived equation (1) by taking the logarithmic transformation of a production function with labour augmenting technological progress. The production function in MRW (1992) follows CRS in physical capital, human capital and effective labor force with $0 < \alpha < 1$ being the share of capital in national income, $0 < \beta < 1$ being the same for human capital, and $\alpha + \beta < 1$.

$$\ln(y_j) = \gamma_0 + \gamma_1 x_{kj} + \gamma_2 x_{hj} + u_j, \quad (1)$$

where, $\gamma_1 = \frac{\alpha}{1-(\alpha+\beta)}$; $\gamma_2 = \frac{\beta}{1-(\alpha+\beta)}$; and $j = 1, 2, \dots, N$ is the number of countries, u_j represents the technology level of country j in MRW (1992). Acemoglu (2009) points out that countries with better technology often save more on physical and human capital. This implies, both x_{kj} and x_{hj} are endogenous with $\text{cov}(x_{kj}, u_j) \neq 0$, and $\text{cov}(x_{hj}, u_j) \neq 0$. As a result, OLS estimates of equation (1) are inconsistent, and we need an IV estimation to achieve consistency. We have estimated equation (1) through GMM and restricted GMM by using z_{kj} as instrument of x_{kj} , and z_{hj} as instrument of x_{hj} . The algorithm of the GMM and restricted GMM; the calculation of $\bar{R}^2$, AIC and SBC are given in the appendix. Please note, the distribution of imputed $\hat{\alpha}$ and $\hat{\beta}$ are calculated using the Delta method.

3. Results

MRW (1992) estimated equation (1) by OLS for 98 non-oil producing countries for the period 1965-1980 using secondary school enrolment as a measure of human capital. They found that both physical and human capital accumulation are important for long-term prosperity of a country, and the two factors jointly explained 78% of the variation of long-run per-capita income.

Table 1. OLS, GMM and Restricted GMM estimates of the MRW (1992) equation

AYS				
	OLS	GMM	Restricted GMM ($r = -0.8$)	Restricted GMM ($r = -0.1$)
$\hat{\gamma}_0$	8.59*** (0.19)	9.11*** (0.50)	9.13*** (0.09)	8.57*** (0.09)
$\hat{\gamma}_1$	0.82*** (0.17)	0.42 (0.47)	0.40*** (0.09)	0.91*** (0.09)
$\hat{\gamma}_2$	0.86*** (0.09)	1.19*** (0.17)	1.20*** (0.09)	1.01*** (0.09)
$\hat{\alpha}_{imputed}$	0.31*** (0.05)	0.16 (0.16)	0.15*** (0.02)	0.31*** (0.01)
$\hat{\beta}_{imputed}$	0.32*** (0.04)	0.46*** (0.11)	0.46*** (0.002)	0.35*** (0.009)
N	74	74	74	74
J -statistic	–	0.098 [0.75]	0.095 [0.95]	1.66 [0.44]
$\bar{R}^2$	0.71	0.65	0.65	0.69

Note: ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively. Standard errors are in parentheses; p-values are in square brackets. The J-statistics follows a chi-square distribution with 1 and 2 degrees of freedom for the unrestricted and restricted GMM, respectively. Restricted GMM is estimated for Average Years of Schooling (AYS) as a measure of human capital. Source: Calculated by the authors.

³ We use identical data sources of Acemoglu *et al.* (2014) to collect data and also followed them to address the problem of missing data for the instruments of human capital. Following Acemoglu *et al.* (2014), we obtain the missing data about the arrival of Protestant missionary in five different countries from Dennis *et al.* (1911).

Further, they found that the share of physical capital and human capital in the national income are 33% and 28% respectively.

Among these 98 non-oils producing countries of MRW (1992), we have data of all control variables and instruments for 74 countries where average years of schooling is considered an indicator of human capital. Columns 2 of Table 1 present the OLS results of equation (1) for AYS as a measure of human capital. The findings indicate that:

1. Physical capital and human capital accumulation are important for long-run prosperity, and they jointly explain 71% of the variation of the long-run per-capita income for the indicator of human capital.

2. The share of physical capital in national income is 31% (column 2), and that of human capital in national income is 32% (column 2) respectively.

Post the OLS estimation of the benchmark MRW (1992) equation, to address the endogeneity concerns explained earlier, we now estimate equation (1) through GMM by using z_{kj} and z_{hj} as instruments for x_{kj} and x_{hj} respectively. It is important to mention here that, unlike least square estimates, GMM estimates do not have criteria for goodness of fit to determine the best fitted model. But we can test the validity of instruments used in the GMM estimation based on the over identification restrictions through the J -statistics. We must discard a GMM estimate when the instruments tested through the J -statistics are not valid.

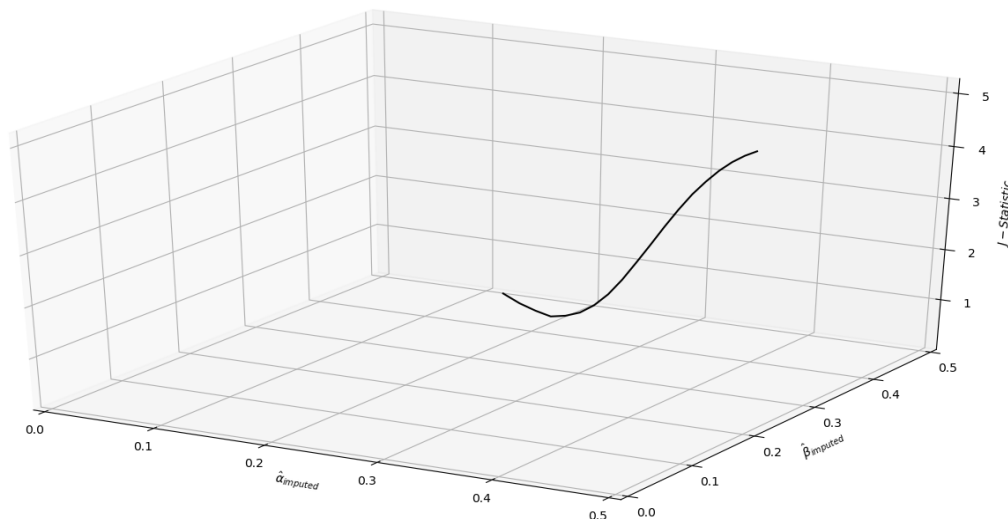
Next, we estimate equation (1) for the 74 non-oil producing countries through GMM by using average years of schooling (AYS) as a measure of human capital; and the results are reported in column 3 of Table 1. The GMM estimation yields correct signs for all the control variables but $\hat{\gamma}_1$ and the share of physical capital ($\hat{\alpha}_{imputed}$) are not significant. As a result, we estimate a restricted version of the GMM model. To do that, we impose the restriction $\gamma_1 - \gamma_2 = r$ by keeping the following parametric restrictions of our model in mind:

1. $\alpha > 0$;
2. $\beta > 0$;
3. $\alpha + \beta < 1$.

The algorithm of the restricted GMM estimation developed by us is given in the appendix section. Following the algorithm of the restricted GMM, we estimate equation (1) for $r = -0.9, -0.8, \dots, 0, \dots, 0.8, 0.9$ and calculate the corresponding $\hat{\alpha}_{imputed}$ and $\hat{\beta}_{imputed}$ from $\hat{\gamma}_1$ and $\hat{\gamma}_2$ using the equation:

$$\gamma_1 = \frac{\alpha}{1 - (\alpha + \beta)}, \gamma_2 = \frac{\beta}{1 - (\alpha + \beta)}.$$

Figure 1. Model Selection for AYS as a measure of Human Capital Using J-statistics

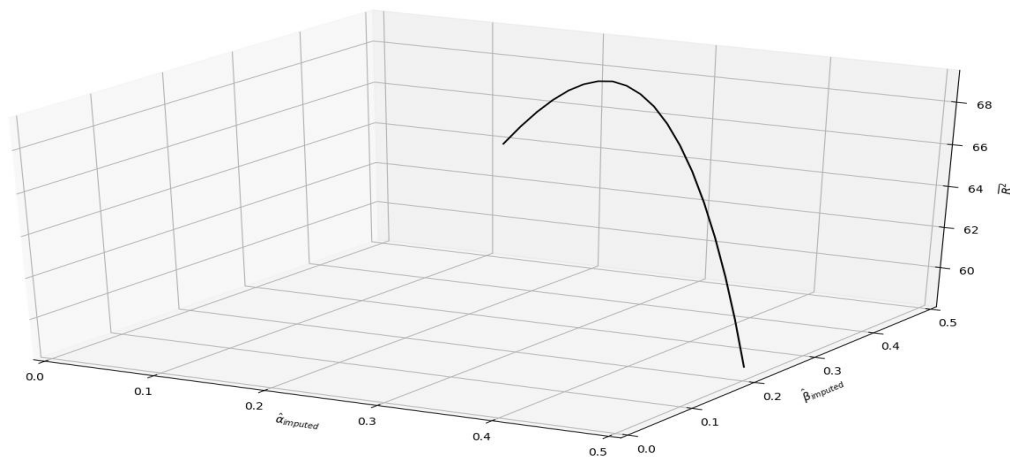


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We also calculate the J -statistic for each model. Figure 1 plots $\hat{\alpha}_{imputed}$, $\hat{\beta}_{imputed}$, and the J -statistic for each of the 19 models. It shows that the J -statistic is minimum for $r = -0.8$ when $\hat{\alpha}_{imputed} = 0.15$, and $\hat{\beta}_{imputed} = 0.46$. We have reported the result of the restricted GMM for $r = -0.8$ in Column 4 of Table 1. The

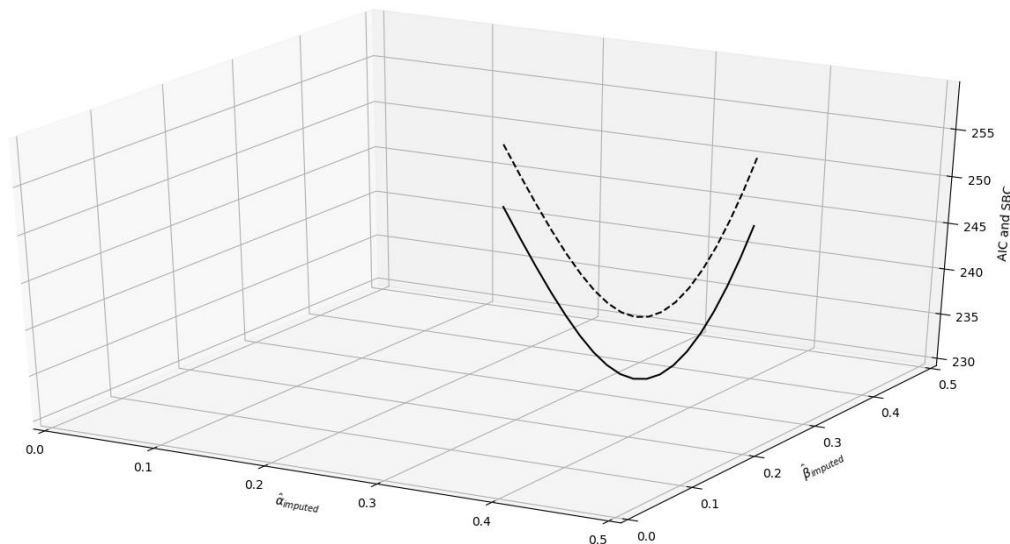
p-value of the J -statistics reported in Column 4 of Table 2 confirms that the instruments of physical capital and human capital used in our analysis are valid. However, we find that the share of physical capital ($\hat{\alpha}_{imputed} = 15\%$) is too low; and that of human capital ($\hat{\beta}_{imputed} = 46\%$) is too high and not matching with the data of national accounts. To address this issue, we also calculate the $\bar{R}^2$ of the 19 restricted GMM models to identify a model whose fit is closest to the benchmark OLS estimation of equation (1). We plot $\hat{\alpha}_{imputed}$, $\hat{\beta}_{imputed}$, and $\bar{R}^2$ for each of the 19 models in Figure 2. Figure 2 shows that the maximum $\bar{R}^2 = 0.69$, which is closest to the corresponding benchmark OLS estimation of equation (1), is achieved for $(r, \hat{\alpha}_{imputed}, \hat{\beta}_{imputed}) = (-0.1, 0.31, 0.35)$. We report the result of restricted GMM for $r = -0.1$ in Column 5 of Table 2. The p-value of the J -statistic reported in Column 5 of Table 2 shows that the instruments of physical capital and human capital used in our estimation remain valid even if the J -statistic rises from 0.095 to 1.66 and its p-value changes from 0.95 to 0.44 when r changes from -0.8 to -0.1 ⁴.

Figure 2. Model Selection for AYS as a measure of Human Capital Using $\bar{R}^2$



Source: Generated by the authors.

Figure 3. Model Selection for AYS as a measure of Human Capital Using AIC and SBC



Source: Generated by the authors.

Moreover, the restricted GMM estimates reported in Column 5 of Table 1 also yield the share of physical capital and human capital in national income (31% and 35% respectively) that belong to the range of the data supported by national accounts statistics.

⁴ We also plot the AIC and SBC of the 19 restricted GMM model against $\hat{\alpha}_{imputed}$ and $\hat{\beta}_{imputed}$ in Figure 3. Figure 3 shows that, the AIC (solid line) and SBC (dotted line) are also minimum at $(r, \hat{\alpha}_{imputed}, \hat{\beta}_{imputed}) = (-0.1, 0.31, 0.35)$.

4. Robustness Check

We have estimated equations (1) by OLS, GMM, and restricted GMM using secondary AYS obtained from Barro and Lee (2013) for 71 countries from 1970-2010 as a measure of human capital to check the robustness of our results. We have also estimated the same model by GMM using z_{kj} and z_{hj} as measures of physical capital and human capital respectively for country j . The result of the OLS estimation is reported in Column 2 of Table 2. The OLS estimation yields, $\hat{\alpha}_{imputed} = 23\%$, $\hat{\beta}_{imputed} = 33\%$ and $\bar{R}^2 = 0.72$. The result of the GMM estimation is reported in Column 3 of Table 2. The p-value of the J -statistic of the GMM estimation shows that our instruments are valid as they satisfy the overidentification restrictions. The GMM estimation yields correct signs for all the control variables, but $\hat{\gamma}_1$ is not significant. As a result, we estimate a restricted version of the GMM model.

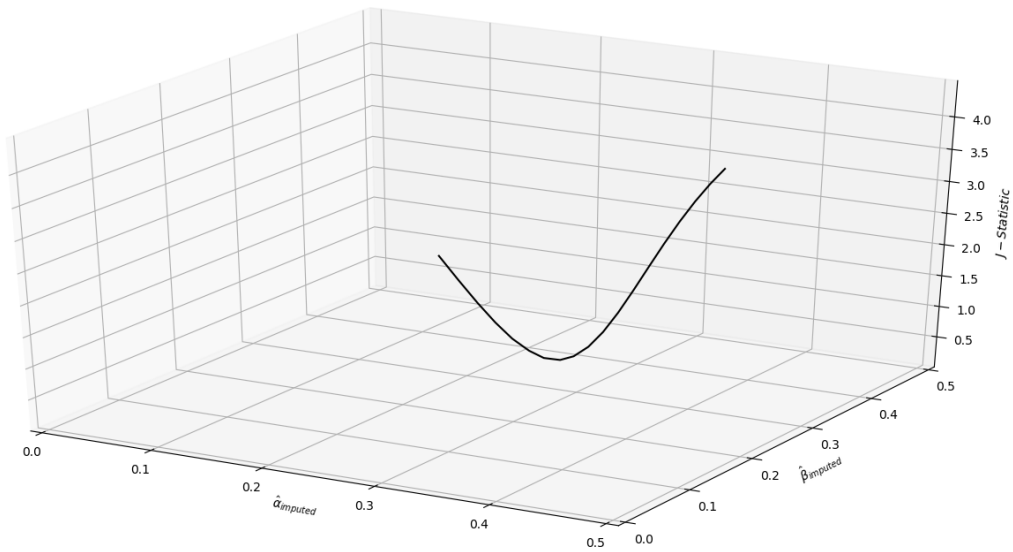
Following the methodology already discussed in the results section, we estimate the model by restricted GMM with restrictions, $\gamma_1 - \gamma_2 = r$; $r = -0.9, -0.8, \dots, 0.8, 0.9$, and calculate the J -statistic along with $\hat{\alpha}_{imputed}$ and $\hat{\beta}_{imputed}$. We plot the J -statistic against $\hat{\alpha}_{imputed}$ and $\hat{\beta}_{imputed}$ in Figure 4. Figure 4 shows that the J -statistic is minimum when $(r, \hat{\alpha}_{imputed}, \hat{\beta}_{imputed}) = (-0.4, 0.21, 0.38)$. We have reported the result of restricted GMM for $r = -0.4$ in Column 4 of Table 2. Note, the result of the GMM estimation reported in Column 4 of Table 2 closely resembles the result of the OLS estimation reported in Column 2 of Table 2. Moreover, the p-value of the J -statistics shows that the overidentification restrictions are satisfied and instruments used in our estimation are valid.

Table 2. OLS, GMM and restricted GMM estimates for Robustness Check

Secondary AYS				
	OLS	GMM	Restricted ($r = -0.4$)	Restricted ($r = -0.2$)
$\hat{\gamma}_0$	9.85*** (0.28)	10.14*** (0.53)	10.17*** (0.07)	9.93*** (0.07)
$\hat{\gamma}_1$	0.54** (0.17)	0.51 (0.33)	0.52*** (0.07)	0.66*** (0.07)
$\hat{\gamma}_2$	0.76*** (0.08)	0.93*** (0.16)	0.92*** (0.07)	0.86*** (0.07)
$\hat{\alpha}_{imputed}$	0.23*** (0.06)	0.21* (0.12)	0.21*** (0.02)	0.26*** (0.01)
$\hat{\beta}_{imputed}$	0.33*** (0.04)	0.38*** (0.09)	0.38*** (0.007)	0.34*** (0.008)
N	71	71	71	71
J -statistic	–	0.09 [0.76]	0.09 [0.96]	0.24 [0.89]
$\bar{R}^2$	0.72	0.70	0.70	0.71

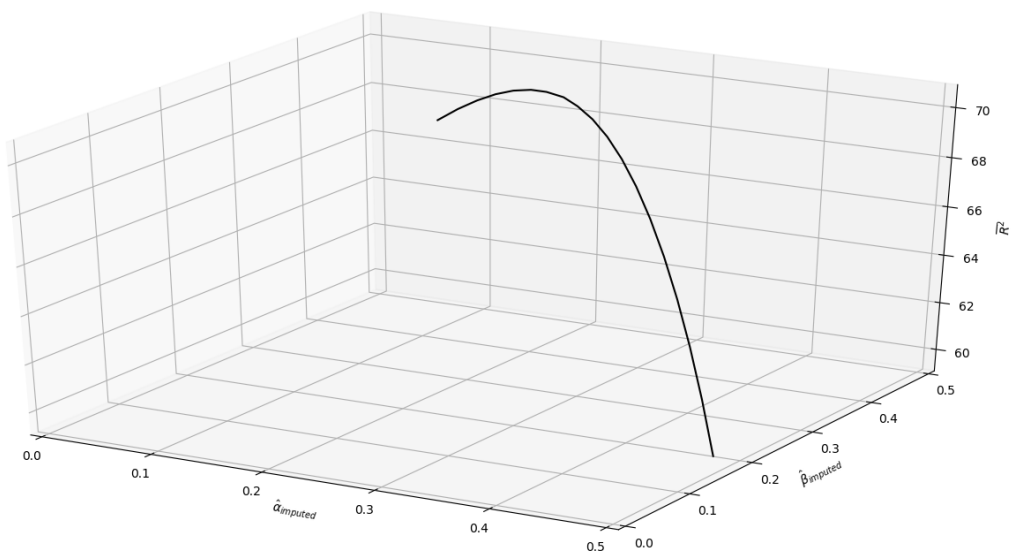
Note: ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively. Standard errors are in parentheses; p-values are in square brackets. The J -statistic follows a chi-square distribution with 1 and 2 degrees of freedom for the unrestricted and restricted GMM, respectively. Restricted GMM is estimated for the Secondary Average Years of Schooling obtained from Barro and Lee (2013) as a measure of human capital. Source: Calculated by the authors.

Figure 4. Model Selection for Secondary AYS as a measure of Human Capital Using J-Statistics



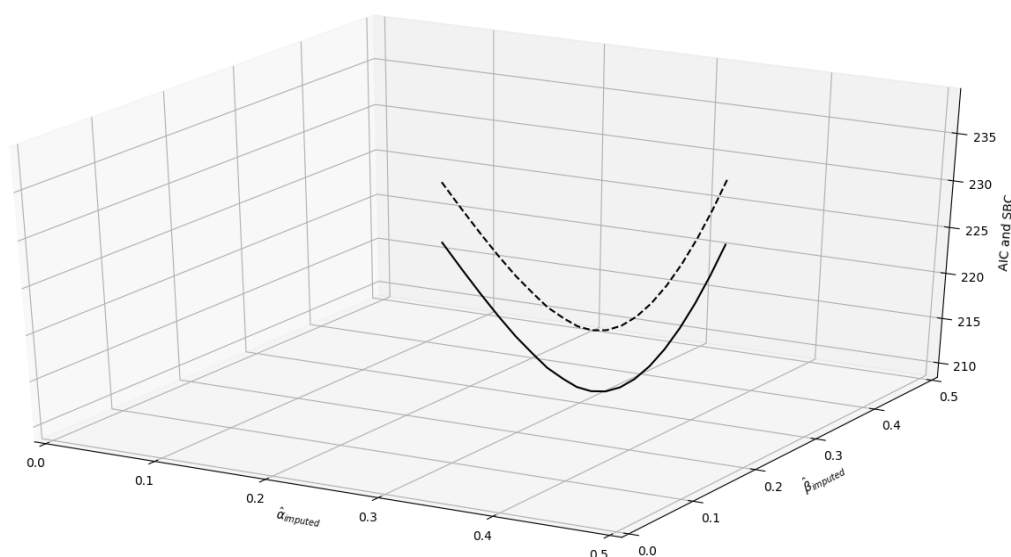
Source: Generated by the authors.

Next, we plot the $\bar{R}^2$ against the corresponding $\hat{\alpha}_{imputed}$ and $\hat{\beta}_{imputed}$ for 19 restricted GMM models in Figure 5 to identify a model whose fit is closest to the same of the benchmark OLS estimation of equation (1). We find that the model with $(r, \hat{\alpha}_{imputed}, \hat{\beta}_{imputed}) = (-0.2, 0.26, 0.34)$ yields maximum $\bar{R}^2 = 0.71$, which is closest to the benchmark OLS estimation of equation (1) reported in Column 2 of Table 2. We also plot the AIC and SBC of the 19 restricted GMM models against $\hat{\alpha}_{imputed}$ and $\hat{\beta}_{imputed}$ in Figure 6. Figure 6 shows that the AIC (solid line) and SBC (dotted line) are also minimum at, $(r, \hat{\alpha}_{imputed}, \hat{\beta}_{imputed}) = (-0.2, 0.26, 0.34)$. We report the result of our restricted GMM estimation for $r = -0.2$ in Column 5 of Table 2. Note, the result of the GMM estimation reported in Column 5 of Table 2 also closely resembles the result of the OLS estimation reported in Column 2 of Table 2. Moreover, the p-value of the J -statistic shows that the overidentification restrictions are still satisfied and instruments used in our estimation remain valid when we choose a model whose fit is closest to the same of the benchmark OLS estimation of equation (1).

Figure 5. Model Selection for Secondary AYS as a measure of Human Capital Using $\bar{R}^2$ 

Source: Generated by the authors.

Figure 6. Model Selection for Secondary AYS as a measure of Human Capital Using AIC and SBC



Source: Generated by the authors.

Conclusion

This study revisits the human capital-augmented Solow growth model of Mankiw, Romer, and Weil (1992) with a focus on addressing the endogeneity issues that have challenged the validity of their empirical estimates. By employing the restricted generalized method of moments (RGMM) framework, we provide a rigorous reassessment of the original model's robustness.

The findings reveal that the key results of MRW (1992) remain robust across datasets and estimation techniques, including under the more stringent restrictions imposed by the restricted GMM. This highlights the strength of their original conclusions and demonstrates that, when properly instrumented the model is resilient to critiques of endogeneity.

By estimating the model using the restricted GMM, we not only validate the empirical relevance of human capital in growth regressions but also contribute a robust econometric method that can be applied to future research on macro-development and other subjects.

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Arpan Chakraborty: Corresponding author, Conceptualization, Investigation, Methodology, Software, Formal analysis, Writing – original draft, Data curation, Validation, Writing – review and editing, Visualization.

Siddhartha Chattopadhyay: Supervision, Conceptualization, Investigation, Methodology, Formal analysis, Writing, Validation, Writing – review and editing, Visualization.

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Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Declaration of Use of Generative AI and AI-Assisted Technologies

The authors declare that they have not used generative AI and AI-assisted technologies in the writing process before submission.

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Appendix

In this section we present the general model which can be used for any datasets in the future. The R code will be made available on request. Suppose our model is:

$$y = X\gamma + u \quad (A1)$$

where,

$$y = (y_1 \ y_2 \ \dots \ y_N)'$$

is a $(NG \times 1)$ vector; where, y_i is a $(G \times 1)$ vector for $i = 1, 2, \dots, N$. The matrix of control variables,

$$X = (X_1 \ X_2 \ \dots \ X_G)'$$

is a $(NG \times K)$ matrix; where X_i is a $(G \times K)$ matrix, and γ is a $(K \times 1)$ vector of parameters. The random error term

$$u = (u_1 \ u_2 \ \dots \ u_G)'$$

is a $(NG \times 1)$ vector; where, u_i is a $(G \times 1)$ vector for $i = 1, 2, \dots, N$. Also assume that the matrix of instruments,

$$Z = (Z_1 \ Z_2 \ \dots \ Z_N)'$$

is a $(NG \times L)$ matrix with $L \geq K$; where, Z_i is a $(G \times L_i)$ matrix with $\sum_{i=1}^N L_i = L$.

Our objective is to minimize the quadratic form,

$$(Z'u)'W(Z'u) = (y - X\gamma)'ZWZ'(y - X\gamma)$$

subject to the linear restrictions $R\gamma = r$ by choosing γ , where W is a $(L \times L)$ symmetric and positive semidefinite weight matrix. Here, R is a $(q \times K)$; and r is a $(q \times 1)$ matrix, where q represents the number of restrictions. Suppose, λ is a $(q \times 1)$ matrix of Lagrange multipliers. Then, the relevant Lagrangian of our problem is,

$$L = (y - X\gamma)'ZWZ'(y - X\gamma) - 2\lambda'(R\gamma - r)$$

FOCs:

$$\frac{\partial L}{\partial \gamma} = -X'ZWZ'y + X'ZWZ'X\gamma - R'\lambda = 0, \quad (A2)$$

$$\frac{\partial L}{\partial \lambda} = R\gamma - r = 0. \quad (A3)$$

Pre-multiplying equation (A2) by $R(X'ZWZ'X)^{-1}$, and using equation (A3) we get,

$$R'\lambda = R'[R(X'ZWZ'X)^{-1}R']^{-1}(r - R\hat{\gamma}). \quad (A4)$$

where,

$$\hat{\gamma} = (X'ZWZ'X)^{-1}(X'ZWZ'y). \quad (A5)$$

Substituting equation (A4) into equation (A2) and pre-multiplying the equation by $(X'ZWZ'X)^{-1}$ gives,

$$\hat{\gamma}_R = \hat{\gamma} + (X'ZWZ'X)^{-1}R'[R(X'ZWZ'X)^{-1}R']^{-1}(r - R\hat{\gamma}). \quad (A6)$$

We have used the following algorithm to obtain the consistent and efficient restricted GMM estimator; its asymptotic variance-covariance matrix, and its asymptotic distribution. Set $W = (Z'Z)^{-1}$ and calculate the 2SLS estimator from equation (A5) as follows,

$$\hat{\gamma}_{2SLS} = (X'Z(Z'Z)^{-1}Z'X)^{-1}(X'Z(Z'Z)^{-1}Z'y).$$

1. Using $\hat{\gamma}_{2SLS}$, obtain the corresponding estimated vector of random errors,

$$\hat{u}_{2SLS} = (\hat{u}_{1,2SLS} \ \hat{u}_{2,2SLS} \ \dots \ \hat{u}_{N,2SLS})',$$

and calculate,

$$\hat{\Lambda}_{2SLS} = \frac{1}{N} \sum_{i=1}^N Z_i' \hat{u}_{i,2SLS} \hat{u}_{i,2SLS}' Z_i.$$

2. GMM estimator: Set $W = (\hat{\Lambda}_{2SLS})^{-1}$, and calculate the GMM estimator from equation (A5) as follows,

$$\hat{\gamma}_{GMM} = (X'Z(\hat{\Lambda}_{2SLS})^{-1}Z'X)^{-1}(X'Z(\hat{\Lambda}_{2SLS})^{-1}Z'y).$$

3. Using $\hat{\gamma}_{GMM}$, obtain the corresponding estimated vector of random errors,

$$\hat{u}_{GMM} = (\hat{u}_{1,GMM} \ \hat{u}_{2,GMM} \ \dots \ \hat{u}_{N,GMM})',$$

and calculate,

$$\hat{\Lambda}_{GMM} = \frac{1}{N} \sum_{i=1}^N Z_i' \hat{u}_{i,GMM} \hat{u}_{i,GMM}' Z_i.$$

4. Distribution of $\hat{\gamma}_{GMM}$: Following Wooldridge (2010), we get,

$$\sqrt{N}(\hat{\gamma}_{GMM} - \gamma) \sim AN(0, \Sigma_{GMM}),$$

where,

$$C = \left(\frac{Z'X}{N}\right), \Sigma_{GMM} = (C'\hat{\Lambda}_{GMM}^{-1}C)^{-1}.$$

The estimated asymptotic variance-covariance matrix of $\hat{\gamma}_{GMM}$ is,

$$\hat{V}(\hat{\gamma}_{GMM}) = [(X'Z)\left(\sum_{i=1}^N Z_i'\hat{u}_{i,GMM}\hat{u}_{i,GMM}'Z_i\right)^{-1}(Z'X)]^{-1}.$$

5. Set $W = (Z'Z)^{-1}$ and $\hat{\gamma} = \hat{\gamma}_{GMM}$ in equation (A6) and calculate,

$$\hat{\gamma}_R = \hat{\gamma}_{GMM} + (X'Z(Z'Z)^{-1}Z'X)^{-1}R'[R(X'Z(Z'Z)^{-1}Z'X)^{-1}R']^{-1}(r - R\hat{\gamma}_{GMM}).$$

6. Using $\hat{\gamma}_R$, obtain the corresponding estimated vector of random errors,

$$\hat{u}_{R2SLS} = (\hat{u}_{1,R2SLS} \quad \hat{u}_{2,R2SLS} \quad \dots \quad \hat{u}_{N,R2SLS})',$$

and calculate,

$$\hat{\Lambda}_{R2SLS} = \frac{1}{N} \sum_{i=1}^N Z_i'\hat{u}_{i,R2SLS}\hat{u}_{i,R2SLS}'Z_i.$$

7. Restricted GMM estimator: Using $W = (\hat{\Lambda}_{R2SLS})^{-1}$, calculate the restricted GMM estimator from equation (A6) as follows,

$$\hat{\gamma}_{RGMM} = \hat{\gamma}_{GMM} + ((X'Z)(\hat{\Lambda}_{R2SLS})^{-1}(Z'X))^{-1}R'[R((X'Z)(\hat{\Lambda}_{R2SLS})^{-1}(Z'X))^{-1}R']^{-1}(r - R\hat{\gamma}_{GMM}).$$

8. Using $\hat{\gamma}_{RGMM}$, obtain the corresponding estimated vector of random errors,

$$\hat{u}_{RGMM} = (\hat{u}_{1,RGMM} \quad \hat{u}_{2,RGMM} \quad \dots \quad \hat{u}_{N,RGMM})',$$

and calculate,

$$\hat{\Lambda}_{RGMM} = \frac{1}{N} \sum_{i=1}^N Z_i'\hat{u}_{i,RGMM}\hat{u}_{i,RGMM}'Z_i.$$

$$\Psi = I - (C'(\hat{\Lambda}_{RGMM})^{-1}C)^{-1}R'[R(\hat{\Lambda}_{RGMM})^{-1}R']^{-1}R.$$

9. Distribution of $\hat{\gamma}_{RGMM}$:

$$\sqrt{N}(\hat{\gamma}_{RGMM} - \gamma) \sim AN(0, \Psi\Sigma_{GMM}\Psi').$$

The estimated asymptotic variance-covariance matrix of $\hat{\gamma}_{RGMM}$ is,

$$\hat{V}(\hat{\gamma}_{RGMM}) = \Psi\hat{V}(\hat{\gamma}_{GMM})\Psi'.$$

10. For GMM, using,

$$\hat{u}_{GMM} = (\hat{u}_{1,GMM} \quad \hat{u}_{2,GMM} \quad \dots \quad \hat{u}_{N,GMM})',$$

Calculate

$$\bar{R}^2 = 1 - \frac{\frac{\hat{u}_{GMM}'\hat{u}_{GMM}}{NG - K}}{\frac{y'M_i y}{NG - 1}}$$

$$AIC = NG \ln(\hat{u}_{GMM}'\hat{u}_{GMM}) + 2K$$

$$SBC = NG \ln(\hat{u}_{GMM}'\hat{u}_{GMM}) + K \ln(NG)$$

where ι is a $(NG \times 1)$ vector of 1, and $M_i = \iota(\iota'\iota)^{-1}\iota'$.

11. For restricted GMM, by using $\hat{u}_{RGMM} = (\hat{u}_{1,RGMM} \quad \hat{u}_{2,RGMM} \quad \dots \quad \hat{u}_{N,RGMM})'$, calculate:

$$\bar{R}^2 = 1 - \frac{\frac{\hat{u}_{RGMM}'\hat{u}_{RGMM}}{NG - K}}{\frac{y'M_i y}{NG - 1}}$$

$$AIC = NG \ln(\hat{u}_{RGMM}'\hat{u}_{RGMM}) + 2K$$

$$SBC = NG \ln(\hat{u}_{RGMM}'\hat{u}_{RGMM}) + K \ln(NG)$$

Similarly, we have calculated the $\bar{R}^2$, AIC, and SBC for the OLS estimator by using $\hat{u}_{OLS} = (\hat{u}_{1,OLS} \quad \hat{u}_{2,OLS} \quad \dots \quad \hat{u}_{N,OLS})'$ respectively.

12. Using $\hat{u}_{GMM}$ and $W = (\hat{\Lambda}_{2SLS})^{-1}$, the J -statistic for GMM as follows,

$$J = (N^{-\frac{1}{2}} \sum_{i=1}^N Z_i' u_{iGMM})' W (N^{-\frac{1}{2}} \sum_{i=1}^N Z_i' u_{iGMM}) \sim \chi_{L-K}^2.$$

13. Using $\hat{u}_{RGMM}$ and $W = (\hat{\Lambda}_{R2SLS})^{-1}$, calculate the J -statistic for the restricted GMM as follows,

$$J = (N^{-\frac{1}{2}} \sum_{i=1}^N Z_i' u_{iRGMM})' W (N^{-\frac{1}{2}} \sum_{i=1}^N Z_i' u_{iRGMM}) \sim \chi_{L-(K-q)}^2.$$

Note, in our paper we have single equation estimation with, $G = 1; \gamma = (\gamma_0 \ \gamma_1 \ \gamma_2)' \Rightarrow K = 3; L = 4$. Moreover, for restricted GMM we have, $R = (0 \ 1 \ -1) \Rightarrow q = 1$ in our paper. Therefore, we can easily calculate,

$$\hat{\Lambda}_{2SLS} = \frac{1}{N} \sum_{i=1}^N \hat{u}_{i,2SLS}^2 z_i' z_i,$$

$$\hat{\Lambda}_{GMM} = \frac{1}{N} \sum_{i=1}^N \hat{u}_{i,GMM}^2 z_i' z_i,$$

and

$$\hat{\Lambda}_{R2SLS} = \frac{1}{N} \sum_{i=1}^N \hat{u}_{i,R2SLS}^2 z_i' z_i,$$

$\hat{\Lambda}_{RGMM} = \frac{1}{N} \sum_{i=1}^N \hat{u}_{i,RGMM}^2 z_i' z_i$, where z_i is the i -th row of matrix Z . We have checked that, the GMM estimator $\hat{\gamma}_{GMM}$ its estimated asymptotic variance-covariance matrix $\hat{V}(\hat{\gamma}_{GMM})$; and the corresponding J -statistic calculated using our algorithm are identical with the same obtained from Stata 13.



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The Economic Impact of Real-Time Connectivity and User Readiness on Digital Health Adoption: An Extended TAM Perspective

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Abstract: This study examines the key determinants of digital health application adoption, extending the Technology Acceptance Model (TAM) to incorporate the economic and practical implications of real-time connectivity and user technology readiness. Given the escalating investment in mobile health technologies, understanding the factors driving user adoption is crucial for maximizing return on digital health investments and achieving widespread public health benefits. Utilizing a quantitative research design, we applied structural equation modeling to analyze survey data from 421 potential users. Our findings confirm the significant positive influence of perceived usefulness, perceived ease of use, and user technology readiness on adoption intention, thereby expanding the TAM framework. Crucially, real-time connectivity significantly impacts TAM factors, highlighting the economic necessity of robust technological infrastructure and user preparedness for successful digital transformation in healthcare. This research offers practical implications for developers, healthcare providers, and policymakers, emphasizing the need to prioritize user-centric designs, reliable connectivity, and initiatives that enhance technology readiness to foster the widespread adoption of interactive digital health solutions and optimize their economic and social impact.

Keywords: technology acceptance model; digital health economics; real-time connectivity; user readiness; mhealth adoption; innovation diffusion; healthcare policy; investment optimization.

JEL Classification: L86; O33; M15.

Introduction

The rapid advancement of mobile technology and the proliferation of smartphones have revolutionized various sectors, including healthcare. Mobile health (mHealth) applications, offering a wide range of functionalities from remote patient monitoring to personalized health tracking, have emerged as a powerful tool for improving healthcare accessibility, efficiency, and patient outcomes (Aljedaani *et al.* 2023). These applications empower individuals to actively participate in their own health management, fostering a more proactive and patient-centered approach to healthcare delivery. The potential of mHealth to transform healthcare systems is vast, particularly in addressing the growing demand for chronic disease management, preventive care, and personalized medicine (Tran and Nguyen 2021). Real-time connectivity, a key feature of many mHealth applications, further enhances their capabilities by enabling continuous data collection, immediate feedback, and timely interventions (Isakovic *et al.* 2016). This real-time data exchange between patients and healthcare providers facilitates proactive monitoring, personalized treatment adjustments, and early detection of potential health issues (Sachdev and Lall 2025). Furthermore, the integration of wearable sensors and other connected devices with mHealth applications expands the scope of data collection, providing a more comprehensive and holistic view of an individual's health status.

Despite the significant potential of mHealth applications, their adoption rates remain suboptimal, hindering the full realization of their benefits. Understanding the factors that influence individuals' acceptance and continued use of these applications is crucial for promoting wider adoption and maximizing their impact on healthcare. The Technology Acceptance Model (TAM) (Davis 1989; Uyen *et al.* 2025) has been widely employed as a theoretical framework for understanding technology adoption in various contexts, including healthcare. TAM posits that perceived usefulness and perceived ease of use are key determinants of an individual's intention to use a technology (Khoa and Huynh 2024; Cuong, Khoa, and Thanh 2025). However, the traditional TAM may not fully capture the unique characteristics of mHealth applications, particularly the role of real-time connectivity and the individual's readiness to embrace mobile app technology.

While the benefits of real-time connectivity in mHealth are acknowledged, its specific influence on individuals' perceptions of usefulness and ease of use remains under-explored (Priya 2024). Existing studies primarily focus on the general features and functionalities of mHealth applications, without explicitly examining the role of real-time data exchange in shaping user perceptions and adoption behavior. This gap limits our understanding of how real-time connectivity can be leveraged to enhance the appeal and effectiveness of mHealth applications. For instance, Kakria, Tripathi, and Kitipawang (2015) highlighted the importance of real-time health monitoring systems, but does not delve into the user's perception of this feature within the context of technology acceptance. Similarly, while Yang *et al.* (2022) discusses the evolution of wearable devices with real-time disease monitoring, the link to technology acceptance models remains unexplored.

Individuals' readiness to adopt and effectively utilize mobile app technology varies significantly, influenced by factors such as prior experience with mobile apps, digital literacy, and comfort with technology. This individual-level technology readiness plays a crucial role in shaping their perceptions and adoption decisions regarding mHealth applications. However, existing research on mHealth adoption often overlooks this critical factor, assuming a uniform level of technology readiness among users. This gap hinders our ability to tailor mHealth interventions and support strategies to the specific needs and capabilities of different user segments. While studies like Mishra, Singh, and Agarwal (2022) discussed the transformation in healthcare with emerging technologies, the specific aspect of individual technology readiness related to mHealth applications remains unaddressed. This research aims to address the identified gaps by:

1. Investigating the influence of real-time connectivity on individuals' perceived usefulness and perceived ease of use of mHealth applications.

2. Examining the role of mobile app technology readiness on the relationship between perceived usefulness/ease of use and Health-care tracking apps adoption.

The remainder of this paper is structured as follows: Section 2 provides a comprehensive literature review on healthcare tracking applications, theoretical model establishment, and hypotheses development. Section 3 describes the research methodology. Section 4 presents the research findings. Finally, Section 5 and 6 concludes the paper with discussion, implications and future research directions.

1. Literature Review

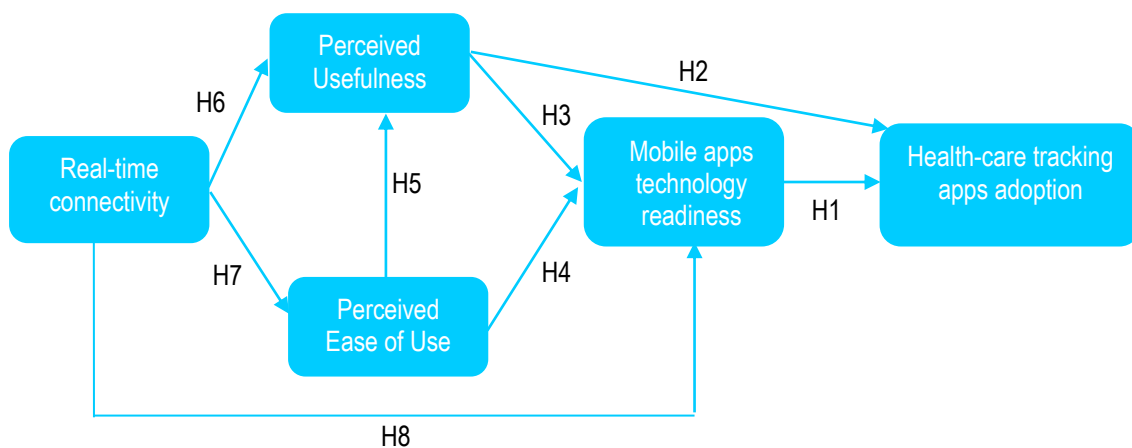
Healthcare tracking applications, a cornerstone of mHealth, empower individuals to monitor various health parameters, manage chronic conditions, and engage in preventive care. These applications leverage mobile devices and sensor technologies to collect and analyze health data, providing personalized insights and facilitating communication with healthcare providers (James and Harville 2018). From tracking physical activity and sleep patterns to managing medication adherence and monitoring vital signs, these applications offer a diverse range of functionalities that cater to various health needs. The integration of real-time connectivity further enhances their capabilities, enabling continuous data monitoring, timely interventions, and improved patient-provider communication (Kakria, Tripathi, and Kitipawang 2015). The proliferation of wearable sensors and connected devices has further expanded the scope of data collection, providing a more comprehensive and holistic view of an individual's health status (Zhang and Mao 2023).

TAM provides a robust framework for understanding technology adoption. TAM posits that perceived usefulness and perceived ease of use are key determinants of an individual's intention to use a technology (Davis 1989; Tran and Khoa 2025b). Perceived usefulness refers to the belief that using a particular system will enhance one's performance, while perceived ease of use refers to the belief that using the system will be free of effort (Venkatesh *et al.* 2003; Tran and Khoa 2025a). These two constructions have been widely used to explain technology adoption across various domains, including healthcare.

This research extends the TAM by incorporating real-time connectivity as an external variable influencing perceived usefulness and perceived ease of use. Real-time connectivity, a defining feature of many mHealth

applications, enables continuous data exchange between patients and healthcare providers, facilitating timely interventions and personalized feedback (Jayakumar, Kumar, and Kharbas 2024). This capability is particularly crucial for managing chronic conditions and promoting proactive healthcare. Studies suggest that real-time feedback enhances user engagement and motivation (Kang and Mo 2024; Khoa 2025), potentially increasing the perceived usefulness of healthcare tracking applications. Furthermore, seamless data transfer and synchronization enabled by real-time connectivity can simplify the user experience, contributing to perceived ease of use. This research also proposes replacing the "attitude" construct in the original TAM with "mobile app technology readiness." While attitude reflects a general predisposition towards a technology, mobile app technology readiness specifically captures an individual's comfort, confidence, and ability to engage with mobile applications (Anh *et al.* 2024). This construct acknowledges the varying levels of digital literacy and prior experience with mobile technology among individuals, which can significantly influence their perception and adoption of mHealth applications (Ben-Zeev *et al.* 2024). Individuals with higher mobile app technology readiness are likely to perceive healthcare tracking applications as more useful and easier to use, leading to increased adoption intention. Hence, the model was proposed as Figure 1.

Figure 1. Theoretical model



Source: Authors' recommendation

Mobile app technology readiness plays a pivotal role in shaping users' intention to adopt healthcare tracking applications. According to Mishra, Singh, and Agarwal (2022), individuals with higher technology readiness are more likely to perceive these applications as accessible and beneficial, leading to increased adoption. The integration of user-friendly interfaces, real-time connectivity, and wearable sensors further enhances the perceived value of healthcare tracking applications, particularly among tech-savvy users. Perceived usefulness is a core determinant of technology adoption, as posited by TAM (Davis 1989; Duy, Nguyen, and Khoa 2025). In the context of healthcare tracking applications, users are more likely to adopt applications that they perceive as valuable for managing their health. For instance, applications that provide real-time health insights and integrate seamlessly with wearable devices are often perceived as highly useful, thereby driving adoption (Kakria, Tripathi, and Kitipawang 2015). The perceived utility of healthcare tracking applications can enhance users' confidence and comfort with mobile technology. Positive experiences with the applications, such as timely health insights and personalized recommendations, reinforce users' trust and familiarity with mobile apps, thereby increasing technology readiness (Guk *et al.* 2019). Applications that are easy to navigate and interact with foster positive user experiences, reducing anxiety and hesitation associated with using mobile technology. This, in turn, enhances users' readiness to adopt and engage with other mobile applications, including healthcare tracking apps (Abdullah *et al.* 2015). When applications are intuitive and user-friendly, users are more likely to explore their features and functionalities, gaining a better understanding of their potential benefits. This relationship between Perceived Usefulness and Perceived Ease of Use is well-documented in the TAM literature (Khanh, Khoa, and Cuong 2025). Hence, the hypotheses were proposed:

- H1: Mobile apps technology readiness has positive impact on Health-care tracking apps adoption.*
- H2: Perceived Usefulness has positive impact on Health-care tracking apps adoption.*
- H3: Perceived Usefulness has positive impact on Mobile apps technology readiness.*
- H4: Perceived Ease of Use has positive impact on Mobile apps technology readiness.*
- H5: Perceived Ease of Use has positive impact on Perceived Usefulness of Health-care tracking apps.*

Real-time connectivity significantly enhances the perceived utility of healthcare tracking applications. Research by Kakria, Tripathi, and Kitipawang (2015) demonstrated that immediate data transmission capabilities improved the effectiveness of remote patient monitoring. Additionally, Mujuni *et al.* (2024) showed that real-time data connectivity enhanced the diagnostic accuracy and clinical utility of health monitoring systems. Studies show that effective real-time connectivity simplifies the use of healthcare tracking applications. Abdullah *et al.* (2015) found that wireless health monitoring systems with reliable connectivity reduced the complexity of health data management. Guk *et al.* (2019) further demonstrated that seamless real-time data transmission improved the user experience of wearable health devices. Research indicates that reliable real-time connectivity enhances users' readiness to adopt mobile health technologies. Singh *et al.* (2022) showed that robust connectivity infrastructure increased users' confidence in mobile health solutions. This is supported by Mishra, Singh, and Agarwal (2022), who found that efficient real-time data exchange capabilities positively influenced users' willingness to engage with mobile health applications. Consequently, the assumptions were formulated:

H6: Real-time connectivity has positive impact on Perceived Usefulness of Health-care tracking apps.

H7: Real-time connectivity has positive impact on Perceived Ease of Use of Health-care tracking apps.

H8: Real-time connectivity has positive impact on Mobile apps technology readiness

2. Method

This study adopts a quantitative research design using a structured online survey to collect data from healthcare app users in Vietnam. The target population comprises adult users who have prior experience using healthcare tracking applications, ensuring relevance to the study objectives. A purposive sampling technique is employed to recruit respondents, focusing on individuals aged 18 and above with diverse demographic backgrounds, such as gender, occupation, and level of digital literacy. Data collection was conducted over four weeks through an online survey platform. The survey link was distributed via social media platforms, healthcare forums, and email invitations to maximize reach. Respondents were briefed about the study's purpose, assured of confidentiality, and provided informed consent before participation. To ensure data quality, responses were screened for completeness, and individuals who did not meet the inclusion criteria (e.g., no prior experience with healthcare tracking apps) were excluded. A total of 421 valid responses were retained for analysis after data cleaning. This sample size exceeds the recommended minimum for Partial Least Squares structural equation modeling (PLS-SEM), providing robust statistical power for hypothesis testing. The high response rate was attributed to the relevance of the topic and the increasing popularity of healthcare tracking applications in Vietnam.

Table 1. Respondent Demographics

Demographics	Frequency	Percentage (%)
Gender		
Male	215	51.07%
Female	206	48.93%
Age Group		
18–25	150	35.63%
26–35	170	40.38%
36–45	75	17.81%
46 and above	26	6.18%
Education Level		
High School	58	13.78%
Bachelor's Degree	245	58.19%
Master's Degree and above	118	28.03%
Experience with Mobile Apps		
1 year	90	21.38%
2-3 years	230	54.63%
More than 3 years	101	23.99%

Source: Authors' calculation

The survey was designed to minimize respondent fatigue by grouping related items and using clear, concise language. Pilot testing was conducted with 30 respondents to refine the questionnaire, ensuring clarity and reliability. Feedback from the pilot phase was incorporated into the final survey instrument.

The demographic profile of the respondents is summarized in Table 1.

The sample includes a balanced representation of genders, with slightly more male participants. Most respondents are aged between 18 and 45, reflecting the demographic most likely to use mobile healthcare applications. Table 1 also highlighted the diversity in education levels and prior experience with mobile apps, ensuring generalizability of findings.

To examine the adoption of healthcare tracking applications through the extended Technology Acceptance Model, the study employs six constructs: Perceived Usefulness (USE), Perceived Ease of Use (EOU), Mobile App Technology Readiness (MRE), Real-time Connectivity (RTC), and Health-care Tracking Apps Adoption (HTA). Each construct is measured using a three-item scale adapted from previous studies, ensuring reliability and validity. All items are scored using a 7-point Likert scale, ranging from 1 ("Strongly Disagree") to 7 ("Strongly Agree"). The items were pre-tested for clarity and relevance prior to the main survey.

Perceived Usefulness refers to the extent to which users believe that healthcare tracking applications enhance their health management. The three items of USE are used to measure USE, adapted from Davis (1989). Perceived Ease of Use assesses how effortless users find the interaction with healthcare tracking applications. Simplified interfaces and user-friendly functionalities are essential for fostering adoption. Three items for EOU are adapted from Davis (1989). Mobile Apps Technology Readiness reflects an individual's comfort, confidence, and preparedness to use mobile healthcare applications. This construct replaces Attitude in the extended TAM model to address varying levels of digital literacy. Three items for MRE are adapted from Anh *et al.* (2024). Real-time connectivity refers to the capability of healthcare tracking applications to provide immediate data exchange and feedback. Three items for RTC are adapted from Guk *et al.* (2019); Mishra, Singh, and Agarwal (2022). Adoption measures the behavioral intention and actual usage of healthcare tracking applications which measured by three items, adapted from Davis (1989); Abdullah *et al.* (2015).

4. Research Results

The measurement model was evaluated using SmartPLS 4.0 to assess reliability and validity. Following Hair Jr *et al.* (2016), this study examined indicator reliability, internal consistency reliability, convergent validity, and discriminant validity. Table 2 presents the results of reliability and convergent validity analyses. All constructs demonstrated satisfactory indicator reliability with outer loadings (OL) ranging from 0.782 to 0.931, exceeding the recommended threshold of 0.70. Composite reliability (CR) values ranged from 0.891 to 0.943, surpassing the 0.70 threshold, indicating strong internal consistency. Average Variance Extracted (AVE) values ranged from 0.731 to 0.847, exceeding the 0.50 threshold and confirming convergent validity. Discriminant validity was assessed using the Fornell-Larcker criterion. Table 2 shows that the square root of AVE for each construct (diagonal values) exceeds its correlations with other constructs, satisfying the Fornell-Larcker criterion.

Table 2. Reliability, Convergent and Discriminant Validity Results

Construct	OL	CR	AVE	α	Fornell-Larcker				
					USE	EOU	MRE	RTC	HTA
USE	0.845-0.912	0.923	0.799	0.875	0.894				
EOU	0.832-0.901	0.911	0.774	0.854	0.612	0.88			
MRE	0.856-0.931	0.943	0.847	0.909	0.687	0.654	0.92		
RTC	0.782-0.898	0.891	0.731	0.817	0.598	0.571	0.643	0.855	
HTA	0.824-0.907	0.918	0.788	0.866	0.701	0.668	0.734	0.623	0.888

Source: Authors' calculation

The model's predictive power was assessed through R^2 values, while predictive relevance was evaluated using Stone-Geisser's Q^2 values through blindfolding procedure. Table 3 demonstrated strong explanatory and predictive power, as evidenced by R^2 values ranging from 0.456 to 0.687 and Q^2 values all above 0. Specifically, the model explained nearly 69% of the variance in Healthcare Tracking Apps Adoption, with a robust predictive validity ($Q^2 = 0.498$). Similarly, Mobile Apps Technology Readiness exhibited strong explanatory and predictive capabilities ($R^2 = 0.598$, $Q^2 = 0.467$). While Perceived Usefulness and Perceived Ease of Use also showed predictive relevance ($Q^2 = 0.412$ and 0.334 , respectively), their slightly lower values suggest potential for enhancing predictive accuracy by considering additional influencing factors. The minimal difference between R^2

and adjusted R^2 across all constructs indicates a good balance between model complexity and explanatory power.

Table 3. R^2 , R^2 adjusted, and Q^2 value

Construct	R^2	R^2 Adjusted	Q^2
HTA	0.687	0.682	0.498
USE	0.543	0.539	0.412
EOU	0.456	0.452	0.334
MRE	0.598	0.593	0.467

Source: Authors' calculation

The analysis of the Variance Inflation Factor (VIF) reveals no multicollinearity issues within the model. All VIF values in Table 4 were well below the threshold of 5, ranging from 1.543 to 2.341. This indicates that the predictor variables are not highly correlated, ensuring the reliability and stability of the regression coefficients. The effect sizes (f^2) provide insights into the practical significance of the relationships between constructs. The strongest effect is observed in the relationship between MRE and HTA ($f^2 = 0.287$), indicating a medium to large effect. Several relationships demonstrate small to medium effects, including the influence of USE on MRE ($f^2 = 0.234$), EOU on USE ($f^2 = 0.245$), RTC on USE ($f^2 = 0.212$), and RTC on EOU ($f^2 = 0.189$). While the remaining relationships exhibit smaller effect sizes, they still contribute to the overall explanatory power of the model.

The path analysis in Table 4, based on the standardized beta coefficients, reveals the strength and direction of the relationships between the constructs. MRE ($\beta = 0.412$) and USE ($\beta = 0.378$) emerge as the strongest predictors of HTA. The positive path coefficients indicate that higher levels of MRE and USE are associated with greater HTA adoption. Furthermore, RTC plays a significant role in influencing USE ($\beta = 0.367$) and EOU ($\beta = 0.312$), indirectly contributing to HTA. The model confirms the hypothesized relationships, with all paths demonstrating statistical significance (t -values > 1.96). These findings highlight the importance of technology readiness, perceived usefulness, and real-time connectivity in driving the adoption of healthcare tracking applications.

Table 4. f^2 , VIF, and path analysis result

Path	β	t-value	VIF	f^2	Result
H1: MRE $\rightarrow$ HTA	0.412	8.876	2.341	0.287	Supported
H2: USE $\rightarrow$ HTA	0.378	7.654	2.156	0.198	Supported
H3: USE $\rightarrow$ MRE	0.356	6.987	1.987	0.234	Supported
H4: EOU $\rightarrow$ MRE	0.298	5.876	1.876	0.176	Supported
H5: EOU $\rightarrow$ USE	0.345	6.543	1.654	0.245	Supported
H6: RTC $\rightarrow$ USE	0.367	7.123	1.789	0.212	Supported
H7: RTC $\rightarrow$ EOU	0.312	6.234	1.543	0.189	Supported
H8: RTC $\rightarrow$ MRE	0.289	5.765	1.912	0.167	Supported

Source: Authors' calculation

5. Discussions

The adoption of healthcare tracking applications (HTAs) has gained significant attention in recent years, driven by advancements in mobile technology and the increasing importance of personalized healthcare. This study extends the Technology Acceptance Model by incorporating Real-Time Connectivity (RTC) and Mobile Apps Technology Readiness (MRE) to examine their combined influence on the adoption of HTAs. The results of this research affirm the relationships between the constructs and provide critical insights into user behavior, aligning with and expanding upon findings from prior studies.

The findings indicate that Perceived Usefulness (USE) strongly influences both Mobile Apps Technology Readiness (MRE) and Health-care Tracking Apps Adoption (HTA), corroborating previous research by Davis (1989), which established USE as a critical determinant in the TAM framework. Consistent with Kakria, Tripathi, and Kitipawang (2015), USE was found to be an essential factor in motivating individuals to adopt healthcare technologies, as users recognize the benefits of improved health management and decision-making capabilities. Similarly, Perceived Ease of Use (EOU) was shown to positively impact both USE and MRE, indicating that user-friendly designs significantly reduce the perceived complexity of HTAs. This finding aligns with Abdullah *et al.*

(2015); Guk *et al.* (2019), who emphasized the importance of intuitive interfaces and simplified functionalities in driving user engagement with mobile health solutions. Furthermore, the strong relationship between EOU and USE supports assertion of Kang and Mo (2024) that ease of use enhances the perceived value of healthcare tracking apps.

A notable contribution of this research is the integration of RTC into the TAM framework. The findings demonstrate that RTC significantly enhances both USE and EOU, highlighting its role in improving the effectiveness and user experience of HTAs. This is consistent with Jayakumar, Kumar, and Kharbas (2024), who found that real-time data exchange capabilities enhance the diagnostic accuracy and clinical utility of healthcare applications. Additionally, the study aligns with Jabbar, Akhtar, and Dani (2020), who emphasized the importance of robust connectivity infrastructure in fostering user confidence and adoption of mobile health solutions. The results further reveal that RTC positively impacts MRE, suggesting that seamless real-time connectivity increases users' readiness to engage with mobile health technologies. This finding supports Mishra, Singh, and Agarwal (2022), who noted that efficient real-time data exchange capabilities positively influence users' willingness to adopt mobile health applications.

MRE emerged as a critical factor influencing HTA adoption in this study. Users with higher levels of comfort, confidence, and preparedness to use mobile technologies were more likely to adopt HTAs. This finding aligns with Çavmak, Söyler, and Çavmak (2024), who highlighted the importance of technology readiness in shaping user behavior toward new technologies. Furthermore, the significant relationship between USE and MRE underscores the importance of perceived benefits in fostering technology readiness, as suggested by Anh *et al.* (2024). The study also highlights the interplay between RTC, EOU, and MRE, providing a more nuanced understanding of how technological infrastructure and user-friendly designs contribute to technology readiness. These findings extend the work of Abdullah *et al.* (2015), who emphasized the role of usability and connectivity in reducing technological barriers.

While the findings of this research align with many prior studies, they also contribute new insights. For instance, Kang and Mo (2024) emphasized the role of user-friendly digital twin frameworks in improving perceived value, but this study extends their work by demonstrating the impact of RTC on both USE and EOU. Similarly, while Mujuni *et al.* (2024) focused on the diagnostic and clinical benefits of real-time connectivity, this research highlights its broader implications for user readiness and adoption. The inclusion of MRE as a construct provides a novel perspective on technology adoption, addressing gaps in previous studies that primarily focused on USE and EOU. By integrating MRE into the extended TAM framework, this study offers a more comprehensive understanding of the factors influencing HTA adoption.

Conclusions and Further Research

This study makes several significant theoretical contributions to the literature on technology acceptance and mobile health. By incorporating RTC and MRE into the TAM framework, this research provides a more comprehensive model for understanding the adoption of HTAs. This extension addresses gaps in previous studies, offering a more holistic perspective on the factors influencing user behavior in the context of mobile health. The inclusion of RTC as a key construct highlights its critical role in enhancing both USE and EOU, as well as its indirect influence on adoption through MRE. This finding contributes to the growing body of literature on the importance of connectivity in mobile health. By introducing MRE as a construct, this study addresses the varying levels of digital literacy and preparedness among users, providing a more nuanced understanding of technology adoption. This extends the work of Mishra, Singh, and Agarwal (2022) by emphasizing the role of user readiness in shaping adoption behavior. The findings reaffirm the importance of USE and EOU in the TAM framework, consistent with Davis (1989). The strong relationships between these constructs and HTA adoption provide further empirical support for their relevance in the context of mobile health.

The findings of this research offer valuable insights for practitioners and policymakers seeking to promote the adoption of HTAs. The significant impact of EOU on both USE and MRE underscores the importance of intuitive designs and simplified functionalities. Developers should prioritize user-centric features to enhance usability and reduce technological barriers. The critical role of RTC in driving adoption highlights the need for robust connectivity infrastructure. Policymakers and healthcare providers should invest in reliable networks to support real-time data exchange and feedback. The strong relationship between MRE and HTA adoption suggests that initiatives to enhance users' digital literacy and confidence can significantly impact adoption rates. Educational campaigns and training programs can play a crucial role in fostering technology readiness. The findings highlight the importance of addressing the diverse needs and preferences of users. Developers should consider demographic factors, such as age and digital experience, when designing HTAs to ensure broad

accessibility and relevance. The strong influence of USE on adoption suggests that highlighting the tangible benefits of HTAs, such as improved health management and decision-making, can drive user engagement. Marketing campaigns should focus on communicating these benefits to potential users.

While this study provides valuable insights, it is not without limitations. The research focuses exclusively on respondents in Vietnam, which may limit the generalizability of the findings to other cultural and geographical contexts. Future research should replicate this study in diverse settings to validate the results. The study employs a cross-sectional design, which limits the ability to examine changes in user behavior over time. Longitudinal studies could provide a more dynamic understanding of the factors influencing HTA adoption. The reliance on self-reported data may introduce response bias, as participants may overestimate their readiness or intention to adopt HTAs. Future research could incorporate objective measures, such as actual usage data, to validate the findings. While the extended TAM framework provides a comprehensive model, additional constructs, such as trust, privacy concerns, and perceived risk, could further enhance the understanding of HTA adoption. Future research should explore these factors to provide a more holistic perspective. As mobile health technologies continue to evolve, the relevance of certain constructs may change over time. Future research should examine the impact of emerging features, such as artificial intelligence and predictive analytics, on user behavior.

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Credit Authorship Contribution Statement

Viet Anh Tran: Conceptualization, Investigation, Methodology, Writing – original draft, Validation.

Bui Thanh Khoa: Methodology, Project administration, Software, Formal analysis, Supervision, Data curation, Writing – review and editing, Visualization.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Declaration of Use of Generative AI and AI-assisted Technologies

The authors declare that they have not used generative AI and AI-assisted technologies in the writing process before submission, but only to improve the language and readability of their paper and with the appropriate disclosure.

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Behavioural Insights for Strategic Planning

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Abstract: This paper explores the integration of behavioural economics into strategic planning frameworks to enhance decision-making in uncertain and complex environments. By unpacking foundational concepts such as cognitive biases, heuristics, and bounded rationality, the discussion challenges traditional assumptions of rational economic behaviour. Practical tools such as nudging, framing, and choice architecture are evaluated for their efficacy in influencing consumer and employee behaviour. The study further distinguishes between risk and uncertainty, proposing adaptive strategies like scenario planning and real options analysis to improve organisational resilience. Drawing on behavioural game theory, the paper offers insights into market competition, highlighting real-world case studies across industries. These show the practical utility of behavioural approaches in achieving sustainable competitive advantage and strategic goals.

Keywords: behavioural economics; strategic planning; uncertainty management; scenario planning; cognitive biases.

JEL Classification: D01; D81; L21; M31; A14.

Introduction

In an increasingly complex and volatile business environment, organisations are under continuous pressure to make strategic decisions that not only respond to immediate challenges but also prepare for long-term uncertainties. Traditional strategic planning has long been rooted in the assumption that decision-makers act rationally, consistently evaluating costs and benefits to arrive at optimal choices. However, insights from behavioural economics reveal a more intricate reality: human decisions are frequently influenced by cognitive limitations, emotional responses, and contextual factors. This departure from classical rational choice theory forms the foundation for integrating behavioural insights into strategic planning. The emerging discipline of behavioural economics, shaped by pioneering work from scholars such as Kahneman and Tversky (1979), proposes that individuals deviate from rationality in systematic and predictable ways. Their contributions, especially through the development of prospect theory, have provided robust explanations for why individuals often make inconsistent choices when faced with risk and uncertainty. Such insights are invaluable for organisations aiming to formulate strategies that align with how individuals - be they consumers, employees, or stakeholders - actually behave, rather than how they are assumed to behave.

In the context of strategic planning, acknowledging behavioural tendencies enables business leaders to adopt more adaptive, responsive, and ultimately effective strategies. Cognitive phenomena such as bounded rationality, overconfidence, anchoring bias, and loss aversion challenge the reliability of purely data-driven models. Instead, these behavioural patterns call for an approach that incorporates psychological realism into strategic thinking. Strategic planners can no longer rely solely on forecasts, quantitative models, or historical data; they must also consider how perception, memory, and emotion shape decision-making processes. By embedding behavioural principles into their frameworks, organisations can design interventions that mitigate biases, improve judgement, and encourage more rational outcomes. This is particularly relevant in contexts where uncertainty is pervasive and where human behaviour significantly impacts strategic outcomes. Through the adoption of behavioural insights, firms are better positioned to develop strategies that are both flexible and robust, accommodating the often-unpredictable nature of individual and group decision-making.

Research Background

The theoretical underpinnings of behavioural economics represent a significant departure from the foundational assumptions of neoclassical economics. Central to this shift is the recognition that individuals do not consistently behave in ways that maximise utility. Instead, decisions are shaped by a host of psychological, social, and cognitive influences. Daniel Kahneman and Amos Tversky's (1979) prospect theory marked a seminal moment in this evolution by demonstrating that people evaluate potential gains and losses asymmetrically. This principle, known as loss aversion, suggests that individuals are more sensitive to losses than to gains of equivalent value. The implication for strategic planning is profound: business leaders may resist abandoning failing projects or hesitate to pursue innovative opportunities due to an exaggerated fear of loss. The theoretical contributions of Kahneman and Tversky thus provide a compelling framework for understanding deviations from rational behaviour, enabling the design of strategies that better reflect actual decision-making patterns.

Beyond prospect theory, other heuristics and biases have been extensively documented in the literature. For instance, the availability heuristic - whereby individuals judge the likelihood of events based on the ease with which examples come to mind - can lead to distorted perceptions of risk and probability. This may result in strategic overreactions to recent events or underestimations of long-term threats. Phillips (1983) posited that while heuristics serve as useful cognitive shortcuts in complex decision environments, they also introduce systematic errors that must be accounted for. Another influential concept is bounded rationality, introduced by Herbert Simon, which contends that individuals operate within the constraints of limited information, time, and cognitive processing power. Rather than seeking optimal solutions, decision-makers often settle for "satisficing" options - those that are good enough under the circumstances. This view aligns more closely with how real-world strategic decisions are made, particularly in high-stakes, uncertain conditions where exhaustive analysis is impractical.

The behavioural literature also highlights the importance of social influence in shaping economic behaviour. Cialdini's (2007) work on persuasion and social norms reveals how individuals are often guided by what others around them are doing, rather than by independent evaluation of options. This has implications for both consumer behaviour and internal organisational dynamics, as conformity, groupthink, and status signalling can significantly impact strategic outcomes. Furthermore, biases such as overconfidence - where individuals overestimate their abilities and the accuracy of their knowledge - can skew forecasts, resource allocation, and risk assessments (Jackson, 2016). Anchoring bias, where initial information serves as a cognitive reference point, can unduly influence subsequent decisions. These behavioural anomalies collectively represent critical variables that must be addressed in any strategic planning process that aspires to realism and effectiveness. By embedding these insights into business strategy, organisations can more accurately predict behaviour, avoid common decision-making traps, and create strategies that are both practical and psychologically informed.

Methodology

The methodological approach adopted in this paper is predominantly qualitative, drawing on an extensive review of scholarly literature, industry reports, and documented organisational practices to explore the intersection of behavioural economics and strategic planning. Rather than relying on statistical inference or experimental design, the analysis employs conceptual synthesis and comparative case study methods to derive insights. This choice reflects the interpretative nature of the subject matter, which seeks to understand human behaviour in complex organisational settings where controlled experiments may not be feasible or appropriate. The objective is to develop a rich and contextual understanding of how behavioural insights can be operationalised in strategic frameworks, particularly in environments characterised by high uncertainty and dynamic change.

The conceptual component of the methodology involves a thematic analysis of key theoretical constructs in behavioural economics - such as cognitive biases, heuristics, and decision-making under uncertainty - and their relevance to strategic planning. Thematic coding and cross-referencing were used to identify recurrent patterns and themes in the literature, which were then mapped onto practical business contexts. Case-based evaluation complements this theoretical grounding by examining real-world examples of organisations that have successfully integrated behavioural principles into their strategic processes. These include multinational firms across sectors such as energy, technology, and finance. Cases were selected for their illustrative value, diversity, and documented outcomes, allowing for both cross-case comparison and context-specific interpretation.

Scenario planning is examined through an adapted version of Royal Dutch Shell's (2013) methodology, which incorporates behavioural inputs such as optimism bias and framing effects. This hybrid model allows for the creation of more realistic, psychologically grounded future scenarios. Behavioural modelling is further employed through the application of behavioural game theory and behavioural portfolio theory, which provide frameworks

for understanding strategic interactions and investment decisions in environments where psychological factors are at play. These models, though not quantitatively tested in this paper, are explored conceptually to demonstrate their practical implications. Overall, the methodology balances rigour with flexibility, providing a comprehensive and multi-faceted exploration of behavioural strategic planning that bridges theory and practice.

Discussions

The application of behavioural economics within strategic planning offers a paradigm shift in how organisations approach uncertainty and decision-making. One of the most significant contributions of behavioural economics is its ability to account for the psychological realities of how decisions are made, especially under conditions of uncertainty. Uncertainty, unlike risk, is not quantifiable in probabilistic terms, and this distinction has critical implications for strategy development. As outlined by Barrie and Jackson (2022), businesses often operate in environments where the future is shaped by unpredictable changes in technology, regulation, consumer behaviour, and macroeconomic conditions. In such contexts, conventional planning models fall short. Behavioural responses to uncertainty - such as ambiguity aversion and status quo bias - can lead firms to adopt overly cautious or inflexible strategies, thereby missing out on potential innovations or opportunities. These insights reinforce the need for strategic approaches that are adaptive and psychologically realistic.

Integrating behavioural insights into scenario planning further enhances strategic agility. Traditional scenario planning has often been limited by linear thinking and a reliance on historical data. However, incorporating behavioural variables such as framing effects, anchoring, and recency bias allows planners to create more dynamic and diverse scenarios. For example, organisations like Shell and Unilever have adopted behaviourally informed scenario planning to anticipate climate-related and geopolitical shifts. This method enables leaders to consider not only external variables but also the likely behavioural reactions of stakeholders, including regulators, consumers, and competitors. Techniques such as stress testing and sensitivity analysis (Bouwman *et al.* 2018) complement this approach by rigorously evaluating the robustness of proposed strategies. The result is a planning process that not only anticipates a wider range of outcomes but also embeds psychological realism into every stage of strategic design.

Competitive strategy also benefits from a behavioural reinterpretation. Classic models such as Porter's Five Forces (1979) are enhanced when viewed through the lens of cognitive bias. For instance, loss aversion may explain why incumbents react aggressively to new entrants, while overconfidence can lead to irrational price wars or unsustainable market expansions. Furthermore, behavioural game theory expands on traditional game theory by acknowledging that competitive players are not always purely rational but are influenced by perceptions of fairness, reciprocity, and trust. These social preferences can shape alliances, negotiations, and rivalries in ways that classical models cannot predict. Companies that grasp these behavioural nuances are better equipped to develop strategies that exploit competitor biases or foster mutually beneficial outcomes.

Beyond competitive dynamics, behavioural economics has practical applications in consumer marketing, organisational leadership, and public policy. Marketers leverage heuristics and emotional triggers to shape buying decisions, using tools such as framing, scarcity appeals, and social proof to influence behaviour. In organisational settings, behavioural insights help leaders understand what motivates employees, how teams make decisions, and why certain cultural patterns persist. For instance, understanding the sunk cost fallacy allows firms to exit failing projects more efficiently, while awareness of groupthink promotes a culture of dissent and critical thinking. Public institutions have similarly adopted behavioural insights to craft more effective health, environmental, and financial policies. These applications highlight the versatility of behavioural economics and its potential to improve outcomes across both private and public domains.

Furthermore, behavioural pricing strategies illustrate how consumer psychology can be leveraged to enhance revenue. Price anchoring, where the initial price sets the reference point for subsequent judgments, is a commonly used technique in retail and e-commerce. Businesses that understand and implement such strategies can better position their products and increase conversions. Likewise, in financial markets, behavioural portfolio theory has provided a more realistic framework for understanding investor behaviour. It recognises that investors are not solely concerned with returns and volatility but also with emotional comfort and perceived control. Mutual funds and advisory services that adopt these principles have shown improved client retention and investment outcomes. Collectively, these examples demonstrate that behavioural economics does not merely critique classical assumptions—it offers actionable insights that improve strategic decision-making in tangible ways.

Conclusions and Further Research

In sum, this paper has illuminated the vital role of behavioural insights in enhancing the strategic planning processes of contemporary organisations. The limitations of the rational actor model have long been acknowledged, but only with the rise of behavioural economics has a comprehensive alternative framework emerged - one that accounts for the cognitive, emotional, and social dimensions of decision-making. By recognising and addressing common cognitive biases - such as overconfidence, anchoring, and loss aversion - organisations can correct flawed assumptions, make better-informed decisions, and design strategies that align more closely with actual human behaviour. The incorporation of tools such as nudging, framing, and choice architecture empowers firms to guide both consumer and employee behaviour in ways that support broader strategic objectives.

Equally important is the behavioural understanding of uncertainty and risk. The distinction between these concepts demands a departure from rigid, deterministic planning models in favour of more flexible and adaptive approaches. Scenario planning, when infused with behavioural realism, equips organisations to anticipate and respond to a wider range of future possibilities. Techniques such as real options analysis and modular strategy development offer pathways for businesses to remain agile in the face of volatility. Real-world case studies from sectors as diverse as energy, finance, technology, and healthcare underscore the practical efficacy of these approaches (Jackson, 2024). They reveal how organisations that integrate behavioural insights are not only more resilient but also more innovative and customer centric.

Moreover, the behavioural reinterpretation of competitive strategy and pricing enables firms to achieve differentiation and market positioning based on a deeper understanding of consumer psychology and competitor behaviour. Concepts from behavioural game theory, behavioural finance, and motivational psychology provide a richer toolkit for strategists. These approaches recognise that human behaviour in the marketplace is rarely linear or rational; it is shaped by context, perception, and emotion. By accounting for these influences, businesses can formulate strategies that are more attuned to the real world and thus more likely to succeed.

Ultimately, the insights offered in this paper advocate for a strategic paradigm that is not only analytical but also behavioural. In a world characterised by rapid change, global interdependence, and complex stakeholder ecosystems, such a paradigm is no longer optional; it is essential. For strategists, policymakers, and business leaders alike, the message is clear: embracing behavioural economics is not merely a theoretical exercise but a practical imperative. It provides the cognitive tools and empirical evidence needed to navigate uncertainty, engage stakeholders meaningfully, and build strategies that are not only robust and flexible but also human-centred and ethically grounded.

Credit Authorship Contribution Statement

Emerson Abraham Jackson: The named author is responsible for all of the following tasks: Conceptualisation, Investigation, Methodology, Project administration, Software, Formal analysis, Writing – original draft, Supervision, Data curation, Validation, Writing – review and editing, and Visualization.

Declaration of Competing Interest

None.

Declaration of Use of Generative AI and AI-Assisted Technologies

Despite the use of the internet to explore thought processes, this is an original work produced by the author without reliance on Generative AI or AI-Assisted Technologies.

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Spillover Effects of CAP Greening Measures on the Economy and Biodiversity of Regional Europe: Evidence from Greece

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Abstract: This study investigates the impact of the 2013 CAP reform related to green payments on the economy and biodiversity of rural Greece. As the literature had addressed only the impact on the agricultural sector, a regional input-output model was constructed to capture the direct and indirect effects of CAP greening on output, income and employment generation for a NUTS-2 region throughout the last implementation period 2013-2020. Input-output modelling was selected for impact analysis as it is suitable for short- and mid-term evaluations in a quick and easy manner. The Shannon's diversity and evenness indices (SDI, SEI) were estimated to determine the effect of green payments on crop diversification in the studied period. Empirical results imply that while farmers' net income decreased, green payments had a minor, yet positive, spillover effect on the regional economy and record on average 0.86% output growth, 0.65% income increase, and 0.43% more jobs created. Additionally, jobs created due to CAP greening provided resilience and a standard share of total regional employment, especially in times of crisis. The main goal of biodiversity increase is slightly achieved as SDI and SEI increased by 7.6% from 2016 to 2019. Further research is needed on the dispersion of income of Common Agricultural Policy payments in rural areas, particularly for those vulnerable to climate change.

Keywords: regional economic impact; CAP greening; spillover; biodiversity indicators; input-output model.

JEL Classification: C67; Q18; Q57; R15; A13.

Introduction

The 2013 reform of the EU Common Agricultural Policy (CAP) introduced green payments to incentivize environmentally friendly farming practices across Member States. While the ecological rationale behind these payments - such as crop diversification, ecological focus areas, and grassland maintenance - is well established, empirical evidence of their broader economic and environmental impacts remains limited. Existing studies have focused predominantly on the direct agricultural effects at the national or EU level, often using simulation models like CAPRI (Gocht *et al.* 2017; Louhichi *et al.* 2018).

However, few studies evaluate the real-world, regional-level spillover effects of green payments on income, employment, and biodiversity - particularly in Southern Europe where small-scale farms dominate and compliance is uneven. This study addresses that gap by employing a regional input-output model for Thessaly (Greece), assessing how CAP greening influenced not only agriculture but also the wider economy during 2013–2020.

We further integrate field-based biodiversity metrics, namely Shannon's diversity and evenness indices, to capture environmental outcomes often missed in macroeconomic simulations. By combining economic and ecological indicators in a regional context, the paper offers novel insights for more targeted and efficient CAP policy design.

1. Literature Review

Ever since the 2013 CAP reform, ecological practices and related payments have been incorporated as a standard for European agricultural policy. Few studies pinpoint the importance of biodiversity in the economic cycle (Ando, 2022; Barbier, 2022) and the notion behind this shift towards environmentally friendly agriculture is justified by the need for crop resilience, food security, biodiversity conservation, climate change mitigation and

farmers' support. The introduction of the "green payments" was the main novelty of the last period and the subject has attracted the attention of academics from the beginning of its implementation (Matthews, 2013; Singh, Marchis and Capri, 2014; Erjavec and Erjavec, 2015). Beneficiaries had to meet three key obligations to receive this payment (European Commission, 2013): i) crop diversification, namely grow at least two crops for farms with more than 10 ha and at least three crops for farms with more than 30 ha, b) maintain permanent grassland with the ratio of pasture to agricultural land being flexible per Member-State and iii) maintain an Ecological Focus Area (EFA) within the agricultural holdings of 15 ha and more; the ratio was set at 5% per holding and EFAs included fallow land, landscape features (hedges, terraces, etc.), afforested areas and nitrogen-fixing crops (legumes, alfalfa, clover etc.).

It should be noted that this scheme affects a portion of the Member-States (MS) as southern countries such as Malta (1 percent), Cyprus (18 percent), Greece (22 percent) and Italy (27 percent) report little compliance with the measure as land is scattered in small farms below 10 ha and were not obliged to CAP greening (Louhichi *et al.* 2018); the fragmentation of land in such small holdings increases crop diversification *de facto*. Therefore, the impact of green payments on the agricultural sector is explored in a handful of studies either at national or regional levels (Sauquet, 2022; Jezierska-Thöle *et al.* 2022; Díaz-Poblete *et al.* 2021) with ambiguous results (Dupraz and Guyomard, 2019).

The majority of studies focuses on the effects of the newly implemented CAP payments on the agricultural sector that include economic benefits such as land use change, income increase (Louhichi *et al.* 2018; Lakner and Oppermann, 2018), environmental gains such as greenhouse gas emissions reduction (Solazzo *et al.* 2016) and biodiversity conservation (Birkhofer *et al.* 2018) or mixed studies that address both economic and environmental perspectives (Bertoni *et al.* 2021; Gocht *et al.* 2017). Results so far suggest that the green payments have little effect on the economic structure of the European agricultural sector and the well-being of farmers.

Although farmers' income is slightly increased in various cases at national (Díaz-Poblete *et al.* 2021), regional (Louhichi *et al.* 2018) and EU-wide level (Gocht *et al.* 2017), the heterogeneity of farms within regions of the same country did not allow for a consensus on the impact of CAP greening (Jezierska-Thöle *et al.* 2022; Hristov *et al.* 2020; Cortignani *et al.* 2018). In some cases, the measure has augmented biodiversity conservation (Sauquet, 2022; Pardo *et al.* 2020) and achieved its goal through crop diversification, fallow land, EFA adoption, etc. but failed to significantly affect farmers attitude towards sustainable farming practices (Gaymard, Goujon and Lefebvre, 2020; Mili, Judez and De Andres, 2017) and reported ecological benefits are attributed to crop diversification and their diminished input requirements (Cortignani, Severini and Dono, 2017; Cortignani and Dono, 2015).

As stated previously, the heterogeneity among territories does not allow for safe and widespread conclusions, thus targeted studies are required to determine the effectiveness, the pitfalls and potential of the CAP greening. Lakner and Oppermann (2018) argue for the regional assessment of green payments to increase the efficiency of intended policies in conjunction with early evidence from Díaz and Concepción (2016) that acknowledged this need.

Nonetheless, more recent studies highlight mixed results, particularly in Southern Member States, where post-2020 CAP evaluations have failed to provide conclusive evidence of improved biodiversity or enhanced environmental sustainability (Sotte and Arcuri, 2025). Similarly, Pe'er *et al.* (2022) argue that the Greening measures delivered limited biodiversity gains across the EU and advocate for a fundamental restructuring of the CAP in the 2023–2027 programming period. On the contrary, other scholars report that the crop diversification criterion for EU payments and pro-environmental policy measures resulted in increased biodiversity and enhanced environmental performance of the farms (Brutti *et al.* 2025; Diop and Védrine, 2025; Rudnicki *et al.* 2023).

One of the most comprehensive simulation efforts to date has been conducted through the Common Agricultural Policy Regionalised Impact model (CAPRI), developed by the European Commission's Joint Research Centre (JRC). Gocht *et al.* (2016) apply a partial equilibrium approach to evaluate the impacts of CAP reform across EU Member States and regions. It assesses a wide range of outcomes including changes in land use, production patterns, prices, greenhouse gas emissions, and biodiversity indicators - typically represented through indices such as Shannon diversity or biodiversity-friendly farming practice (BFP) scores. Although highly useful at the EU scale, the CAPRI model has been limited in its ability to capture economic spillovers at sub-national levels and to evaluate resilience effects during economic downturns. Moreover, CAPRI simulations are largely predictive or counterfactual in nature, whereas there remains a significant need for empirical, *ex post* evaluations of the actual effects of greening measures on local economies and ecosystems study. However, as

with most studies, this tool focuses only on the farming sector and the generated effects and neglects the indirect impact of greening measures even at the regional level (Bertoni *et al.* 2021).

2. Materials and Methods

2.1 Economic Assessment

The Input-Output analysis is a widely applied methodology for impact assessment purposes that has gained prominence among scholars for its versatility that extends from environmental issues such as energy consumption (Ueda, 2022), greenhouse gas emissions (Akpan *et al.* 2015) and natural resources consumption (Gkatsikos and Mattas, 2021) to policy evaluation and particularly CAP measures implementation; especially for regional territories in Greece (Karelakis *et al.* 2019; Loizou *et al.* 2019). The method connects linearly the sectoral output and final demand (Leontief, 1936, 1941) hence allowing for impact assessment through the utilization of multipliers. These indicators are valuable for they estimate the effect of an exogenous change in final demand such as household spending, foreign investments and government payments (in our case CAP greening payments) on the whole economy.

A symmetric table or square matrix describes the structure of an economy where rows represent the output of each sector that is distributed to the rest of the economy and columns represent the inputs required by each sector to produce its output (Miller and Blair, 2009). The ratio of an input for a given sector over the total output of this sector, known as the technical coefficient, forms the basic linear equation as in Equation (1):

$$X = AX + F \quad (1)$$

As the final demand is considered exogenous for impact assessment purposes, Equation (1) is solved with regard to X and can be written as:

$$x = (I - A)^{-1} \times f, |I - A| \neq 0 \quad (2)$$

where $(I - A)^{-1}$ is the Leontief inverse matrix and describes the total requirements (direct and indirect) of an economy to produce its total output given a specific final demand.

The related input-output multipliers and elasticities are estimated based on the Leontief inverse to account for policy measure evaluation and impact analysis; further notice can be found in (Miller and Blair, 2009). Since there is no available I-O table for the study area, we constructed a regional I-O by adapting the National I-O table of Greece by applying a technique known as GRIT (Gkatsikos *et al.* 2022) based on Mattas *et al.* (2006).

2.1 Environmental Assessment and Biodiversity

As one of the targets for the greening measure was to increase the number of species cultivated this study will examine its success with the use of the well-known Shannon's diversity index (Shannon, 1948) that can be applied in various fields from wild animal dispersion (Evans and Potts, 2015) to agricultural land use (Wąs, Zawalińska and Britz, 2014). A lot of studies have assessed changes in crop biodiversity as a result of CAP measures with Shannon's diversity (SDI) and evenness (SEI) indices (Dabkiene, Balezentis and Streimikiene, 2021; Pardo *et al.* 2020; Lazíková *et al.* 2019; Mahy *et al.* 2015) and is even acknowledged by Eurostat. The index estimates the proportion of different species in a single dataset. In our study the species are the selected crops, and the dataset refers to total cultivated land in the Region of Thessaly. The Shannon's diversity index (SDI) is expressed mathematically as:

$$H_s = - \sum_{i=1}^s p_i \times \ln(p_i) \quad (3)$$

where H_s is the Shannon's diversity index, s is the number of crops observed in the dataset, and p_i is the proportion of hectares of one particular species (n) divided by the total hectares of crop production (N). As SDI does not have specific boundaries, a more interpretable and comparable index is estimated to measure the evenness of species in the study area known as the Shannon's evenness index (SEI) that is expressed as:

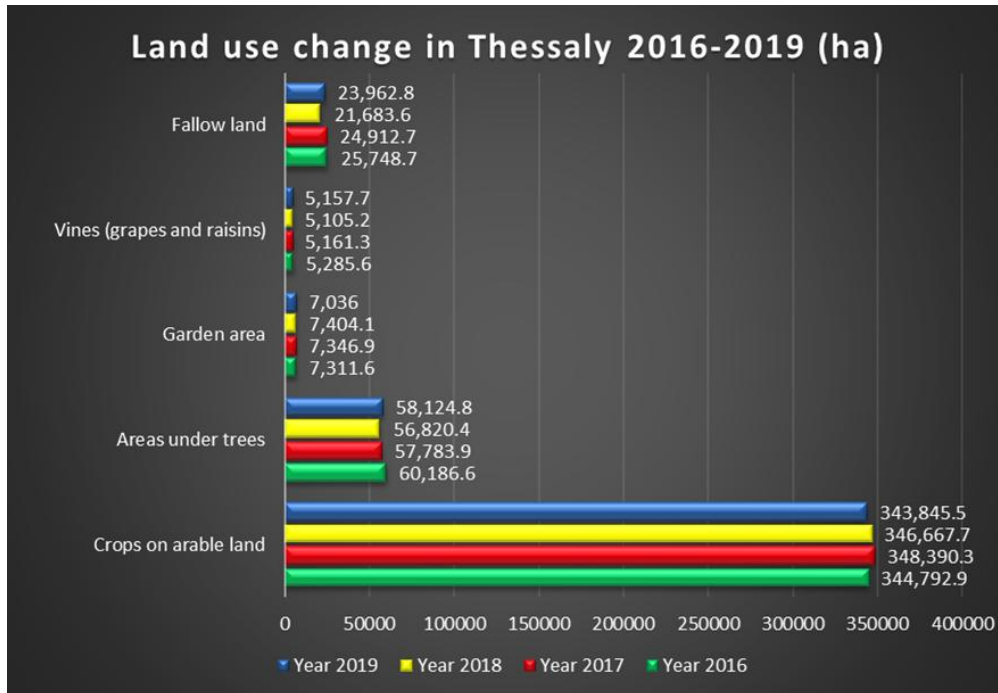
$$E_H = \frac{H_s}{H_{max}}, \quad H_{max} = \ln s \quad (4)$$

SEI takes values between 0 and 1 with 1 indicating that all species are evenly allocated in the study area.

2.3 Profile of Study Area

Thessaly (NUTS-2 region), located in central Greece, is commonly referred to as Greece's "breadbasket." The area is a significant food producer, with cereal grown and cattle bred in the central plain and sheep and goats bred in surrounding mountains (Pindos, Mt Olympus, Mt Pelion). The Region of Thessaly is one of the 13 administrative Regions of Greece and produces 5% of national GDP. Agriculture is the main employer in the area with 20.8% of total employment being farmers and the significance of the primary sector is demonstrated by its 12% of total gross added value share in the regional economy (ELSTAT, 2019a, 2019b).

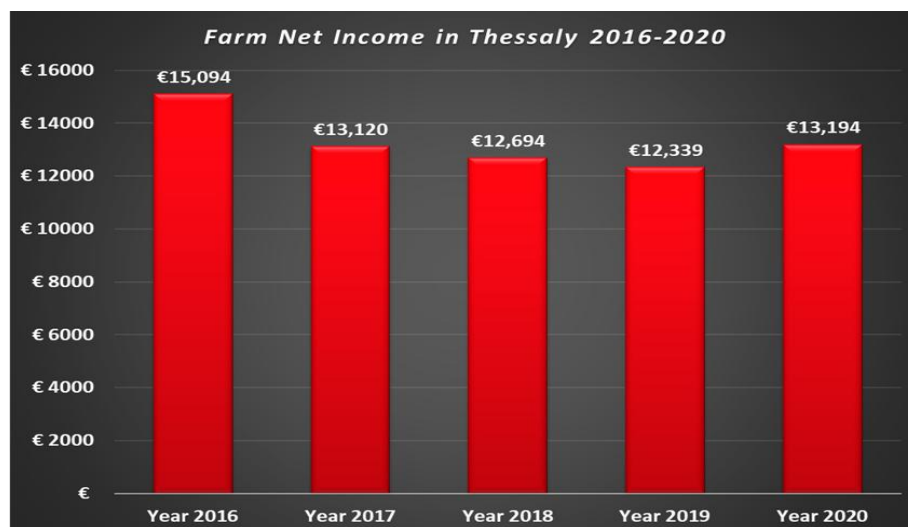
Figure 1. Land use change in Thessaly 2016-2019



Source: (ELSTAT, 2019c)

Land use is dominated by arable crops with a modest cultivation of trees. During the implementation of the CAP greening policy no significant changes have occurred in the structure of cultivated land (see Figure 1). The 2013 reform and its initial evidence denote a net income reduction for farmers in Thessaly by 12.6%. From an annual average of €15,094, the net farmer's income reduces to €13,194 marking a contradictory change to studies reviewed in the first chapter, where the green payments increased slightly the income of farmers (see Figure 2).

Figure 2. Farmer's net income in Thessaly



Source: (FADN, 2022)

2.4 Data

The latest available National Input-Output Table for Greece (2015), set at 64x64 sectoral size, was used to apply the GRIT technique to construct the regional model; employment data that were used to calibrate the national table and construct the regional one was obtained from the National Statistics Service. Data for the CAP greening payments for Thessaly for the years 2018, 2019 and 2020 were available and were obtained from the Greek Payment Authority of Common Agricultural Policy Aid Schemes (OPEKEPE) to be used for the impact analysis. For the estimation of the diversity indices (SDI, SEI) the Annual Farm Surveys for 2016 and 2019 were utilized to explore the crop diversification in Thessaly after the implementation of CAP greening.

3. Research Results

The first part of this chapter demonstrates the key multipliers and elasticities for the Region of Thessaly; the second part illustrates the results of the impact analysis associated to the green payments for 2016-2020 and the last part reveals the crop diversification changes from 2016 to 2019.

3.1 Analysis of the Economy of Thessaly

Multiplier-Based Analysis for Thessaly

The results of the calculation of output, income, and employment multipliers, depicted in Table 1, reveal the apparent dependence of the region of Thessaly on manufacturing sectors rather than services and agri-food sectors, with few exceptions for growth in terms of welfare indicators such as income and employment.

Textiles, wearing apparel, and leather products appear to be the most significant industry within Thessaly's economy in terms of output multipliers, with a positive stimulation of the final demand by one million euros generating almost triple the output (2.836). The sector is followed by Rubber and other non-metallic products (2.020), Wood, paper, and printing (1.920), Furniture and other manufactured goods (1.905), and the Petroleum and pharmaceuticals industry (1.881). To recap, the most impactful sectors in terms of output multipliers appear to be all related to manufacturing in the region of Thessaly.

Table 1. Key I-O multipliers for the Region of Thessaly

Sector	Output	R	Income	R	Employment	R
Agriculture, hunting & related services	1.492	19	1.839	15	1.223	24
Forestry, logging, and related services	1.258	26	1.171	25	1.144	28
Fish and other fishing products	1.596	14	3.490	5	3.456	19
Food products, beverages and tobacco	1.827	8	1.880	14	3.397	4
Textiles, wearing apparel and leather	2.836	1	4.078	1	2.964	5
Wood, paper, printing	1.920	3	2.363	10	1.982	9
Real estate	1.053	29	1.232	22	3.780	1
Petroleum, pharmaceuticals	1.881	5	3.490	3	3.546	2
Rubber and other non-metallic	2.020	2	2.323	11	2.076	8
Electric, electronics and other equipment	1.828	7	3.651	2	2.841	7
Motors and transport equipment	1.609	13	3.247	4	2.901	6
Furniture; other manufactured goods	1.905	4	3.122	6	1.724	11

Source: Author's elaboration

It is worth mentioning that of the three primary sectors Forestry, logging, and related services (1.258) is the least impactful and the Fish and other fishing products sector ranks among the top five in terms of income multipliers in Thessaly's economy with a multiplier of 3.160. Finally, Food products, beverages and tobacco products ranked 8th in terms of output multiplier (1.827). More interestingly, products of Agriculture, hunting, and related services ranked 19th with an output multiplier of 1.492. In other words, a one-million-dollar stimulation of final demand for agricultural products boosts the output by 1.492 times in the region of Thessaly.

Regarding income generation, the Food products, beverages, and tobacco sectors and products of Agriculture, hunting, and related services ranked 14th and 15th in terms of their multiplier, with a one-million-euro stimulation of final demand generating 1.880 1.839 times more income, respectively. In terms of the employment multiplier effect, the Real estate activities and imputed rents sector ranked first with a multiplier amounting to 3.780. In other words, the sector generates 3.780 times more jobs for a one-million-dollar stimulus of final

demand for its products. The rest of the top five, in order, are Petroleum and Pharmaceutical (3.546), Mining and Quarrying (3.467), interestingly, Food products, Beverages, and Tobacco products (3.397), and Textile, Wearing apparel, and Leather products (2.964). Nevertheless, it is interesting to see the food products sector ranking fourth in the economy of Thessaly with such a powerful multiplier effect on employment. Products of Agriculture, hunting, and related services ranked 24th out of the 30 sectors with an employment multiplier of 1.223.

The sector of products of Agriculture, hunting, and related services in Thessaly ranked 19th in terms of the output multiplier (1.492), 15th in terms of the income multiplier (1.839), and 24th in terms of the employment multiplier (1.223). Based on that, the sector may rank around 18th in terms of its overall multiplier effect. On the other hand, Food products, beverages, and tobacco products ranked 8th in terms of the output multiplier (1.827), 14th in terms of the income multiplier (1.880), and 4th in the employment multiplier. Based on that, the sector is estimated to be ranked 6th in terms of its overall multiplier effect on output, income, and employment.

Elasticity Based Analysis for Thessaly

Contrary to the results of the multiplier-based analysis in which manufacturing industries dominated the regional economy of Thessaly in terms of impact, the output, income, and employment elasticities (Table 2) show the high impact of some tertiary sectors such as trade, real estate, and public administration services on the region's economy which was not clear in the previous analysis.

The Real estate and Food, beverages, and tobacco sectors ranked first and second in all three types of elasticities in the Thessalian economy. A 1% increase in the final demand for the Real estate will generate 0.208%, 0.206%, 0.294% (output, income, employment) and Food, beverages and tobacco products 0.106%, 0.098%, and 0.160% (output, income, employment) increases in Thessaly, respectively.

Table 2. Key I-O elasticities for the Region of Thessaly

Sector	Output	R	Income	R	Employment	R
Agriculture, hunting & related services	0.052	7	0.065	11	0.043	10
Food products, beverages and tobacco	0.106	2	0.098	2	0.160	2
Petroleum, pharmaceuticals	0.047	8	0.081	6	0.084	3
Motors and transport equipment	0.027	12	0.093	3	0.079	4
Trade	0.084	3	0.063	12	0.060	8
Transport, warehouse, postal services	0.062	6	0.073	8	0.062	7
Accommodation and food services	0.074	4	0.090	4	0.070	5
Real estate activities and imputed rents	0.208	1	0.206	1	0.294	1
Public administration and defense services	0.069	5	0.060	13	0.067	6
Health and Social work	0.042	9	0.039	16	0.039	11

Source: Author's elaboration

Interestingly, products of the "Agriculture, hunting, and related services" sector ranked 7th in terms of output elasticity (0.052). In other words, a 1% increase in the final demand for the agriculture sectors induces a 0.052% increase in total output. On the other hand, the Fish and other fishing products and related services and Repair and installation services of machinery and equipment sectors ranked last in terms of output elasticity with 0.001% elasticity for both.

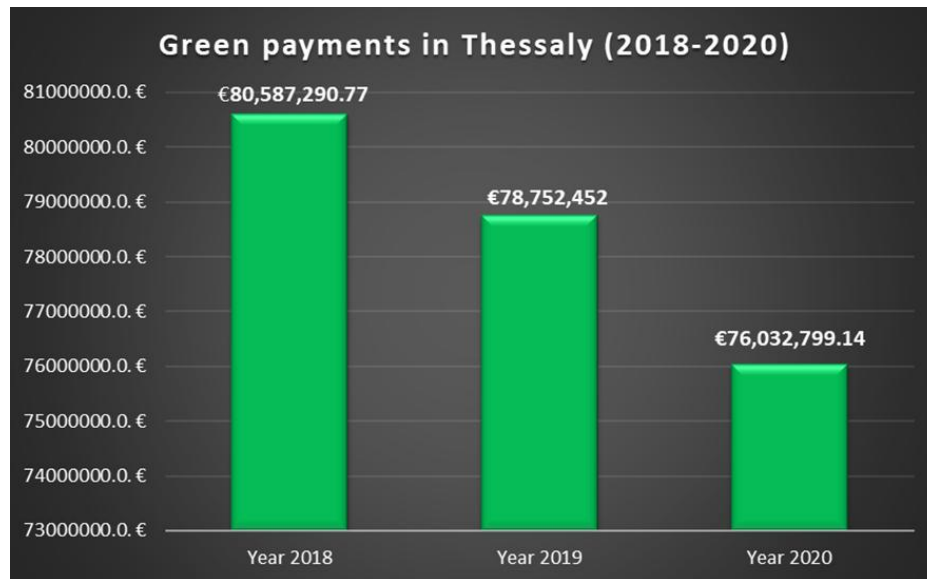
Products of Agriculture, hunting, and related services sector ranked 11th in terms of income elasticity (0.065). In other words, a 1% increase in the final demand for the agriculture sector induces a 0.065% increase in total income, while they ranked 10th in terms of employment elasticity (0.043). In other words, a 1% increase in the final demand for the agriculture sector induces a 0.043% increase in total employment. On the other hand, the Wood, paper, printing, and products of Forestry, logging, and related services sectors ranked last in terms of employment elasticity, with elasticities of 0.009% and 0.006%.

3.2 Impact Analysis of the Green Payments on the Thessalian Economy

The impact analysis is based mainly on the utilization of the multipliers and elasticities calculated for the region of Thessaly based on its regional input-output table. In this analysis, we refer to the payments made to farmers who benefited from green payments as being the exogenous shock within the studied economy. The final demand for agricultural products in the region of Thessaly has been estimated at €786,102,220.8 and the economy of

Thessaly generated a total output of €22,556.63 million, a total income of €3,155.718 million, and total employment of 256,574 people.

Figure 3. Green payments in Thessaly (2018-2020)



Source: Author's elaboration derived from OPEKEPE.

The amounts of green payments made in Thessaly between 2018 and 2020 totaled €235,715,715.52 and are depicted in Figure 3. The payments were provided to 63,154, 62,927, and 62,821 beneficiaries in 2018, 2019, and 2020, respectively. Data reveals a diminishing trend both for beneficiaries and green payments throughout the studied timeline.

Multiplier-based impact analysis

The multiplier-based impact analysis reveals that in 2018, the total output increased by €120,236,332.1 plus the initial amount of the green payments, while the total income increased by €148,200,027.71, and 99 jobs were created in Thessaly as a result of the exogenous shock of the green payments. In 2019, the total output increased by €117,498,751.52 plus the initial amount of the green payments, while total income increased by €144,825,759.23, and 96 jobs were created in Thessaly as a result of the exogenous shock of the green payments. The total amount of green payments for 2019 amounted to 10.02% of the final demand of the model. Finally, in 2020, the total output increased by €113,953,041.72 plus the initial amount of the green payments, while total income increased by €140,455,413.91, and 93 jobs were created in Thessaly as a result of the exogenous shock of the green payments (Table 3). The total amount of green payments for 2020 amounted to 9.72% of the final demand of the model.

Overall, over the three years, green payments led to an accumulative direct and indirect increase in total output by €587,060,667.24, total income by €433,481,200.85, and the creation of 288 jobs during the three years studied.

Table 3. Multiplier effects of Green Payments in Thessaly

I-O Multiplier effect in Region of Thessaly			
Year	Output	Income	Employment
2018	€ 120,236,332.1	€ 148,200,027.7	99
2019	€ 117,498,751.5	€ 144,825,759.2	96
2020	€ 113,953,041.7	€ 140,455,413.9	93

Source: Author's elaboration

Elasticity-based impact analysis

Based on the available data, the number of green payments made in 2018, 2019, and 2020 correspond to 10.25%, 10.02%, and 9.72% of the final demand for agricultural products in the region of Thessaly, respectively. Based on the latter and the elasticities demonstrated previously in the results, in 2018, the green payments led to

a 0.533% increase in total output, a 0.668% increase in total income, and a 0.441% increase in employment. Translating those proportions into euros, the results indicate an indirect increase of total output by €120,226,837.90, an increase in total income by €21,080,196.24, and 1,131 new jobs. By the same approach, the green payments in 2019 increased total output indirectly by 0.521% (€117,520,042.30), generating 0.653% more total income (€23,235,672.42), and 1,106 new jobs. Finally, the green payments in 2020 indirectly increased total output by 0.505% (€113,910,981.50), generating 0.633% more total income (€19,975,694.94) and 1,072 new jobs (see Table 4). Overall, according to the elasticity-based analysis, the green payments over the three years generated €587,030,403.60 more total output, €61,662,729.72 more total income, and 3309 new jobs in the Region of Thessaly.

Tabel 4. I-O Elasticity effect in Region of Thessaly

I-O Elasticity effect in Region of Thessaly			
Year	Output	Income	Employment
2018	€ 120,226,837.9	€ 21,080,196.2	1131
2019	€ 117,520,042.3	€ 20,606,838.5	1106
2020	€ 113,910,981.5	€ 19,975,694.9	1072

Especially for employment as total jobs decreased in the same period for the Region of Thessaly at a rate of 1.79%, the jobs created due to CAP greening were 1,103 on average and consisted 0.38% of total employment, thus abating unemployment phenomena, and offering resilience in the economy in times of crisis.

Land use change and biodiversity

Crop biodiversity increased during the first CAP greening period. The Shannon's diversity index was estimated at 2.622 in 2016 and at 2.821 in 2019 which indicates that there were more species cultivated in total agricultural land. Additionally, the normalized Shannon's evenness index was estimated at 0.581 in 2016 and at 0.625 in 2019 indicating that not only did the number of species cultivated increased, but their land allocation was more evenly distributed after the implementation of the green payments scheme in the Region of Thessaly.

4. Discussion

The findings of this paper contribute to the ongoing discourse surrounding the efficacy of the CAP's greening instruments by offering a regionally disaggregated and empirically grounded evaluation. While studies such as Gocht *et al.* (2017) and Louhichi *et al.* (2018) conducted through the JRC CAPRI framework provided important ex ante projections, this study delivers an ex-post assessment for the Region of Thessaly - a prominent agricultural region in Greece. By utilizing a regional input-output model, we go beyond the CAPRI model's partial equilibrium scope to estimate how green payments ripple through the entire local economy, including the manufacturing, services, and trade sectors. This approach captures both the direct economic benefits to agriculture and the indirect multiplier effects in related industries, which are often underestimated in macro-scale models.

Our estimates reveal modest but positive spillover effects: on average, green payments led to a 0.86% increase in output, a 0.65% rise in income, and 0.43% more employment in Thessaly. These numbers highlight the resilience-enhancing properties of CAP greening in rural regions, particularly under stress conditions such as the COVID-19 pandemic, which is a dimension not considered in CAPRI simulations. Furthermore, while CAPRI includes biodiversity indicators based on modeled land use changes or ecological scores, this paper uses observed field-level data to compute Shannon's biodiversity and evenness indices. Results show a 7.6% increase in crop diversity and a more equitable land allocation among crops over the study period (2016–2019), validating the environmental intent of CAP greening. This lends empirical support to broader findings in the CAPRI literature while also reinforcing the need for field-based biodiversity metrics in policy evaluation frameworks.

Empirical data collected from the FADN database for Thessaly imply that farmer's net income has diminished during the 2016-2020 by 12.6% (see Figure 3), contrary to the literature that argues for a slight increase in farmer's income around 1% (Louhichi *et al.* 2018; Louhichi *et al.* 2017; Gocht *et al.* 2017), and CAP greening could not reverse this negative shift. A possible explanation for this contradiction is that CAP greening is not widely implemented in Greece due to small agricultural holdings that are mostly funded under the Small Farmers scheme, hence all economic benefits are not captured through CAP greening.

Yet, the main goal of the Scheme for crop diversity was achieved through the studied period as the Shannon's diversity index increased by 7.6% between 2016 and 2019 and land allocation of the various species was more equally distributed as illustrated by the evenness index increase. Evidence from other published

studies suggests that this is a controversial issue as land use change is multifactorial and cannot be attributed solely to subsidized farming (Wąs, Zawalińska and Britz, 2014). Rotchés-Ribalta *et al.* (2021) report that agricultural policy measures that seek to increase biodiversity are effective for extensive farming while Dabkiene, Balezentis and Streimikiene (2021) argue that they have a lower impact on more intensive farms such as horticulture. As the study area is dedicated mostly to extensive farming with cotton and cereals dominating cultivated land, it can be concluded that CAP green payments contributed to the increase of crop biodiversity in the region. Moreover, crop diversity increases in regions with high soil fertility as is the study area but may cause an overall decrease at the national level (Lazíková *et al.* 2019). As smallholder farms adopt crop diversification as vital tool for their resilience (Mahy *et al.* 2015) this could be an alternative factor that contributed to local biodiversity increase.

Importantly, the study confirms earlier observations (Bertoni *et al.* 2021; Hristov *et al.* 2020) that while environmental gains may be apparent, economic benefits - especially farmer income - remain limited or even negative in some contexts. In Thessaly, farmers' net income declined by 12.6% during the implementation period, highlighting the disconnect between policy intent and local outcomes. This discrepancy aligns with CAPRI projections that green payments yield only marginal income improvements EU-wide but also underscores the need for region-specific targeting, as suggested by Díaz and Concepción (2016).

Conclusions and Further Research

This study aimed to assess the ex-post economic impact of the post-2013 CAP green direct payments on the entire economy of the Thessaly area (NUTS-2 region) in Greece. Additionally, crop biodiversity changes were assessed with the estimation of Shannon's biodiversity and evenness indices to unveil the increase or reduction of number of species cultivated in the study area.

The green payments provided in 2018, 2019, and 2020 were used as an exogenous shock in the model to estimate their generated impact on the regional economy. Results suggest that on average, CAP greening generated on average an increase of 0.86%, 0.65%, and 0.43% in the region's total output, income, and employment, respectively. Although it cannot be denied that the CAP green payments have contributed to the economic growth and employment in the Region of Thessaly, it is hard to judge the contribution as being exceptionally significant, considering proportionality. However, results of the study for 2020, during the COVID-19 pandemic, underpin the importance of agriculture as a main employer in rural areas and as a resilient industry for every economy.

Future research should explore the distributional impacts of green payments across farm sizes and production systems, ideally through disaggregated micro-data. Further integration of spatial ecological metrics could also help assess the long-term sustainability of biodiversity gains. Finally, extending the input-output approach to other NUTS-2 regions across Europe could enhance the generalizability of results and inform the design of more equitable and effective CAP instruments under the 2023–2027 programming period.

Credit Authorship Contribution Statement

Alexandros Gkatsikos: Conceptualization, Investigation, Methodology, Project administration, Software, Formal analysis, Writing – original draft, Supervision, Data curation, Validation, Writing – review and editing, Visualization

Declaration of Competing Interest

The author declares that he has no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Declaration of Use of Generative AI and AI-assisted Technologies

The author declares that he has used generative AI and AI-assisted technologies during the preparation of this work for improving academic language.

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The Influence of the Internet on Consumer Purchasing Behavior across Different Product Categories

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Abstract: This study explores how the internet influences consumer purchasing behavior across various product categories, with particular attention to trust in online information and the impact of demographic factors such as age, income, and digital habits. A systematic literature review (SLR) was combined with an empirical survey conducted in Croatia involving 251 respondents. Non-parametric statistical tests were used to examine differences in online behavior based on age, income, employment status, and daily internet use. The internet exerts a stronger influence on purchasing decisions for categories like clothing, technology, and travel than for food or hygiene products. Trust in online information is also higher in product categories that typically require more research or personal investment. Younger users show significantly greater online engagement and reliance on digital content when shopping. However, no significant behavioral differences were observed based on employment or income levels. This study integrates quantitative analysis with bibliometric visualization, offering a comprehensive view of how the internet shapes consumer decisions across product types. It also reveals key psychological and demographic drivers of online behavior, providing a valuable framework for future research and digital marketing strategies. The sample is geographically limited to Croatia, which may affect the generalizability of the findings. Marketers and e-commerce platforms can tailor strategies based on product type and target demographic to enhance engagement and trust.

Keywords: consumer behavior; online shopping; internet influence; product categories; trust; digital marketing.

JEL Classification: D12; L81; M31; A12.

Introduction

The rapid advancement of digital technologies in recent decades has fundamentally transformed how consumers search for information, evaluate options, and make purchasing decisions. The internet has emerged as a critical component of this process, playing a central role at nearly every stage of the customer journey. Online reviews, product comparisons, influencer endorsements, and social media content have become powerful tools that shape consumer preferences and decisions in the digital marketplace. The study of Chen *et al.* (2022a) investigates how online product reviews influence consumer purchasing decisions, highlighting the significant role of digital information sources in shaping consumer behavior.

Internet's influence is particularly prominent in specific product categories - namely technology, fashion, and travel - where consumers tend to engage in more extensive research due to higher costs or greater personal relevance. These products often require more deliberation, making online information more impactful. Conversely, everyday items such as food, hygiene products, and household essentials are frequently purchased based on habit, urgency, or in-store experience, where the internet plays a comparatively smaller role. The study Tarnanidis *et al.* (2023) emphasizes that consumers are more likely to engage in extensive online research and be influenced by digital content when purchasing fashion items, which are often associated with personal identity and social expression. The findings of Šostar & Ristanović, (2023a) indicate that while the internet significantly shapes consumer behavior across various product categories, individual psychological factors, particularly financial capacity, ultimately play a more decisive role in purchasing decisions than external digital or social influences.

A critical factor shaping this dynamic is the level of trust consumers place in online sources. Elements such as website credibility, the authenticity of customer reviews, and the presence of social proof can significantly affect how consumers perceive the reliability of the information they encounter online. There is significant influence of customer reviews and consumer trust on online purchasing behavior, highlighting how trust in online information sources impacts consumer decisions (Mallik *et al.* 2025). Generational differences are also evident - young adults who have grown up with digital technology are typically more influenced by online content, more comfortable with digital platforms, and more active in e-commerce compared to older age groups. In addition to generational trends, demographic characteristics such as age, income, education level, employment status, and digital literacy are essential to understanding consumer behavior in the digital sphere. These variables not only shape what individuals buy online, but also how frequently they shop, through which platforms, and from where. The study Syamsudin *et al.* (2025) highlights that Generation Z relies more heavily on social media platforms like Instagram and TikTok for shopping inspiration, whereas Millennials emphasize brand reputation and sustainability. Consumers are becoming increasingly demanding, as evidenced in the study by Šostar and Ristanović (2024), which shows a clear preference for organic and locally produced products, highlighting the growing importance of sustainable practices in consumer behavior. Also, emerging trends such as mobile commerce, personalized advertising, and algorithm-driven marketing have further strengthened the internet's role in influencing purchasing behavior. These innovations are reshaping consumer habits and raising new questions about motivation, decision-making, and trust in the digital economy. Advertising, which uses consumer behavior data to present relevant content, has significant potential to affect purchase decisions (Apriansyah *et al.* 2025).

The purpose of this study is to explore how the internet influences consumer purchasing behavior across different product categories, how trust in online information varies among consumers, and how demographic factors affect patterns of online shopping in the digital age.

1. Literature Review

1.1. Analysis using VOSviewer

This study adopts a Systematic Literature Review (SLR) approach to critically synthesize existing research on the influence of the internet on consumer purchasing behaviour across different product categories. The SLR method was chosen because it enables a comprehensive, transparent, and replicable evaluation of prior academic work, ensuring the development of a well-grounded theoretical framework. Following the guidelines outlined by established systematic review protocols, the research process was divided into defined stages: formulation of research questions, identification of studies, eligibility screening, data extraction, and synthesis.

Table 1 presents a thematic classification of keywords into five distinct clusters, each marked by a specific colour and characterized by closely related keywords. These clusters help us understand the main areas of research focus in the field of online consumer behaviour, e-commerce, and digital influence. Cluster 1: Yellow revolves around general digital engagement and its influence on consumer behaviour. It represents the foundational concepts of how the internet has transformed consumer behaviour, facilitated online information access and changed how consumers interact with products and services. It highlights a broad spectrum of digital consumption behavior. Cluster 2: Red emphasizes the influence of social media on consumer decisions. The inclusion of keywords like word of mouth and credibility points to how peer reviews and online opinions affect purchase intentions. The term impact suggests a focus on the effectiveness and reach of social platforms in shaping consumer trust and behavior. Cluster 3: Blue centres on e-commerce adoption and trust issues. It explores how trust and privacy concerns affect online shopping behaviour. The presence of information technology also indicates the technological infrastructure enabling secure and seamless digital transactions. Cluster 4: Green delves into the psychological and behavioural dimensions of consumer behavior. It looks at how

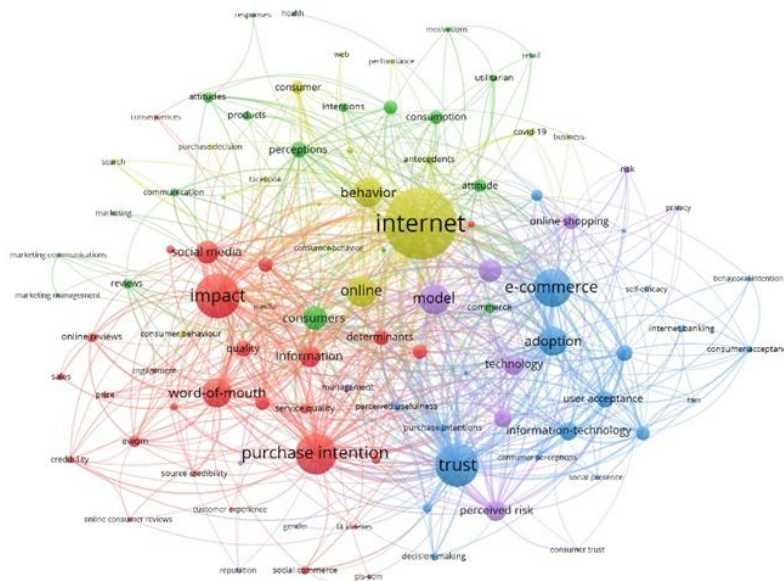
consumer perceptions and attitudes drive motivations behind online consumption and the consequences thereof. This is a more introspective look into the decision-making process from a consumer psychology perspective. Cluster 5: Purple is theory-driven, focused on technology adoption models like TAM (Technology Acceptance Model). It investigates determinants such as perceived usefulness and the role of models in explaining how consumers accept and use new technologies. This cluster is crucial for understanding structured theoretical frameworks in consumer behavior. This clustering provides a comprehensive thematic map of how digital tools, platforms, psychological factors, and theoretical models interconnect in understanding online consumer behavior. From practical implications (social media and e-commerce) to theoretical underpinnings (TAM and behavioural models), the table systematically categorizes complex topics into digestible research domains, facilitating focused analysis and deeper insight into consumer studies in the digital age.

Table 1. Clusters and Keywords

Sl. No	Clusters	Mapped colour	Keywords
1	Cluster-1	Yellow	Internet, behaviour, online, information, consumers
2	Cluster-2	Red	Social media, impact, word of mouth, purchase intention, credibility
3	Cluster-3	Blue	E-commerce, adoption, trust, online shopping, information technology, privacy
4	Cluster-4	Green	Perceptions, attitudes, consumption, motivations, consequences
5	Cluster-5	Purple	Model, technology, determinants, perceived, usefulness, acceptance models

The network visualization map illustrates the intellectual structure of research surrounding the influence of the internet on consumer behaviour, using keyword co-occurrence analysis. At the core of the map is the keyword “Internet”, (Figure 1) depicted as the most central and frequently occurring term, signifying its overarching relevance in connecting various sub-themes. Distinct color-coded clusters represent thematic groupings within the broader research field. The yellow cluster highlights general consumer interaction with online environments, featuring keywords like internet, behaviour, and information. The red cluster focuses on the impact of social media, word-of-mouth, and purchase intention, pointing to studies on online marketing and consumer influence. The blue cluster emphasizes e-commerce, trust, online shopping, and privacy, addressing adoption and risk perceptions in digital purchasing. The green cluster reflects consumer psychology and attitudinal factors with keywords such as attitudes, consumption, and motivations. Meanwhile, the purple cluster is grounded in theoretical frameworks, showcasing terms like technology, model, and perceived usefulness, which link to models like the Technology Acceptance Model (TAM). Larger nodes such as trust, impact, and purchase intention indicate frequently discussed concepts, while the interlinking lines depict strong co-occurrence relationships between them. Collectively, the map provides a visual summary of the dominant themes and interrelationships in the literature, offering valuable insights for researchers, marketers, and e-commerce strategists seeking to understand consumer behaviour in online contexts.

Figure 1. Network based on Co-occurrence Keyword Map. Source: Map created through the VOS viewer application

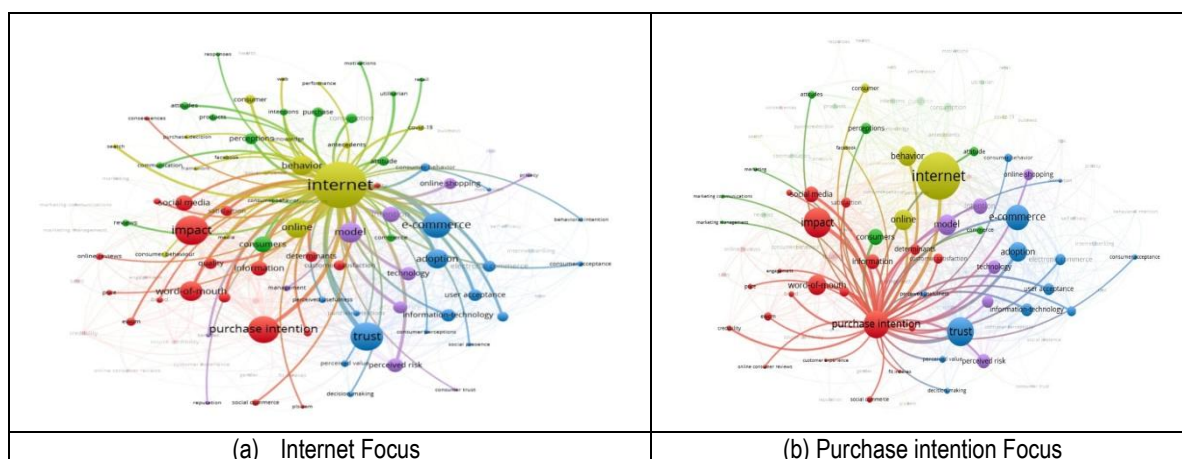


Source: Map created through the VOS viewer application

The central theme of this network is the concept of the "internet," which acts as the core node connecting various research topics. The visualization reveals a highly interconnected structure where internet-related behaviours, trust, and e-commerce adoption are closely tied. Social media, word-of-mouth, and consumer behaviour are strongly linked to online purchasing intentions. Notably, the model also suggests that consumer perceptions and attitudes significantly influence online behaviour. Additionally, theoretical models such as TAM and UTAUT are employed to explain the dynamics of internet usage and technology acceptance. This highlights the comprehensive nature of research focusing on the internet's impact on consumer behaviour, with an emphasis on trust, risk perception, and social influence (Figure 2a).

In this map, "purchase intention" emerges as a central element, sharing equal prominence with the "internet." The dual-core structure of the visualization emphasizes the interaction between internet-related behaviours and the factors influencing purchase decisions. Social media, word-of-mouth, and online reviews play a critical role in shaping consumer purchase intentions, while trust and perceived risk are crucial determinants for e-commerce adoption. The connections between "trust," "purchase intention," and "e-commerce" underscore the importance of building consumer trust in online platforms to drive purchasing decisions. Additionally, the use of theoretical models (e.g., TAM, UTAUT) helps explain the underlying factors influencing online consumer behaviour. The overall structure of the network highlights the interconnectedness of social influence, trust, and purchase behaviour in the digital marketplace (Figure 2b).

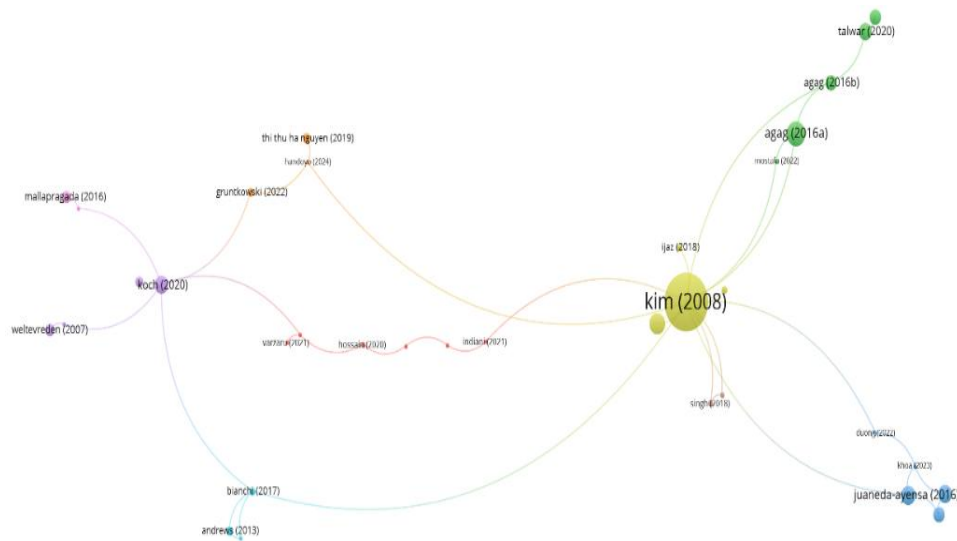
Figure 2. Highlights Internet Focus and Purchase intention from network based on Co-occurrence Keyword Map



Source: Map created through the VOS viewer application

Analysis in Figure 3 focuses on a multi-coloured co-authorship network graph generated using VOS viewer, which visually represents collaborative relationships among researchers. In this graph, Nodes represent individual authors. Edges (lines) represent co-authorship links between them. Colours indicate different clusters - groups of authors who frequently collaborate or work on related themes. Each colour cluster signifies a distinct research focus or collaborative group. Each cluster interprets different ideas like Yellow Cluster, represent a group working on a specific or emerging research theme. This cluster may indicate interdisciplinary studies, new technologies, or novel research domains. Authors here might be early adopters or innovators introducing new approaches or combining methods from different disciplines Green Cluster, often form a well-established collaborative group. Likely associated with foundational research areas or popular topics within the broader field. This cluster may reflect large-scale projects, institutional collaborations, or frequent publication activity in core domains Blue Cluster, typically engaged in specialized or trendsetting research areas. May represent niche topics or technical innovations within a specific domain. This group could be pushing the boundaries of traditional methodologies and exploring novel techniques. Red Cluster, engage in interdisciplinary or cross-domain research. Likely includes authors working at the intersection of multiple fields. Indicates strong collaboration between different perspectives, enriching academic discourse with diverse approaches and methodologies. The central position in the network is occupied by the work of Kim (2008), which clearly shows a high degree of connection with numerous other studies and clusters, indicating its methodological or theoretical significance within this academic field.

Figure 3. Interaction and linkages between the 9 clusters.



Source: Map created through the VOS viewer application

Table 2 groups research papers into clusters based on their similarities in themes, keywords, citations, or bibliographic coupling. Each cluster represents a set of closely related studies, indicating that the papers within a cluster share common research objectives or focus areas. For example, Cluster 1 includes authors like Akhlaq (2016), Hossain (2020), suggesting a shared thematic link among their works. Similarly, Cluster 2 groups together papers by Agag (2016 a & b), Khanra (2021), and Mostafa (2022), likely focusing on a particular aspect of consumer behavior or e-commerce. Other clusters, such as Cluster 3 and Cluster 4, include papers by authors like Duong (2022), Gensler (2022), and Kim (2008), reflecting a different thematic orientation. Clusters 5 to 9 include fewer papers but represent distinct thematic niches or emerging research areas. The presence of some authors in the same year but in different clusters (e.g., Agag 2016 a & b) indicates nuanced variations in their focus. The table essentially maps the intellectual structure of the literature in a particular field -possibly digital marketing or online consumer behavior - highlighting how groups of studies are interlinked and contribute to the development of specific research streams. The note at the bottom confirms that the clustering was done using VOSviewer, a bibliometric tool, and that multiple papers from the same year may belong to different clusters depending on their content.

Table 2. Clusters and authors

Sl. No.	Cluster 1	Sl. No.	Cluster 2	Sl. No.	Cluster 3	Sl. No.	Cluster 4
1	Akhlaq (2016)	1	Agag (2016 a)	1	Duong (2022)	1	Ijaz (2018)
2	Hossain (2020)	2	Agag (2016 b)	2	Flavián (2020)	2	Kim (2008)
3	Huterska (2022)	3	Khanra (2021)	3	Gensler (2022)	3	Pappas (2016a and 2016b)
4	Indiani (2021)	4	Mostafa (2022)	4	Juaneda-Ayensa (2016)	4	Van-Dat Tran (2019)
5	Vărzaru (2021)	5	Talwar (2020)	5	Khoa (2023)	5	-
Sl. No	Cluster 5	Sl. No.	Cluster 6	Cluster 7		Cluster 8	
1	Goel (2022)	1	Andrews (2013)	1	Grunkowski (2022)	1	Singh (2018)
2	Koch (2020)	2	Bianchi (2017)	2	Handoyo (2024)	2	Zerbini (2022)
3	Wei (2024)	3	Sánchez-Torres (2018)	3	Nguyen (2022)	3	-
4	Weltevreden (2007)	4	-	4	-	4	-

Source: Output from VOS viewer application (a) & (b) this shows the sub papers under the same author in the same year

Trust emerges as one of the most influential determinants in shaping consumer behaviour in online settings. It significantly moderates the relationship between perceived value and purchasing intentions across various sectors, such as fashion, travel, and cross-border commerce (Kim *et al.* 2019). Website quality, security,

and reputation remain essential factors in developing consumer trust, while third-party seals play a marginal role (Kordzadeh and Warren, 2017). In newer formats like live-streaming e-commerce, real-time visuals and direct interaction further reduce perceived risk, enhancing trust (Liu *et al.* 2017). Sánchez-Franco and Rondán-Cataluña (2010) conducted a qualitative comparative analysis (QCA) and identified that combinations of product risk, web-vendor risk, price-quality perceptions, and marketing strategies influence consumer trust and decision-making in online transactions.

1.2. Drivers of Consumer Channel Choice: Psychological, Cultural, and Product Influences

Trust and perceived risk are critical in influencing consumer online purchase behavior, as demonstrated by Kim *et al.* (2008). Similarly, Sánchez *et al.* (2006) analyzed the role of perceived value in shaping tourists purchase decisions in travel contexts. Trust developed through social networking sites was found to positively affect customer equity among Thai consumers as explored by Kananukul *et al.* (2015). Using both PLS-SEM and fsQCA methods, Liang *et al.* (2020) analyzed the user acceptance of Internet of Vehicles services, identifying key influencing factors. Liu *et al.* (2017) focused on the importance of product and website quality in online purchasing behavior. Park and Huang (2017) identified trust issues and security concerns, that prevent consumers from booking hotels via smartphones. According to Mattison *et al.* (2019), trust marks are effective tools to enhance consumer confidence and contribute to e-commerce. Technical cues and situational factors like boredom can trigger impulsive buying in social commerce as noted by Xue *et al.* (2024a). In store live streaming has emerged as a novel method influencing offline purchasing intentions (Zhang *et al.* 2023). Chen *et al.* (2022b) pointed out that product tolerance can seriously affect consumers' choice of purchasing channels. The study by Chocarro *et al.* (2013) examines how situational elements make the consumer decision-making process between online and offline shopping. Gensler *et al.* (2022) focused on the discussion on showrooming, showing that beyond pricing, product experience and convenience greatly affect consumer choices. Risk perception remains a vital element in online grocery shopping behavior, as found by Habib *et al.* (2021). Hou *et al.* (2023) explored the impact of consumer discussion patterns on multichannel purchasing intentions using the ESG evaluation system. Webrooming, a tactic used to reduce uncertainty, was examined by Kaduskeviciute *et al.* (2019). Offline shoppers' preferences for online or offline search channels and devices are highly dependent on the product category as shown by Kim *et al.* (2019). Szopiński *et al.* (2019) analyzed the complexities of cross-channel information search in purchasing electronics. Šostar *et al.* (2024a) highlight that while traditional marketing mix elements shape loyalty in supermarkets, trust in online information increasingly influences consumer decisions across product categories.

Ge (2008) focused on how traceable food cues affect purchase intentions. Improving consumer attitudes towards websites, especially in the tourism sector, was the focus of Alcántara-Pilar *et al.* (2018). According to Bhatti *et al.* (2022), various factors affect the transition from browsing to buying in online purchases. Luo *et al.* (2024), using signaling and social exchange theories, examined how live-streaming environments lead to impulse buying. The influence of both product and website characteristics on online behavior was investigated in depth by Mallapragada *et al.* (2016). Pappas (2016a) analyzed how marketing strategies, perceived risks, and consumer trust interact to shape online purchasing behavior. In a related study, Pappas (2016b) applied qualitative comparative analysis to explore how marketing strategies can mitigate perceived risks in tourism e-commerce. In China, Zhu *et al.* (2020) highlighted the role of consumer privacy policies in boosting trust in e-commerce platforms. Online product reviews play a vital role in consumer decisions, as shown by Chen *et al.* (2015). Ngo *et al.* (2024) stressed the impact of electronic word-of-mouth (eWOM) credibility on online purchase intentions via social networking sites. Credibility can be reduced by typographical errors in reviews, which Cox *et al.* (2017) found to negatively affect consumer trust. Forman *et al.* (2008) revealed that disclosing identity information in reviews can boost trust and sales impact. Kang *et al.* (2022) explored how online reviews shape decisions regarding new products. According to Wang *et al.* (2020), doctor's reputations in online spaces influence patients' willingness to share medical experiences. Zhang *et al.* (2022) illustrated how purchase intentions evolve under the influence of opinion dynamics. Gag and El-Masry (2016) showed that perceived usefulness and trust are vital for hotel booking intentions. In Egypt, Aref and Okasha (2020) emphasized how trust, price sensitivity, and convenience influence online shopping behavior among educated consumers. Elbeltagi *et al.* (2016) analyzed the role of ethical e-retailing in fostering customer satisfaction and repurchase intentions. The role of the internet in travel decision-making was highlighted by Garín-Muñoz *et al.* (2010), particularly in Spain's tourism sector.

Using machine learning, Mendieta-Aragón *et al.* (2023) analyzed how technology-driven trends shape consumer behavior in e-tourism. Mostafa *et al.* (2022) identified the determinants of online purchase intention and their impact on buyer behavior. Pinto *et al.* (2019) examined the importance of website quality, ease of use, and

trust in shaping travel agency purchase decisions. Andrews *et al.* (2013) observed that in Chile, trust and convenience are major influences on internet purchasing behavior. Trust, ease of use, and social influence are critical components of social commerce participation (Bianchi *et al.* 2017). In their meta-analysis, Luceri *et al.* (2022) confirmed that timesaving and convenience are primary motivators for mobile shopping. Steinhoff *et al.* (2020) highlighted the emerging role of technology in relationship marketing, focusing personalization and privacy concerns. Zhao *et al.* (2023) found that trust and perceived benefits play central roles in consumer behavior in China's C2C e-commerce market. Agag and El-Masry (2016a) integrated Innovation Diffusion Theory and TAM to explore online travel community engagement and purchasing behavior. Alrawad *et al.* (2023), using SEM, revealed how risk perception varies across different consumer segments. Chen *et al.* (2022c) applied Innovation Resistance Theory to identify barriers to mobile ticketing adoption, including complexity and trust issues. Talwar *et al.* (2020) investigated barriers to online travel booking and found that perceived security risks and high prices are major concerns. In a similar way, Xue *et al.* (2024b) analyzed consumer resistance to electric vehicle purchases due to high costs and infrastructure concerns. Finally, Dang *et al.* (2018) observed that in Vietnam, consumer attitudes toward online food purchasing are moved by product variety and convenience, though trust and delivery remain barriers. Exploring consumer behavior in emerging smart product categories, Chen *et al.* (2023) found that expectancy and social influence significantly shape intentions to buy smart clothing.

1.3. Digital Touchpoints and Design: Enhancing User Experience and Decision-Making

Rehman *et al.* (2019) find that trust and commitment can moderate the relationship between consumers' purchase intentions and their actual online shopping behaviour. The study by Saleem *et al.* (2022) investigates consumer motivation for adopting e-shopping, revealing that factors such as usefulness, ease of use, attitude, and subjective norms influence online shopping behaviour. According to Theodorou *et al.* (2023), the pandemic had played a major impact on online consumer behaviour, with attitude, subjective norms, and perceived behavioural control shaping consumers' intentions to shop online during the crisis. Nguyen *et al.* (2019) used an extended Technology Acceptance Model (TAM) to explore online food purchasing in Vietnam, showing that perceived usefulness, ease of use, trust, and attitude positively influence consumers' purchase intentions in emerging economies. Agag and El-Masry (2016a) examined the factors influencing consumers' hotel booking intentions online, concluding that trust, attitude, subjective norms, and perceived risk are crucial in determining booking intention. Alrawad *et al.* (2023) analysed how customers perceive risks in online shopping using Structural Equation Modelling (SEM) with multigroup analysis, identifying that financial, privacy, product, and delivery risks negatively affect customer trust and purchase intentions. Chen *et al.* (2022c) found that value and risk barriers hinder the adoption of mobile ticketing apps, suggesting that reducing perceived risks and enhancing usefulness could encourage user acceptance.

Talwar *et al.* (2020) identify significant barriers to purchasing from online travel agencies, such as risk perceptions, lack of trust, and technological complexity, which deter consumer engagement. According to Gruntkowski *et al.* (2022), the pandemic accelerated consumer adoption of online grocery shopping in Germany, driven by convenience, safety concerns, and changes in purchasing behaviour. Handoyo *et al.* (2024) conducted a meta-analysis on the factors influencing e-commerce purchasing and emphasized the important roles of trust, risk, and security in shaping consumer decisions. Social media communication and electronic word-of-mouth (e-WOM) can influence brand equity, as Lin *et al.* (2023) explain, showing that high product involvement strengthens the impact of these communication channels on brand value. Oktaviani *et al.* (2024) examine green consumer behaviour towards purchasing imperfect products, highlighting how sustainable labelling influences online shopping intentions. According to Rani and Shivaprasad (2021), key factors such as trust, risk, and emotional responses influence online communication behaviours. Wang *et al.* (2023) explore how consumer perceptions like trust, product quality, and platform reputation can affect purchase intentions on cross-border e-commerce platforms, emphasizing their importance in global online shopping behaviour. Gender-based differences in online shopping behaviours were explored by Akhlaq and Ahmed (2016), who found that women emphasize trust and security, while men focus more on convenience and timesaving. Bhati *et al.* (2022) examined the influence of e-service quality on online buying intention and found that factors such as ease of use, trust, and customer satisfaction significantly impact consumers' intention to purchase online. The role of social networking in promoting mobile commerce was investigated by Hossain *et al.* (2020), who found that trust, mobile phone use, and social influence are key drivers of online shopping and payment behaviours through mobile platforms. According to Huterska and Huterski (2022), technological infrastructure, consumer trust, and socio-economic conditions can influence online purchasing behaviours across different EU nations. Indiani *et al.* (2021) examined key factors influencing consumer purchasing behaviour in emerging online retail markets focusing the roles of

trust, convenience, price sensitivity, and the impact of digital payment systems on shaping online shopping decisions. Andon *et al.* (2024) explored how gamification, virtual-try-on technology, and e-logistics service quality affect online shopping behaviour, showing the significance of technological advancements in shaping consumer decisions. In their study, Duong *et al.* (2022) investigated how online interpersonal relationships and data ownership awareness mediate the link between perceived benefits and problematic internet shopping highlighting the role of consumer awareness in addressing online shopping issues.

Gallart-Camahort *et al.* (2023) examined how the internet influences retailer quality and contributes to building retailer brand equity, underlining the growing importance of online presence in brand perception. Juaneda-Ayensa *et al.* (2016) studied the key drivers of technology acceptance in omnichannel retailing, showing that perceived ease of use and usefulness significantly influence consumer purchase intentions across both online and offline channels. Khoa *et al.* (2023) found that customer anxiety negatively affects their interactions with omnichannel systems, influencing customer trust, satisfaction, and purchase intentions. Liu and Zheng (2023) examined the factors which influence consumers' purchase intentions for agricultural products. Ramayah *et al.* (2018) explored how consumption values such as social, emotional, functional, and epistemic influence online purchase intentions, showing that emotional and social values play a significant role in shaping buying behaviour. Web advertising visual design impacts online purchase intention, as Shaouf *et al.* (2016) explain, revealing that females are more influenced by visual appeal in advertisements compared to males. Singh and Srivastava (2018) found that the type of product moderates online shopping behaviour and purchase intention in India, concluding that product type influences consumers' online shopping decisions for different product categories.

1.4. Theoretical and Technological Foundations of Modern E-Commerce

Zerbini *et al.* (2022) conduct a meta-analysis to identify the key drivers of consumer adoption of e-commerce, revealing that factors such as trust and perceived risk play significant roles. These findings provide valuable insights for businesses looking to enhance online adoption strategies. The role of sustainable consumer behavior in driving innovation within the retail sector is explored by Šálková *et al.* (2023), who examine how eco-friendly product preferences influence retail strategies and the development of sustainable practices. Shi *et al.* (2021) investigate how the built environment impacts online purchases of intangible services, stating that environmental factors mediate the role of online purchase attitudes in shaping consumer behavior. The online shopping behavior of Guangzhou residents during the COVID-19 pandemic is explored by Wei *et al.* (2024), identifying shifts in consumer patterns driven by health concerns and restrictions, which have heightened reliance on e-commerce. Weltevreden *et al.* (2007) compare e-shopping and city center shopping, finding that the attractiveness of city centers influences consumer preferences, while e-shopping is increasingly favored for its convenience. However, city centers continue to appeal due to their social and experiential offerings. Budhathoki *et al.* (2024) use a text mining approach to explore consumer satisfaction with farmed salmon imports in China, finding that factors such as product quality, price, and delivery times significantly shape e-commerce satisfaction. Hong *et al.* (2019) analyzes consumer satisfaction in fresh e-commerce logistics, revealing that timely delivery, product quality, and customer service are crucial factors in ensuring satisfaction for the success of fresh product e-commerce. Customer satisfaction in e-commerce during the COVID-19 pandemic is examined by Ilieva *et al.* (2022), who found that timely delivery, product quality, and customer support were essential in driving satisfaction, with a greater emphasis on online shopping due to the pandemic. Vasić *et al.* (2019) investigate how online shopping determinants influence customer satisfaction in the Serbian market, concluding that website quality, product variety, and customer service play crucial roles in shaping satisfaction. The relationships between e-impulse buying tendency, customer satisfaction, and the intention to continue e-shopping are explored by Goel *et al.* (2022), showing how these factors shape consumer decision-making. Hidayat *et al.* (2021) highlights the importance of consumer trust as a key element in online purchase decisions, revealing that trust influences online purchase decisions significantly. During the COVID-19 pandemic, Koch *et al.* (2020) reveal that safety concerns, convenience, and the desire for contactless transactions were major drivers of online shopping, with these trends likely to continue post-pandemic. Nguyen *et al.* (2022) examine how perceptions, attitudes, and subjective norms influenced online shopping behaviors in Vietnam during the COVID-19 pandemic, finding that convenience, safety, and trust were significant motivators for online shopping. Also, Šostar & Ristanović, 2023b confirms that the greatest impact of the COVID-19 pandemic was observed in the goods market, where disruptions in supply (delivery delays, product shortages) and shifts in distribution channels (increased online shopping) occurred. Gao *et al.* (2020) analyze how the pandemic influenced the adoption of e-commerce for food purchases in China, showing significant shifts in consumer behavior towards online food shopping. Grădinaru *et al.* (2022) examine

students' perceptions of mobile commerce, revealing a shift in consumer preferences towards mobile-based shopping platforms. The key drivers influencing mobile commerce adoption are identified by Vărzaru *et al.* (2021), who focus on factors that affect the use of mobile shopping platforms. Flavián *et al.* (2020) explore how webrooming and showrooming practices enhance smart shopping decisions by integrating online and offline channels, showing that these practices positively affect consumer decisions. The disruption of offline sales by online research is analyzed by Li *et al.* (2023), who demonstrate how digital information influences traditional purchasing behavior. Singh and Swait. (2017) explores the impact of mobile internet on consumer behavior, showing how mobile channels influence search and purchase decisions in retail. Alzate *et al.* (2022) use text mining of online consumer reviews to analyze brand image and positioning in retail, revealing how consumer perceptions influence brand perceptions and purchase decisions. Dankwa *et al.* (2021) explore the role of social media advertising in consumer decision-making, finding that consumer engagement acts as a key intermediary, strengthening the effect of social media ads on purchase decisions.

The internet has profoundly transformed consumer purchasing behavior across different product categories by enhancing access to information, expanding choices, and shaping decision-making processes. Consumers now rely heavily on online reviews, social media, and digital platforms to guide their purchases, leading to more informed and personalized buying patterns. As technology continues to evolve, understanding these shifting behaviors remains crucial for businesses aiming to meet the dynamic expectations of modern consumers, as evidenced by the works of Zerbini *et al.* (2022), Wei *et al.* (2024), Vasić *et al.* (2019) and Šostar *et al.* (2024b).

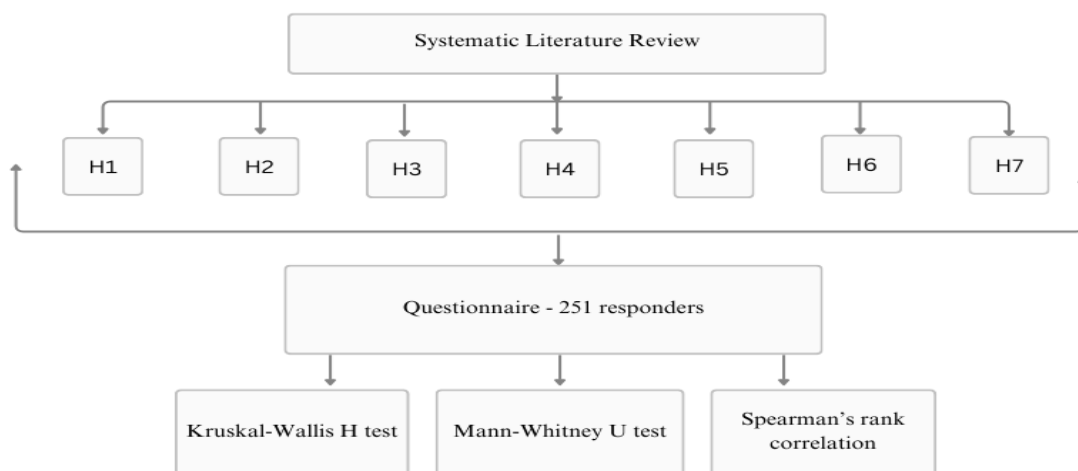
2. Materials and Methods

2.1. Research Procedure

This study adopts a systematic literature review (SLR) methodology to explore the key areas of interest. Based on the outlined theoretical framework, the SLR approach plays a crucial role in building a comprehensive understanding of existing knowledge within the field, identifying research directions and patterns, and informing the development of future research agendas. The growing emphasis on evidence-based approaches has led to a wider range of literature review types in recent years. For this study, academic sources were collected through a targeted keyword search in the Web of Science database, selected for its broad and authoritative coverage of scientific, technological, and social science research.

Following an in-depth review of relevant literature, the study established its research hypotheses, which were then tested through a survey-based approach. Data was collected in 2025 through an online questionnaire distributed via social media, targeting a random sample of 251 participants from Croatia. Data collected from the survey were analyzed using nonparametric statistical methods, including the Kruskal-Wallis H test, Mann-Whitney U test, and Spearman's rank correlation, due to the non-normal distribution of the dataset, as illustrated in Figure 4.

Figure 4. Research Design and Methodology Framework



Note: H1: The internet significantly influences product selection for most users, regardless of product category; H2: Consumer trust in online information is higher for technological and travel-related products than for food and hygiene products; H3: Younger users (18–35) spend more time online and shop online more frequently compared to users over 36;

H4: Employed users spend more time online and shop more frequently online compared to unemployed users; H5: Users with higher monthly income (800 euros or more) show greater trust in online information during the purchasing process; H6: Users who purchase clothing and tech products rely more heavily on the internet in their purchasing decisions compared to those who buy food.

When examining the gender distribution of respondents (Table 3), it can be observed that 73.7% are female, while 26.3% are male. Regarding age, 33.2% of participants are between 18 and 25 years old, 20.0% are aged 26–35, 23.2% are 36–45, 15.6% are 46–55, and 8.0% are over 56 years of age. As for employment status, 62.2% indicated that they are employed, while 37.8% reported being unemployed. Concerning marital status, 57.6% of respondents are married, while 42.4% are single. In terms of monthly income, 20.8% reported earning up to 499 euros, 21.2% earn between 500 and 799 euros, 26.9% between 800 and 1099 euros, and 31.0% earn more than 1099 euros per month. When asked about their average daily internet usage, 21.9% reported using the internet up to 60 minutes per day, 32.3% between 61 and 120 minutes, 25.9% between 121 and 180 minutes, and 19.9% more than 180 minutes per day. Regarding the frequency of online purchases, 10.4% shop online once or more per week, 38.2% once or more per month, and 51.4% once or more per year. When it comes to the type of products most frequently purchased online, the largest share of respondents reported clothing and footwear (48.0%), followed by sports equipment and children's toys (12.9%), and hygiene or pharmaceutical products (12.1%).

Table 3. Demographic Structure of Responders

		N	%
Gender	Male	185	73,7%
	Female	66	26,3%
	Total	251	100,0%
Age	18-25	83	33,2%
	26-35	50	20,0%
	36-45	58	23,2%
	46-55	39	15,6%
	56 +	20	8,0%
	Total	250	100,0%
Working status	Employed	156	62,2%
	Unemployed	95	37,8%
	Total	251	100,0%
Marriage status	Married	144	57,6%
	Single	106	42,4%
	Total	250	100,0%
Monthly income	To 499 EUR	51	20,8%
	500-7999 EUR	52	21,2%
	800-1099 EUR	66	26,9%
	Above 1099 EUR	76	31,0%
	Total	245	100,0%

3. Research Results

The following section presents the key findings of the research, based on the collected survey data, including demographic characteristics of the respondents, patterns of internet usage, online purchasing behavior, and consumer preferences across different product categories.

Table 4. Internal Consistency of Scales by Product Category (Cronbach's Alpha Values)

Product Category	Cronbach's Alpha	N of Items
Food	0,900	3
Clothing	0,899	3
Hygiene/Pharmaceutical	0,946	3
Household/Garden	0,944	3
Technology	0,935	3
Sports/Toys	0,958	3
Travel Packages	0,960	3

When examining the Cronbach's Alpha coefficients for the observed factors in Table 4, it becomes evident that the values are consistently high across all categories, exceeding the threshold of 0.7. This indicates a very high level of reliability for all the scales used in the study, and therefore, the grouping and further analysis will be conducted based on the specified product categories.

Based on the significance values presented in Table 5, the distribution patterns can be assessed using the Kolmogorov-Smirnov and Shapiro-Wilk tests. If the significance value for a given category (factor) is greater than 0.05 ($p > 0.05$), the data is considered to follow a normal distribution. Conversely, if the significance is below 0.05, the distribution deviates from normality. Since the significance values for all observed categories are below the 0.05 threshold, it can be concluded that the assumption of normality was not met. As a result, the subsequent analysis was conducted using nonparametric statistical methods.

Table 5. Normality Distribution Test

Product Category	Kolmogorov-Smirnov ^a			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Food	,154	224	,000	,943	224	,000
Clothing	,098	224	,000	,964	224	,000
Hygiene/Pharmaceutical	,127	224	,000	,940	224	,000
Household/Garden	,119	224	,000	,947	224	,000
Technology	,142	224	,000	,948	224	,000
Sports/Toys	,137	224	,000	,940	224	,000
Travel Packages	,118	224	,000	,941	224	,000

Note: a. Lilliefors Significance Correction

The Table 6 provides an overview of how respondents rated the influence of the internet on their purchasing decisions, their trust in online information, and how accurate they find that information, across seven different product categories. These categories include food, clothing, hygiene and pharmaceutical products, household and garden products, technology, sports equipment and toys, and travel packages. The first set of values shows the extent to which the internet affects purchase decisions. The highest ratings were recorded for clothing (average score 2.93) and travel (2.87), followed by technology (2.85) and sports equipment and toys (2.82). On the other hand, food products received the lowest average score (2.42), suggesting that the internet plays a smaller role in guiding purchases in that category. These differences support the idea that while the internet does have an influence across all product types, the strength of that influence varies depending on the nature of the product. This partially supports the first hypothesis (H1), which assumed a generally strong influence of the internet across product categories. The second and third sets of values in the table relate to the level of trust in online information and how accurate that information is perceived to be. Travel and technology products stand out with the highest ratings in both aspects - travel scores 2.88 for trust and 2.89 for accuracy, while technology scores 2.77 and 2.83 respectively. In contrast, food and hygiene products receive noticeably lower ratings in both categories. Food, for example, scores 2.50 for trust and 2.60 for perceived accuracy. These findings align with the second hypothesis (H2), which suggested that consumers are more likely to trust online information when shopping for products such as travel services and technology, compared to more everyday items like groceries and personal care products. The results in this table point to clear differences in how consumers rely on the internet depending on what they are buying. While digital sources influence most purchase decisions to some extent, they play a more central role in certain categories—particularly those involving more planning, comparison, or technical knowledge.

Table 6. Average Ratings of Internet Influence, Trust, and Perceived Accuracy across Product Categories

Product Category	Influence of Internet ($\bar{x}$)	Trust in Internet ($\bar{x}$)	Perceived Accuracy of Online Info ($\bar{x}$)
Food	2.42	2.50	2.60
Clothing	2.93	2.93	2.91
Hygiene/Pharmaceutical	2.80	2.76	2.81
Household/Garden	2.70	2.71	2.73
Technology	2.85	2.77	2.83
Sports/Toys	2.82	2.85	2.83
Travel Packages	2.87	2.88	2.89

Tables 7 and 8 present the results of a nonparametric analysis (Kruskal-Wallis H test) examining whether there are statistically significant differences in consumer behavior across different age groups. The analysis is based on ranked data and compares responses within seven product categories: food, clothing, hygiene/pharmaceuticals, household/garden products, technology, leisure, and travel. Table 7 displays the mean rank scores for each age group (18–25, 26–35, 36–45, 46–55, and 56+). In most product categories, the highest average ranks are found among younger respondents, particularly those aged 18–25 and 26–35. This suggests that these groups exhibit stronger engagement with the internet during the purchasing process. Table 8 provides the test statistics and corresponding p-values for each product category. Significant differences between age groups ($p < 0.05$) were found for the following categories: Food ($p = .032$); Clothing ($p = .000$); Hygiene/Pharmaceuticals ($p = .002$); Technology ($p = .002$); Leisure ($p = .029$); Travel ($p = .002$). These results indicate that age plays a statistically significant role in shaping consumer behavior for these product types. The only category where no significant difference was observed is Household/Garden products ($p = .112$).

Table 7. Mean Ranks of Online Consumer Behavior by Age Group across Product Categories

Product Category	Age	N	Mean Rank	Product Category	Age	N	Mean Rank
Food	18-25	83	128,24	Clothing	18-25	83	133,30
	26-35	49	142,32		26-35	48	160,54
	36-45	56	123,46		36-45	57	110,25
	46-55	39	95,15		46-55	39	97,35
	56 +	19	112,58		56 +	19	80,55
	Total	246	128,24		Total	246	133,30
Health	18-25	83	125,47	Household/Garden	18-25	82	125,32
	26-35	47	153,94		26-35	47	138,47
	36-45	58	115,89		36-45	58	122,86
	46-55	36	96,18		46-55	37	105,39
	56 +	20	102,85		56 +	19	96,63
	Total	244	125,47		Total	243	125,32
Technology	18-25	83	130,90	Sports/Toys	18-25	79	122,89
	26-35	46	147,32		26-35	48	145,44
	36-45	58	118,15		36-45	57	120,45
	46-55	37	100,92		46-55	39	96,64
	56 +	20	83,13		56 +	20	116,10
	Total	244	130,90		Total	243	122,89
Travel Packages	18-25	81	116,14				
	26-35	48	148,61				
	36-45	57	120,77				
	46-55	35	86,61				
	56 +	18	123,53				
	Total	239					

Table 8. Kruskal-Wallis H Test for Age Differences Across Product Categories ^{a,b}

Product Category	Kruskal-Wallis H	df	Asymp. Sig.
Food	10,594	4	,032
Clothing	29,164	4	,000
Hygiene/Pharmaceutical	16,920	4	,002
Household/Garden	7,487	4	,112
Technology	17,158	4	,002
Sports/Toys	10,797	4	,029
Travel Packages	17,040	4	,002

Note: a. Kruskal Wallis Test; b. Grouping Variable: Age

These findings directly support Hypothesis H3, which proposes those younger users (ages 18–35) spend more time online and engage more frequently in online shopping compared to older users. The consistently higher rank scores for the younger age groups across almost all product categories confirm that this demographic is more likely to rely on the internet during their purchasing process. Data highlight a clear generational difference in online consumer behavior. Younger individuals are not only more active online but also tend to show greater reliance on digital content when making purchasing decisions, particularly in categories such as clothing, technology, and travel.

Tables 9 and 10 present the results of a nonparametric analysis (Mann-Whitney U test) aimed at identifying whether there are significant differences in online purchasing behavior between employed and unemployed respondents across selected product categories. Table 9 shows the mean rank scores for both employed and unemployed participants in relation to six product categories: clothing, hygiene/pharmaceutical products, household/garden items, technology, leisure, and travel services. The rank values are relatively close across all categories, indicating that there are no substantial behavioral differences between the two groups in terms of how they interact with the internet when shopping for these products. Table 10 confirms this observation with statistical results. In all six categories, the significance levels (Asymp. Sig. 2-tailed) are well above the threshold of 0.05. For example, in the category of clothing, the p-value is .738; for technology, it is .995; and for leisure products, it is .923. These values clearly indicate that the differences in behavior between employed and unemployed respondents are not statistically significant. These findings directly address Hypothesis H4, which suggested that employed individuals would spend more time online and shop more frequently via the internet than their unemployed counterparts. Based on the results, H4 is not supported. The data indicate that employment status does not have a measurable impact on online purchasing patterns in the observed categories. regardless of employment status, consumers appear to engage with online content in a similar way when it comes to making purchasing decisions. This suggests that other factors - such as age, digital habits, or personal interest - may play a more influential role than employment itself.

Table 9. Mean Ranks of Online Consumer Behavior by Employment Status

Product Category	Employment status	N	Mean Rank	Sum of Rank		Employment status	N	Mean Rank	Sum of Rank
Food	Employed	153	122.50	17742.50	Clothing	Employed	153	122.82	18791.00
	Unemployed	94	126.00	11844.00		Unemployed	94	125.93	11837.00
	Total	247				Total	247		
Health	Employed	152	120.09	18254.00	Household/Garden	Employed	151	123.64	18670.00
	Unemployed	93	127.75	11881.00		Unemployed	93	120.65	11220.00
	Total	245				Total	244		
Technology	Employed	152	122.98	18692.50	Sports/Toys	Employed	152	122.16	18569.00
	Unemployed	93	123.04	11442.50		Unemployed	92	123.05	11321.00
	Total	245				Total	244		
Travel Packages	Employed	147	118.69	17447.00					
	Unemployed	93	123.37	11473.00					
	Total	240							

Table 10. Mann-Whitney U & Wilcoxon W Test for Differences Based on Employment Status

Product Category	Mann-Whitney U	Wilcoxon W	z	Asymp. Sig. (2- tailed)
Food	7000.000	18742.500	-.420	.675
Clothing	7010.000	18791.000	-.334	.738
Hygiene/Pharmaceutical	6626.000	18254.000	-.831	.406
Household/Garden	6849.000	11220.000	-.326	.744
Technology	7064.500	18692.500	-.007	.995
Sports/Toys	6941.000	18569.000	-.096	.923
Travel packages	6569.000	17447.000	-.514	.607

Note: a. Kruskal Wallis Test; b. Grouping Variable: Age

Tables 11 and 12 explore whether there are significant differences in online consumer behavior based on respondents' monthly income levels. The analysis was conducted using the Kruskal-Wallis H test, a nonparametric method suitable for comparing more than two independent groups, in this case: respondents earning up to 499 euros, 500-799 euros, 800-1099 euros, and over 1099 euros per month. Table 11 presents the mean ranks for each income group across various product categories. While there are slight variations in ranks - for example, respondents in the 500-799 euro range consistently show higher ranks in categories like food, hygiene, and leisure - the differences are neither large nor consistent enough to suggest a clear trend. In fact, in several categories such as clothing, travel, and health, the highest earners (over 1099 euros) do not demonstrate stronger engagement or trust in online information compared to lower-income groups. Table 12 summarizes the statistical significance of these observed differences. The p-values for all categories are above the 0.05 threshold, indicating that the differences in behavior across income groups are not statistically significant. For example, in the case of food products, the p-value is 0.061; for clothing, it is 0.179; and for travel, 0.518. These results suggest that income level does not play a decisive role in shaping consumers' trust in online information or their behavior when purchasing these types of products.

Table 11. Mean Ranks of Online Consumer Behavior by Monthly Income Level

Product Category	Monthly Income (EUR)	N	Mean Rank	Product Category	Monthly Income (EUR)	N	Mean Rank
Food	Up to 499	50	113,44	Clothing	Up to 499	51	123,44
	500-799	52	137,47		500-799	52	134,13
	800-1099	64	129,39		800-1099	64	124,07
	Above 1099	75	107,46		Above 1099	74	107,43
	Total	241			Total	241	
Health	Up to 499	51	115,60	Household /Garden	Up to 499	50	105,67
	500-799	52	135,78		500-799	52	138,15
	800-1099	62	122,07		800-1099	63	121,71
	Above 1099	74	110,21		Above 1099	73	113,78
	Total	239			Total	238	
Technology	Up to 499	50	106,59	Sports/Toys	Up to 499	50	111,23
	500-799	52	134,28		500-799	52	134,05
	800-1099	63	128,06		800-1099	65	124,28
	Above 1099	74	112,16		Above 1099	71	110,30
	Total	239			Total	238	
Travel Packages	Up to 499	50	116,90				
	500-799	51	129,52				
	800-1099	62	114,60				
	Above 1099	71	111,82				
	Total	234					

Table 12. Kruskal-Wallis H Test for Differences Based on Monthly Income ^{a,b}

Product Category	Kruskal-Wallis H	df	Asymp. Sig.
Food	7,358	3	,061
Clothing	4,909	3	,179
Hygiene/Pharmaceutical	4,559	3	,207
Household/Garden	6,554	3	,088
Technology	6,043	3	,110
Sports/Toys	4,713	3	,194
Travel Packages	2,270	3	,518

Note: a. Kruskal Wallis Test; b. Grouping Variable: Monthly Income

These findings are directly related to Hypothesis H5, which proposed that respondents with higher monthly incomes (800 euros or more) would demonstrate greater trust in online information during the purchasing process. Based on the analysis, H5 is not supported. Trust and engagement with online content do not significantly vary according to income level, at least not in a statistically meaningful way. The results suggest that monthly income is not a major factor influencing how consumers perceive and use internet-sourced information when shopping across various product categories. Other variables, such as age or time spent online, may have a more pronounced effect.

Tables 13 and 14 explore the connection between the amount of time users spend online each day and their online purchasing behavior. The results are particularly relevant to Hypothesis H7, which assumes that individuals who spend more than 180 minutes online daily are more likely to shop online more frequently. The data in Table 13 show that for categories such as clothing, technology, and leisure products, the mean ranks are noticeably higher among those who reported spending between 121 and 180 minutes, or more than 180 minutes online. This pattern suggests that increased daily internet use is associated with greater online shopping activity in these categories. Table 14 confirms that the observed differences are statistically significant for clothing ($p = .008$), technology ($p = .004$), and leisure ($p = .030$). For other product types, such as food or travel, no significant differences were found. These results provide partial support for H7, indicating that time spent online does influence online purchasing behavior — but primarily for products that often involve browsing or personal interest.

Table 13. Mean Ranks of Online Consumer Behavior by Daily Internet Usage

Product Category	Time on Internet per day (minutes)	N	Mean Rank	Product Category	Time on Internet per day (minutes)	N	Mean Rank
Food	Up to 60	53	117,00	Clothing	Up to 60	54	103,11
	61-120	80	115,45		61-120	79	115,31
	121-180	64	136,39		121-180	65	141,66
	More than 180	50	129,24		More than 180	49	137,60
	Total	247			Total	247	
Health	Up to 60	54	110,31	Household /Garden	Up to 60	54	108,29
	61-120	78	115,82		61-120	77	118,90
	121-180	64	139,47		121-180	65	132,22
	More than 180	49	126,91		More than 180	48	131,11
	Total	245			Total	244	
Technology	Up to 60	55	100,75	Sports/Toys	Up to 60	55	108,94
	61-120	76	114,04		61-120	76	111,14
	121-180	65	138,11		121-180	64	139,05
	More than 180	49	141,83		More than 180	49	133,72
	Total	245			Total	244	
Travel Packages	Up to 60	52	113,96		Up to 60	52	113,96
	61-120	75	112,13		61-120	75	112,13
	121-180	65	128,13		121-180	65	128,13
	More than 180	48	130,32		More than 180	48	130,32
	Total	240			Total	240	

Table 14. Kruskal-Wallis H Test for Differences Based on Daily Internet Usage ^{a,b}

Product Category	Kruskal-Wallis H	df	Asymp. Sig.
Food	3,908	3	,272
Clothing	11,699	3	,008
Hygiene/Pharmaceutical	6,280	3	,099
Household/Garden	4,441	3	,218
Technology	13,349	3	,004
Sports/Toys	8,923	3	,030
Travel Packages	3,365	3	,339

Note: a. Kruskal Wallis Test; b. Grouping Variable: Time spend on Internet per day

Tables 15 and 16 present an analysis related to Hypothesis H6, which assumed that users who primarily purchase clothing or technology products online rely more heavily on the internet when making purchasing decisions, compared to users who primarily buy food. Table 15 shows the mean ranks for each product category based on the type of item respondents reported buying most frequently online. While there are some variations in rank scores, these differences are not consistent or substantial. For example, respondents who most often purchase technology products or clothing do not show markedly higher levels of online influence or trust than those purchasing food or hygiene products.

Table 15. Mean Ranks of Online Consumer Behavior by Most Frequently Purchased Product Type

Product Category	Most Frequently Purchased Products Online	N	Mean Rank	Product Category	Most Frequently Purchased Products Online	N	Mean Rank
Food	Food	19	129,03	Clothing	Food	19	106,58
	Clothing	116	123,82		Clothing	117	131,12
	Hygiene/Pharmaceutical	29	116,83		Hygiene/Pharmaceutical	28	109,98
	Household/Garden	17	140,53		Household/Garden	17	122,65
	Technology	16	116,59		Technology	16	114,97
	Sports/Toys	32	122,16		Sports/Toys	32	118,64
	Total	15	101,60		Total	15	114,93
Health	Food	19	109,24	Household /Garden	Food	19	113,58
	Clothing	117	121,92		Clothing	115	121,83
	Hygiene/Pharmaceutical	28	125,57		Hygiene/Pharmaceutical	28	114,45
	Household/Garden	16	124,28		Household/Garden	17	124,44
	Technology	16	110,28		Technology	16	127,81
	Sports/Toys	31	124,74		Sports/Toys	31	113,26
	Total	15	128,43		Total	15	141,07
Technology	Food	19	103,97	Sports/Toys	Food	19	104,97
	Clothing	116	121,59		Clothing	118	117,61
	Hygiene/Pharmaceutical	28	111,54		Hygiene/Pharmaceutical	25	118,44
	Household/Garden	17	117,21		Household/Garden	17	123,29
	Technology	16	134,81		Technology	16	119,06
	Sports/Toys	31	125,61		Sports/Toys	31	141,58
	Total	15	143,77		Total	15	129,13
Travel Packages	Food	18	101,64		Food	18	101,64
	Clothing	117	118,62		Clothing	117	118,62
	Hygiene/Pharmaceutical	27	116,02		Hygiene/Pharmaceutical	27	116,02
	Household/Garden	17	116,09		Household/Garden	17	116,09
	Technology	14	122,32		Technology	14	122,32
	Sports/Toys	29	116,59		Sports/Toys	29	116,59
	Total	15	153,07		Total	15	153,07

Table 16. Kruskal-Wallis H Test for Differences Based on Most Frequently Purchased Product Type ^{a, b}

Product Category	Kruskal-Wallis H	df	Asymp. Sig.
Food	2,974	6	,812
Clothing	4,100	6	,663
Hygiene/Pharmaceutical	1,364	6	,968
Household/Garden	2,354	6	,884
Technology	4,122	6	,660
Sports/Toys	4,335	6	,631
Travel Packages	5,117	6	,529

Note: a. Kruskal Wallis Test; b. Grouping Variable: Most Frequently Online Purchased Product Type

Table 16 reports the results of the Kruskal-Wallis H test and confirms that none of the observed differences between groups are statistically significant. In all seven product categories, the p-values exceed 0.05, indicating that the frequency with which certain types of products are purchased does not correspond with significantly different patterns of online behavior. These findings lead to the rejection of Hypothesis H6. While it might be expected that consumers of tech or fashion items would be more reliant on online content when making purchasing decisions, the data do not support this assumption. Instead, the results suggest that the type of product most frequently purchased online does not, by itself, predict how much influence or trust a user places in online information.

4. Discussions

The findings of this study provide nuanced insights into how the internet shapes consumer purchasing behavior across product categories. While the internet generally exerts significant influence on consumer decisions, this impact is not uniform. For example, product types such as clothing, technology, and travel services consistently show higher levels of digital influence, trust, and perceived accuracy compared to categories like food and hygiene products. This aligns with the conclusions of Liu *et al.* (2017), who emphasized the role of product involvement in shaping online shopping behavior. Interestingly, generational differences emerge as a key factor. Younger consumers, especially those aged 18–35, demonstrate significantly greater reliance on digital content and spend more time online. These patterns confirm observations made by Gensler *et al.* (2022), who argued that digital natives exhibit more dynamic and exploratory purchasing behavior influenced by social media and personalized content. Conversely, older demographics remain more skeptical toward digital information, which may be linked to lower digital literacy or different purchasing habits. However, contrary to our initial hypotheses, income and employment status were not statistically significant variables in determining online purchasing behavior. These challenges assumptions often found in earlier research (e.g., Andrews *et al.* 2013) that linked higher income with increased e-commerce engagement. The results suggest that digital behavior is more closely tied to individual preferences and online familiarity than to economic capacity. Moreover, trust continues to be a central factor in consumer decision-making. Categories involving higher perceived risk (such as travel or electronics) show a stronger correlation between trust in online sources and purchase intent, echoing findings from Kim *et al.* (2008) and Pappas (2016a). Surprisingly, consumers who frequently buy technology or fashion online do not necessarily express greater trust in online content, suggesting that habit and product familiarity may moderate trust dependencies in some categories. Taking together, these results support the growing body of research indicating that the influence of the internet is multi-dimensional- dependent on product characteristics, consumer demographics, and psychological factors such as trust and risk perception (see Liang *et al.* 2020; Park & Huang, 2017). While the digital environment has democratized access to information, it has not equalized how consumers interact with that information, nor how they translate it into behavior.

Conclusions and Further Research

This study explored the influence of the internet on consumer purchasing behavior across different product categories, with particular attention to trust, product type, and demographic variables. The findings confirm that digital platforms play a central role in shaping consumer decisions, especially for products that involve personal relevance or require more research, such as fashion, technology, and travel services. Age emerged as a crucial determinant, with younger users exhibiting stronger online engagement and a higher tendency to rely on internet-sourced information when shopping. Meanwhile, trust in online content was shown to be a key mediator between internet use and purchase behavior, particularly in high-risk or complex product categories. However, variables such as income and employment status were not statistically significant, suggesting that access to and use of online content is widespread and increasingly independent of socio-economic status. By combining systematic literature review with empirical analysis, this research contributes to a deeper understanding of digital consumer behavior. It highlights the importance of tailoring e-commerce strategies to different demographic groups and product types and underlines the need for building trust in digital platforms to sustain consumer confidence.

As digital technology becomes increasingly embedded in the fabric of daily life, the internet's role in influencing consumer behavior has expanded beyond mere information access. It now represents a dynamic, multidimensional space where individuals encounter marketing stimuli, evaluate credibility, and make complex purchasing decisions. Despite the growing body of literature on online consumer behavior, few studies offer a comparative analysis across diverse product categories while simultaneously accounting for trust and demographic variability. This study addresses that gap by providing both empirical evidence and theoretical insight into how digital environments shape decision-making in distinct consumer contexts. By doing so, it

contributes novel findings to the ongoing discourse on digital commerce and offers timely implications for marketers, platforms, and policymakers aiming to adapt to an increasingly segmented and trust-sensitive online marketplace.

Future research could expand this analysis by exploring cross-cultural comparisons or integrating behavioral tracking data to complement self-reported survey responses. As digital ecosystems continue to evolve, ongoing research will be essential to capture the complexity of consumer behavior in the online age.

Credit Authorship Contribution Statement

Marko Šostar: Conceptualization, Investigation, Methodology, Project administration, Software, Formal analysis, Writing – original draft, Supervision, Data curation, Validation, Writing – review and editing, Visualization, Funding acquisition.

Kavya Sujith Kumar: Conceptualization, Investigation, Methodology, Formal analysis, Data curation, Writing – review and editing, Visualization.

Magdalena Dražetić: Conceptualization, Investigation.

Declaration of Competing Interest

The authors declare no conflicts of interest.

Declaration of Use of Generative AI and AI-Assisted Technologies

The authors declare that they have not used generative AI.

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Socio-Economic Resilience of Ukraine as an Imperative of the Policy of Strengthening Migration Security and Minimizing Vulnerability

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Abstract: The management of migration processes in terms of ensuring their volumes within optimal limits to minimize social vulnerability is an imperative of the policy of ensuring socio-economic resilience in the context of instability, crisis, and the deepening of new challenges. The article aims to analyze the social vulnerability of Ukraine (on the example of the oblasts of the Carpathian region) in the context of the migration crisis and the weakening of security factors in 2010-2023 as determinants of reduced resilience of socio-economic systems. Based on the calculated composite indicators of social vulnerability, the authors find that the human resource donor regions (the oblasts of the Carpathian region of Ukraine) demonstrated a critical situation of social vulnerability of the population with a tendency to approach the lower marginal

threshold, which significantly weakened their migration security and led to a decrease in the socio-economic resilience of the country. The study reveals that the region demonstrated a critical situation of social vulnerability of the population with a tendency to approach the lower marginal threshold (the indicator in the Carpathian region of Ukraine was 0.499). The main triggers for the spread of social vulnerability, and thus the weakening of social resilience, included a decline in the standard of living, disruption of the demographic balance, and the poor quality of the social and labor sphere. In 2010-2015, the trend of ensuring social resilience in the Carpathian region reproduced to the national one, with the highest value of the divergence indicator in 2010 (3.2 pp) and the lowest in 2020 (0.9 pp). The results of the empirical study show that declining living standards, demographic imbalances caused by high migration activity, and structural imbalances in regional labor markets were the main triggers for the spread of social vulnerability and, consequently, the weakening of resilience. The conceptual model of the mechanism envisages analysis of the environment (identification of geopolitical and socio-economic factors influencing migration and assessment of current and potential threats), definition of goals and objectives, drafting scenarios for the development of the migration situation and the impact of each scenario on national security, selection of optimal solutions, and development of alternative planning for socio-economic resilience.

Keywords: security; resilience; vulnerability; Ukraine; migration; mechanisms; challenges; economic recovery; potential.

JEL Classification: O15; H56; I30.

Introduction

The intensification of migration processes that threaten national and economic security is an existential challenge for every country regardless of its level of socio-economic development. The scale of population emigration in the context of a critical weakening of security is a shock to the socio-economic resilience of territories, requiring timely regulation and adaptive minimization of risks and threats. The implementation of appropriate migration security mechanisms will ensure the controllability of migration processes and the efficient use of migration capital, reduce risks to the development and sustainability of the economic system, preserve intellectual and human resources, and increase the investment and financial potential of the territory. The resilience of the territory will also be facilitated by the effective use of the migration potential of certain elements of the country's socio-economic system, which are the driving force behind the development of small and medium-sized enterprises, the accumulation and commercialization of innovations and technologies, the balancing of the local labor market, etc.

The article offers a complementary study of the social vulnerability of the population and a conceptual and theoretical model of migration security as an imperative to ensure socio-economic resilience. The study is based on and develops the authors' previous research in the context of identifying cause-effect relationships in the system of increasing social vulnerability – weakening migration security – reducing resilience of the socio-economic system and substantiating the mechanisms of ensuring migration security and their impact on the socio-economic resilience of the country's regions (Boiko *et al.* 2021; Mulska *et al.* 2023a).

The study aims to analyze the social vulnerability of Ukraine (on the example of the oblasts of the Carpathian region) in the context of the migration crisis and the weakening of security factors in 2010-2023 as determinants of reducing the resilience of socio-economic systems. The objectives of the study include the identification of the degree of social vulnerability of the oblasts in the Carpathian region of Ukraine as human resource donor territories; identification of catalysts for strengthening and triggers for weakening vulnerability as determinants of the impact on migration security; substantiation of the conceptual model of mechanisms for ensuring migration security in the regions of Ukraine.

The article has the following structure. The first section presents a literature review. The second shows the research methodology. The third section presents the results of the study. The fourth section is devoted to the authors' opinion on the results obtained and substantiation of the conceptual (authors' model) mechanisms for ensuring migration security of the territory. The last section contains the concluding remarks.

1. Research Background

The socio-economic resilience of the country is an existential task, as well as a trigger and the object of attention of researchers (from the conceptual and methodological point of view) and practitioners (in the light of the development of political decisions) in the projection of identifying its state, factors, causes, and consequences, as well as substantiating the mechanisms and tools for its provision and management of the relevant processes. Therefore, the range of research on the issues of stable socio-economic development, security, and crisis management of the economy is expanding. In this environment, publications in the field of social development form a separate cluster. They deal with systemic and complex characteristics, such as sustainability (Aldrich & Meyer, 2015; Drury *et al.* 2019), security (Kaunert & Léonard, 2021), resilience (Léonard, 2020), wellbeing

(Mulska *et al.* 2023), safety (Voznyak *et al.* 2024), etc. Developments in this area imply the establishment of a comprehensive diagnosis and the application of a systematic approach to the management of the social progress of society.

It is worth mentioning that complex categories are perceived and defined differently in society, especially when they are considered at the intersection of social and psychological aspects. For example, attitudes towards certain goods or the depth of the same social problem are not the same in rich and poor societies (Djafar, 2012). The emphasis in research is differentiated depending on the situation in the country and thus the level and quality of life (Humphery, 2013). The greater the crisis, and even more so a full-scale war, the more urgent the issues of countering challenges and threats and ensuring resilience (Arends *et al.* 2023; Pfefferbaum *et al.* 2017; Levytska O. *et al.* 2022; Voznyak *et al.* 2024).

The strategic target orientation of the state policy of ensuring resilience is adapted in accordance with the level of development of society, the extent of social problems and threats in it, as well as the state's ability to resolve the situation and ultimately democratize the society and strengthen its middle class. There is no doubt that each of these cases is about the quality of life. However, the focus on resilience is more relevant and important when it comes to security (Brauch, 2011), both in terms of consequences and factors of its further destabilization (Bloom, 2014), as well as interactions, e.g., intensification of migration processes and the development of social problems (Podgórzanska, 2019; Sperling & Webber, 2019) and, conversely, deterioration of the quality of life and increase of migration aspirations (Faist, 2004; Vezovnik, 2018).

The war in Ukraine has certainly exposed a wide range of problems and threats in various spheres and in virtually all components of national security. At the same time, migration security remains the main trigger for maintaining the country's resource, including human, potential for both preserving the country and restoring its economy in the postwar period in response to the most significant challenges such as forced population movements both within the country and abroad (according to UN estimates, migration caused by the war in Ukraine is recognized as the fastest and largest migration crisis since the Second World War), destruction of social and industrial infrastructure, and destabilization of labor and employment markets. The problems of its development and provision also relate to regional and local socio-economic and migration policies (Shubalyi & Gordiichuk, 2022), job creation, development of small, including innovative, businesses (Syrtseva *et al.* 2022), and regulation of youth mobility and their migration aspirations and attitudes (Vasylytsiv T. *et al.* (2024)).

Research on the management of migration processes in the context of the socio-economic resilience of territories focuses on the study of risks and potential threats. Migration in the modern sense is a factor of socio-economic development of the countries involved in migration systems, whose main task is economic growth and socio-economic resilience in the context of instability and deepening globalization as ideologized by the International Organization for Migration. Migration risks of the "outflow" of highly skilled labor for human resource donor countries have long been the focus of attention of scholars worldwide (Andersson & Siegel, 2020). Theoretical studies have shown that brain drain depletes the human capital accumulated in human resource donor countries, reduces budget revenues, and thus leads to potentially large economic costs. Economic systems with a low level of human capital make less efficient use of other factors of production, so the loss of intellectual and human resources has critical consequences for both potential output and actual GDP growth rates (Alpaslan *et al.* 2021; Levytska *et al.* 2022).

Forming a "brain bank", which is a kind of intellectual and human resource environment in host countries for human resource donor countries, is a positive consequence of migration of highly skilled labor for ensuring the socio-economic resilience of the territory (Lupak *et al.* 2022). Scaling up the emigration of highly qualified personnel and generators of innovations is a trigger for gaining access to valuable knowledge accumulated abroad, increasing the efficiency of diaspora networks, and developing new centers for the transfer of innovations, know-how, etc. Migration contributes to the establishment and development of business cooperation between local economies and the economic systems of the migration resource destination countries.

The management of migration processes in terms of ensuring their volumes within optimal limits to minimize social vulnerability is an imperative of the policy of ensuring socio-economic resilience in the context of instability, crisis, and the deepening of new challenges. The stages of development of mechanisms are determined by the effectiveness of planning and programming for the development of territories, and the stages of implementation of mechanisms are determined by the effectiveness of organization and control (Wielechowski *et al.* 2021). The development of a comprehensive methodology for assessing social vulnerability as an information and analytical basis for studying the causes of weakening migration security of the country and its territories and the consequences of deepening negative impacts on economic security, the resilience of the socio-economic system, and the potential for economic growth are of existential importance.

Ensuring migration security in the system of socio-economic resilience of the territory has a complementary methodological and practical value, which is associated with the unique characteristics of migration processes as an object of regulation (e.g., volumes, dynamics, risks for structural transformation of the economy, migration transfers, and entrepreneurial capital) of the variability of the relationship between the structural characteristics of migration and the parameters of economic security, resilience, and development (Tamasauskiene & Žičkienė, 2021). The policy of strengthening migration security and minimizing the socio-economic vulnerability of Ukraine is a trigger for the development of its resilience, as well as effective management of migration processes, state and regional migration policies, protection of national interests, and ensuring socio-economic resilience of the territories (Vasylytsiv *et al.* 2022). The conceptual model of migration security policy allows identifying key components, interactions between elements, potential threats, and ways to minimize risks. The conceptual model of the mechanism stipulates the analysis of vulnerability and environment (identification of geopolitical and socio-economic factors influencing migration and assessment of current and potential threats), definition of goals and objectives, development of scenarios of economic growth, migration situation, and impact of each scenario on economic security and resilience, selection of optimal solutions, and development of alternative socio-economic planning.

In recent academic discourse, social vulnerability is considered a multidimensional phenomenon that determines the capacity of populations to adapt to external risks, maintain social stability, and resist threats of natural, economic, or technological origin. Modern approaches to its assessment increasingly rely on the integration of geospatial methods, index analysis, and conceptual frameworks of resilience. Subham *et al.* (2024) proposed a comprehensive methodology for mapping urban social vulnerability using an index-based approach that incorporates exposure, sensitivity, and adaptive capacity of territories. Their study revealed clear spatial patterns of vulnerability in cities of West Bengal, emphasizing the importance of targeted interventions in urban environments. Cutter (2024) analyzes the evolution and diffusion of the Social Vulnerability Index (SoVI), highlighting its importance for formalizing assessments in the field of risk management. The author stresses the need to account for socioeconomic inequalities and ethnic stratification when calculating SoVI.

Expanding spatial approaches to the analysis of social vulnerability in the context of mobility in rural regions is demonstrated in the study by De Roulet *et al.* (2024), which applies a participatory GIS methodology to identify barriers to daily movement in Kenya and Nepal [64]. In a related context, Roy *et al.* (2024) employed the Sustainable Livelihood Security (SLS) approach to determine development priorities for vulnerable communities in regions of India, illustrating the integration of socioeconomic and environmental factors into strategic planning. The assessment of social vulnerability in connection with natural hazards is presented in the study by Asl *et al.* (2025), which identifies correlations between vulnerability indicators and flood risks for agricultural land and buildings. Spatial regression revealed key socioeconomic drivers that define vulnerability levels [67]. A similar topic is addressed by Sundqvist (2025), who examines a household-level social vulnerability index in Malawi, considering employment in agriculture. An innovative perspective is offered by Viana *et al.* (2025), who examine social vulnerability in the digital domain, particularly in the context of social engineering attacks. Their study identifies varying levels of vulnerability across generations of digital technology users, showing that social vulnerability is acquiring new forms in cyberspace.

The Ukrainian context of social vulnerability is explored in the work of Nebrat and Kurbet (2025), who emphasize the post-Soviet phenomenon of social paternalism as a factor shaping the structural vulnerability of the population. Their approach is based on a historical-social analysis of transformational processes and the corresponding behavioral models of the population.

The calculation of thresholds for catalysts, regressors, and social vulnerability components is a unique form of research, which allows comparing composite coefficients with thresholds to determine vulnerability/danger zones and safety margins. Unlike other studies of vulnerability and resilience (Mulska *et al.* 2022; Levytska *et al.* 2022; Vasylytsiv *et al.* 2022), the methodological and applied significance of this approach lies in a more thorough study of social vulnerability as a trigger for weakening migration security and a determinant of the decrease in the resilience of the country and its regions, including the identification of the limits of safe existence and development of socio-economic systems.

Security policy is based on the identification of challenges and threats that generate danger. In other words, eliminating a threat or danger is a direct way to guarantee the resilience, stability, and security of its target. A number of publications that directly or indirectly address the issue of the migration security of the state/territories (Keudel & Huss, 2023) analyze the main reasons for the intensification of external migration, in particular, critical in terms of volume and intensity external migration (Balzacq *et al.* 2016), which is primarily

related to the war and a high level of social (Panebianco, 2020; Williams, 2003) and economic (Umukoro, 2016) instability and deprivation in rural and remote areas (Shepherd, 2021; Lupak *et al.* 2022).

All the above-mentioned determinants of increased migration aspirations of the population are systemic and complex and thus create conditions and an environment in which the difficulties of adaptation become stronger than the problems and uncertainties associated with changing the place of permanent residence and labor and capital investment. The social vulnerability of the territory, or rather the population living there, has become a form, a reflection, and, at the same time, an indicator of strategic decision-making. It is specified from the point of view of the social resilience of the community (Magis, 2010; Angenendt, 2008), the links with poverty and inaccessibility of social services (Parker, *et al.* 2009), the consequences of natural disasters and other force majeure circumstances (Yoon, 2012), the impact of natural and anthropogenic environmental factors (Zahran *et al.* 2008), and the high level of risk inherent in a particular sector (Zou & Yi-Ming, 2010).

Social vulnerability is not a clearly defined concept and is multidisciplinary in nature, referring to an individual, a household, a community, a region, and a country. Social vulnerability is expressed in the inability to withstand stressful situations or risks. It increases in times of macroeconomic instability, political crises, and man-made and natural disasters (Bello, 2022). The study of social vulnerability is actualized through links and effects in chains of events: increase in social vulnerability (Metlev, 2016) → implementation of policies to improve social resilience (Mulska *et al.* 2023a) → strengthening migration security (Molnár & Vecsey, 2022), including the development of policy mechanisms, tools, and instruments (Diskaya, 2013) in the analyzed aspects, however, with a view to maintaining the resilience and stability of the functioning and development of the country's socio-economic system (Dmytryk *et al.* 2024) and those of its territories.

The study of social vulnerability of the population in the Carpathian region of Ukraine is of a practical nature. Its methodological basis is formed by theories of security, systems, social and human development, institutionalism, and risks and the concepts of quality of life and social conflict (Yoon, 2012; Zahran *et al.* 2008; Mulska *et al.* 2022). According to the authors, social resilience as an object of research, from the point of view of compositional analysis, requires both supplementation and equal consideration of a few of the specified and new (complementary) characteristics and features that consider the level and quality of life, parameters of social and labor relations, as well as aspects of demographic, environmental, and food security. This method allows, on the one hand, to more systematically analyze and diagnose the state of social vulnerability, identifying the full range of challenges, risks, and threats that weaken the social resilience of the population, and, on the other hand, to differentiate the tools and means of state policy to strengthen the migration security of the state and its territories, especially socially vulnerable in terms of complex social, economic, and natural conditions, external challenges, instability and crisis, structural transformations, and even war.

2. Materials and Methods

To study the social vulnerability as a cause of weakening migration security and a trigger for reducing the socio-economic resilience of Ukraine, the following hypothesis was developed and tested:

H: Migration security is a determinant of the country's socio-economic resilience, and its weakening is determined by a critical increase in social vulnerability, which has a permanent reverse effect on the Ukrainian economy and society in the long run.

The study consists of four stages:

1. Development of the information and analytical basis for the study of social vulnerability and selection of the research object (oblasts of the Carpathian region of Ukraine). The region was chosen because the oblasts of the Carpathian region are the largest donor territories of human resources from Ukraine to the EU countries.
2. Generation of an empirical indicator of social vulnerability based on the spatio-temporal approach
3. Building a social vulnerability-resilience plateau of Ukrainian oblasts, considering the scenario of weakening migration security.
4. Substantiation of the conceptual model of migration security mechanisms.

The decomposition of social resilience using the system-structural approach is represented by 6 components:

- *component 1. Quality of social and labor relations* (employment rate of the population aged 15-70, % of the total population of the corresponding age; level of recruitment, % of the average number of full-time employees; number of individual entrepreneurs, per 1,000 population; employment rate of the registered unemployed, %; the level of working time losses, %; the ratio of the number of registered unemployed to the number of available jobs, persons; level of informally employed population, % of the employed population; share of employees engaged in work with hazardous working conditions, % of the average number of full-time

employees; unemployment of the total population aged 15-70, % of the population of the corresponding age; level of forced part-time employment, % of the average number of full-time employees; rate of employee dismissal, % of the average number of full-time employees);

- *component II. Standard of living* (average monthly nominal wages, €, on average per full-time employee; pension benefits, € per €1,000 of GRP; disposable income, € per capita; Internet coverage, % of the total population; average state assistance to low-income families and to unemployed, €; state budget expenditures on health care, social protection, social security, and education, € per capita; average benefits and subsidies (non-cash) for housing and communal services, electricity, and fuel, €, per household; average monthly pension for all categories of pensioners, €; the ratio of the average monthly pension to wages, %; consumer price index, % y-o-y; share of total household expenditures on food, %, per household per month; dilapidated housing stock, total area of residential premises, m² per 1,000 population; share of wages in total income of the population, %; the ratio of the subsistence minimum to the average monthly wage; wage arrears per full-time employee, €; population with average monthly per capita equivalent total income below the actual subsistence level, % of the total population; decile coefficient of differentiation of total income);

- *component III. Quality of life* (coverage of children by preschool education institutions, % of the number of children of the corresponding age; share of households with no employed persons, %; share of households whose housing is equipped with water supply and sewerage and has convenient access to public transport, %; hospital beds per 1,000 population; visits to outpatient facilities per shift per 10,000 population; coverage of the population with medical personnel, persons per 100,000 population; housing stock per capita, m² of total area; teachers of 3 and 4 accreditation levels higher education institutions per 1,000 students; research and teaching staff with a candidate and doctoral degree per 100 graduate students; share of the population living in overcrowded housing, %; share of the population aged 6 and older with higher education, %; places in residential care homes for the elderly and people with disabilities per 100,000 population; general secondary and higher education institutions per 100,000 population; recorded crimes per 1,000 population; morbidity, newly registered cases of diseases per 1,000 population).

- *component IV. Demographic security* (children per 1,000 population; total fertility rate; average life expectancy at birth, years; total marriage rate per 1,000 population; share of households with 3 or more children, %; elderly people per 1,000 population; demographic load factor, %; disabled people per 10,000 population; marriage instability rate, %; out-migrants per 10,000 population; share of single-parent families with children, %; mortality rate for children under 1 year of age per 1,000 newborns);

- *component V. Environmental security* (water withdrawal from natural water bodies, m³ per person; fresh water consumption, m³ per person; total water disposal, m³ per person; capacity of treatment facilities, m³ per person; waste recycling rate; share of built-up land, %; share of capital investment in environmental protection in GRP, %; share of current environmental protection costs in the GRP, %; share of land in the nature reserve fund, %; current environmental protection costs, € per person; share of agricultural land area, %; discharge of contaminated wastewater into surface water bodies, m³ per person; emissions of pollutants into the atmosphere from stationary sources, tonnes per 1,000 population; waste generation, tonnes per person);

- *component VI. Food security* (the ratio of daily caloric intake to the daily norm; consumption of meat, oil, fruits, berries, eggs, fish, fish products, sugar, milk and dairy products, potatoes, vegetables, bread, and bread products in relation to the norm, per person; share of the population aged 18 and over with low body weight, %).

Formulas (1-2) were used to normalize the indicators (catalysts and regressors) according to the criterion of distance to thresholds, respectively.

$$z_{itn}^k = \begin{cases} 2^{(1-\frac{a_{in}}{x_{itn}})/\ln 10/3}, & x/a > 1 \\ 2^{-\log_{10} \frac{a_{in}}{x_{itn}}}, & x/a \leq 1 \end{cases} \quad (1)$$

$$z_{itn}^r = \begin{cases} 2^{(1-\frac{x_{itn}}{a_{in}})/\ln 10/3}, & x/a < 1 \\ 2^{-\log_{10} \frac{x_{itn}}{a_{in}}}, & x/a \geq 1 \end{cases} \quad (2)$$

where z_{itn}^k is the normalized value of the i catalyst indicator of the n region in the t period; z_{itn}^r is the normalized value of the i regressor indicator of the n region in the t period; a_{in} is the threshold of the i indicator of the n region; x_{itn} is the initial value of the i indicator of the n region in the t period.

The proposed methodological approach to the study of social resilience differs in the simultaneous normalization of indicators and their thresholds (Formula 3).

$$a_i = \begin{cases} a_{ik}/a_{norm}, & a_{norm} \geq a_{max} \\ a_{norm}/a_{ir}, & a_{norm} \leq a_{min} \end{cases}, \quad (3)$$

a_i is the normalized value of the i indicator; a_{ik} is the initial value of the threshold of the i -catalyst indicator; a_{ir} is the initial value of the threshold of the i regressor indicator.

It is worth mentioning that the upper thresholds (marginal and optimal) become lower in the process of determining the thresholds of the regressor indicators.

The calculation of weighting coefficients that are constant during the study period significantly undermines the scientific and practical value of the obtained results. The criterion of the constancy of the values of the weighting coefficients for the calculation of composite scores does not meet the conditions of a changing socio-economic environment and contradicts the concept of dynamic equilibrium. Significant changes in the socio-political, foreign, and macroeconomic situation in the country and its regions are triggers of structural transformations that lead to changes in the empirical assessments of both the components of social resilience and their interrelations. Structural and quantimetric transformations of system interrelations cause changes in the weighting effects of indicators on the problem under study. Therefore, methods based on the construction of static weighting coefficients of indicators demonstrate an average pattern and do not consider the exact correspondence of the situation in the dynamics. The construction of a dynamic series of weighting coefficients based on the theory of sensitivity permits correcting this drawback. Formula 4 was used to calculate the dynamic weights of the social resilience indicators and components.

$$w_{itn}^m = \frac{|\mu_{in}^m \Delta x_{itn}^m|}{\sum_{i=1}^j |\mu_i \Delta x_{it}^n|}, \quad (4)$$

where w_{itn}^m is the weight of the i indicator of the m group of the n region in the t period; μ_{in}^m is the sensitivity ratio of the i indicator of the m group of the n region; Δx_{itn}^m is the coefficient of change of the i indicator of the m group of the n region in the t period; j – number of indicators in each group.

The weighting coefficients of the indicators within each group of indicators are calculated using formula (5):

$$Y_{itn}^m = z_{itn}^{w_{itn}^m}, \quad (5)$$

where Y_{itn}^m is the weighting coefficient of the i indicator of the m group of the n region in the t period.

Dynamic series of empirical indicators of the components and the composite index of social resilience are constructed based on a multiplicative approach using formulas (6-7):

$$Cmp_{mt}^n = \prod_{i=1}^j Y_{itn}^m, \quad (6)$$

$$ISS_t^n = \prod_{k=1}^l Cmp_{mt}^n, \quad (7)$$

where Cmp_{mt}^n is the weighting coefficient of the m social resilience component of the n region in the t period; ISS_t^n is the composite index of social resilience of the n region in the t period; l is the number of social resilience components.

3. Research Results

The construction of social resilience indices using the structural-temporal approach allows comparing the dynamics of component indices and thresholds on the same scale (Application 1-5). This comparative analysis helps to identify the state of social resilience, while deviations from thresholds indicate the state of social vulnerability of the territory. According to the results of the calculations, the state of social resilience of the population in Zakarpatska oblast is in a dangerous and critical zone – below the lower threshold value – in two components (quality of social and labor relations and standard of living). Social resilience in terms of the quality of life, demographic security, and food security components balances between the lower optimal and marginal values, while environmental security is in the pre-crisis zone.

The average value of the empirical indicator of the quality of social and labor relations in Zakarpatska oblast in 2010-2023 was 0.528, which is 5.0 pp less than the lower marginal threshold and 13.9 pp less than the lower optimal threshold. Such dynamics of deviations of the current values of the component index from the average thresholds determine the unsatisfactory state of the employment sector and the low level of labor market competitiveness in the region (Application 1). The critical situation regarding social resilience in Zakarpatska oblast is observed in the standard of living component, where the deviation from the lower marginal threshold was

43.6 pp, and from the lower optimal threshold – 50.9 pp. The main reason for the low standard of living in Zakarpatska oblast is that a few indicators are below the lower marginal threshold, which poses a threat to ensuring decent living conditions and is a trigger for the spread of social vulnerability. These indicators are average monthly nominal wages, pensions, disposable income, and the consumer price index.

The components of the quality of life, demographic security, and food security of Zakarpatska oblast balance between the lower marginal and lower optimal thresholds. The deviations of the average component indicator from the lower marginal threshold for the period under study were 2.4 pp, 7.0 pp, and 3.2 pp, respectively, and from the lower optimal threshold – 2.5 pp, 28.3 pp, and 6.7 pp, respectively. The drivers of maintaining below-moderate levels of social resilience in the projection of these components in the region include:

- population morbidity, share of households with no employed persons, number of general secondary education institutions, number of higher education institutions, number of teachers of 3 and 4 accreditation levels higher education institutions (*quality of life component*);
- total fertility rate, total marriage rate, marriage instability rate (*demographic security rate*);
- ratio of daily caloric intake to the daily norm, the share of the population aged 18 and over with low body weight, consumption of oil, bread, and bakery products in relation to the norm (*food security component*).

The environmental resilience of Zakarpatska oblast is in an extremely critical state. Only in 2010-2011 and 2015 did the empirical values of the component approach the lower marginal thresholds. The dynamics of deviations from the lower optimal values over the period under study was 28.3 pp, and from the upper marginal threshold – 71.9 pp. Therefore, 8 out of 14 indicators (57%) pose a threat to the region's social resilience in terms of environmental resilience. These include the use of fresh water, discharge of contaminated wastewater into surface water bodies, capacity of treatment facilities, emissions of pollutants into the atmosphere from stationary sources of pollution, waste recycling rate, current environmental protection costs, share of capital investments in environmental protection in the Gross Regional Product, share of current environmental protection costs in the Gross Regional Product.

The calculations of the state of social resilience of Ivano-Frankivska oblast for 2010-2023 show that the vulnerability of the population is increasing in such components as the quality of social and labor relations and the standard of living. The levels of deviations of the mean values of the component indices from the lower marginal threshold were 17.1 pp and 41.5 pp, respectively, and from the lower optimal threshold were 26.5 pp and 49.3 pp (Application 2). The catalysts for the spread of social vulnerability in these components in the region were:

- recruitment rate, dismissal rate, number of individual entrepreneurs, the ratio of the number of registered unemployed to the number of available jobs, unemployment rate of the total population aged 15-70 (*quality of social and labor relations component*);
- pension, disposable income, consumer price index, Internet coverage, average amount of state social assistance to low-income families, average amount of benefits and subsidies (non-cash) for housing and communal services, electricity, and fuel per household, unemployment benefits, average monthly nominal wages (*standard of living component*).

There is a steady trend of permissible deviations of social resilience from the lower marginal thresholds for the quality of life (3.5 pp) and demographic security (1.9 pp) components in Ivano-Frankivska oblast in 2010-2023. During the period under study, the empirical values of the component indices did not fall below the lower marginal threshold, except for demographic security in 2017.

The dynamics of the environmental security component index in Ivano-Frankivska oblast is sigmoidal, with a downward trend in 2012 (the indicator value was 0.437 with a lower marginal threshold of 0.410), in 2016 (0.401), and in 2019 (0.405). It is worth mentioning that the environmental resilience of the region in 2011 and 2018 balanced between the lower and upper optimal thresholds, which demonstrated the tendency of the region to be in the range of "safety margin". Meanwhile, the empirical indicators of the food security component were in the "social vulnerability" zone during the study period but not below the critical level. The deviation from the lower marginal value was around 1.3 pp.

The catalysts for increasing the social vulnerability of the population of Ivano-Frankivska oblast in 2010-2023 in the projection of weakening environmental safety included general sewage, the discharge of polluted wastewater into surface water bodies, the capacity of treatment facilities, the current environmental protection costs, and the share of land in the nature reserve fund. The dynamics of deviations of these indicators from the optimal thresholds during the study period increased by 0.8% annually and from the marginal thresholds – by 1.5%. The regressors of the weakening of social resilience in Ivano-Frankivska oblast in the food security component were the consumption of eggs, vegetables, fruits, berries, and meat in relation to the norm. Deviations from the optimal thresholds ranged from 0.7% to 0.9%.

Among all the components of social resilience in Lvivska oblast, the critical situation was observed only for the standard of living component, whose empirical values were below the lower marginal threshold throughout the entire study period. The average deviation of the indicators for 2010-2023 was 44.1 pp and 76.5 pp from the lower and upper marginal thresholds, respectively, and 52.5 pp and 63.4 pp from the lower and upper optimal thresholds, respectively (Application 3). The critical spread of social vulnerability in the region was observed during periods of crisis, with the lowest empirical values of the standard of living component being 0.199 in 2012, 0.203 in 2015, and 0.135 in 2021.

The quality of life, demographic security, and food security components balanced between the lower marginal and lower optimal thresholds. Thus, the average deviation from the lower optimal threshold was 6.8 pp, 7.2 pp, and 5.8 pp, respectively. Interestingly, the social vulnerability of the population in Lvivska oblast in terms of the quality of life, demographic security, and food security components was below the moderate level with a tendency to the zone of "margin of safety". Therefore, the catalysts of the region's social resilience in these components were:

- number of recorded crimes, morbidity of the population, the share of households with no employed people, number of general secondary education institutions, number of teachers of 3 and 4 accreditation levels of higher education institutions, the share of households with water supply and sewerage (*quality of life component*);
- mortality rate of children under 1 year of age, number of out-migrants, total marriage rate (*demographic security component*);
- ratio of daily caloric intake to the daily norm, consumption of sugar and potatoes in relation to the norm (*food security component*).

In 2010-2023, the environmental resilience of Lvivska oblast demonstrated a tendency to approach the zone of "social vulnerability", except for 2010-2011 and 2016, when the empirical indicators of environmental security reached critical values. The deviations of the current environmental security values from the upper and lower marginal thresholds amounted to 3.2 pp and 62.2 pp, and from the upper and lower optimal thresholds – 18.6 pp and 38.8 pp, respectively. Challenges for Lvivska oblast, as well as for other oblasts of the Carpathian region of Ukraine, in terms of ensuring environmental resilience include illegal deforestation, river pollution, waste disposal, environmental losses from mining activities, as well as sanitary felling more than the limits established by law. Therefore, the catalysts for the spread of vulnerability of the population against the background of weakening environmental security are the use of fresh water, discharge of contaminated wastewater into surface water bodies, emissions of pollutants into the atmosphere from stationary sources of pollution, waste generation, waste utilization rate, and current environmental protection costs. The current values of these indicators are 20-22 pp below the lower marginal thresholds.

The empirical values of the quality of social and labor relations in Lvivska oblast in 2010-2023 ranged within the "social vulnerability". In 2011-2014, there was a clear downward trend in the indicators, while in 2016-2023, on the contrary, there was an upward trend. The deviation from the lower marginal threshold was 8.6 pp and from the lower optimal threshold – 17.4 pp. The non-critical situation in the quality of social and labor relations component of social resilience in the Carpathian region is explained by the high degree of sensitivity of Lvivska oblast's labor market to modern transformations in the employment sector, especially the development of virtual and informal employment and the formation of IT clusters that contributed to the spread of non-standard forms of employment and the scaling of individual entrepreneurship.

Accordingly, the catalysts for maintaining a moderate level of resilience of social and labor relations during the study period included the employment rate of the population aged 15-70, the number of individual entrepreneurs, the level of informally employed population, the employment rate of the registered unemployed, and the ratio of the number of registered unemployed to the number of available jobs (the indicator for 2019-2023 decreased by 3 times). A similar situation in terms of social resilience was observed in Chernivetska Oblast in 2010-2023 (Application 4). The indicators of the standard of living component were critically low (especially in 2011), with an average value of 0.198 (for comparison, the lower marginal threshold was 0.675). The deviations from the lower and upper optimal thresholds were 52.4 pp and 63.3 pp, respectively. The following factors had the greatest impact on the spread of social vulnerability against the background of declining living standards in Chernivetska oblast, with deviations from the threshold values of around 55-62 pp: the average monthly nominal wage, disposable income, consumer price index, the share of total household expenditures on food, the decile coefficient of differentiation of total income, the average amount of benefits and subsidies (non-cash) for housing and communal services, electricity, and fuel, unemployment benefits, and the average amount of the monthly pension for all categories of pensioners.

The empirical indicators of the quality of social and labor relations in Chernivetska oblast were in the critical zone, below the lower marginal threshold. The deviation of the average indicator from the optimal thresholds is 15.7 pp (lower) and 28.6 pp (upper). A significant increase in the social resilience of the region in the projection of ensuring the quality of social and labor relations was observed in 2016-2019 (from 0.533 to 0.575). The Covid-19 pandemic has triggered negative transformations in the labor market, a significant increase in the rate of employee dismissals, transfer to part-time work, and a decrease in the number of individual entrepreneurs, which has launched a chain of causality with other catalysts for weakening the resilience of the employment sector in Chernivetska oblast. The following indicators are regressors of the weakening of social resilience in the region: the rate of dismissal of employees, the level of informally employed population, the number of individual entrepreneurs, the level of working time losses, the ratio of the number of registered unemployed to the number of available jobs, the unemployment rate of the total population aged 15-70, and the level of forced part-time employment.

According to the calculations, the quality of life, demographic security, and food security in Chernivetska oblast in 2010-2023 were in the zone of "social vulnerability" without approaching the critical zone. The average value of the empirical indicator of quality of life was 0.591, which was 2.1 pp higher than the lower marginal threshold, and the average value of the empirical indicator of demographic security was 0.654, which was 2.5 pp higher than the lower marginal threshold. The dynamics of the empirical values of the food security component of social resilience over the study period had an upward trend, and in 2020 it balanced in the "safety margin" zone. Interestingly, the indicators that stimulated social resilience in the region were:

- coverage of children by pre-school education institutions, number of hospital beds, coverage of the population with medical personnel, number of general secondary education institutions, number of research and teaching staff with a candidate and doctoral degree, share of households with water supply and sewerage (quality of life component);
 - number of children, demographic load ratio of the able-bodied population to the disabled, total marriage rate, share of single-parent families with children, marriage instability rate (demographic security component);
 - ratio of daily caloric intake to the daily norm, share of the population aged 18 and over with low body weight, sugar and oil consumption in relation to the norm (food security component).
- The environmental situation in the Carpathian region has been forming over a long period of time due to the neglect of the objective laws of development and reproduction of natural geosystems and is characterized by excessive techno- and anthropogenic pressure on the environment and a high degree of pollution. Therefore, it is crucial for Chernivetska oblast, as well as for other oblasts of the Carpathian region of Ukraine, to address the problem of diversification of sources of financial and investment support for integrated environmental management through changes in inter-budgetary relations regarding the distribution of rent for special use of natural resources, land fees, and environmental tax, which provides for an increase in the share of these payments to local government budgets. Therefore, such indicators as current environmental protection costs, the share of capital investments in environmental protection in GRP, and the share of current environmental protection costs in GRP were stimulators for strengthening social and environmental resilience in the region. It is worth mentioning that environmental resilience was in the zone of social vulnerability, and in 2012-2013, 2016, and 2021-2023 it was in the zone of social resilience. The average value of the empirical indicator of environmental resilience in Chernivetska oblast for 2010-2023 was 0.510, which is 13.2 pp higher than the lower marginal threshold but 2.3 pp below the lower optimal threshold.

Ukraine was in the zone of social vulnerability by all components of social resilience in 2010-2023, except for the standard of living component (critical vulnerability range). For comparison, the average value of the quality of social and labor relations component for Ukraine and the Carpathian region was 0.481 and 0.499, respectively, which is 8.4 pp and 9.6 pp less than the lower marginal threshold, respectively (Application 5). Ensuring the effective employment of the population and the creation of new high-tech and high-performance jobs are catalysts for the optimal level of social resilience of the territory in the focus of guaranteeing high quality of social and labor relations. During periods of crisis, the so-called labor market security balanced at a critical level (the empirical indicator of the quality of social and labor relations component in Ukraine in 2014 was 0.439, and in the Carpathian region – 0.417). It is worth mentioning that to strengthen social resilience, the focus is on the development of fundamentally innovative measures to create well-paid jobs, which will ultimately help reduce real unemployment, increase effective employment and labor and capital productivity, reduce external labor migration, and ultimately minimize the effects of the shortage of workers.

The results of the study show that precarious and informal employment are both catalysts and regressors

of social resilience. For example, in 2010-2023, the values of the quality of social and labor relations component were below the social vulnerability threshold, indicating significant negative transformational changes in the labor market, which only intensified and led to a drain on human resources and an increase in personnel hunger in the country and especially in the border regions. In the context of instability caused by globalization and socio-political upheavals, state regulation of precarious and informal employment was a measure to reduce risks and costs for enterprises and create opportunities for employment on flexible terms, which increased the adaptability of labor relations to changes in the economic situation and contributed to the development of the labor potential of the economically active population. On the other hand, such forms of employment created the basis for the spread of precarization processes in the economy of the country and the Carpathian region, which resulted in an increase in the shadowing of employment and the spread of hidden unemployment, a shortfall in state budget tax revenues, etc.

A slight differentiation in the average values for Ukraine and the Carpathian region was observed for the quality-of-life component (0.667 and 0.643, respectively). Throughout the entire period under study, Ukraine and the Carpathian region were in the zone of social vulnerability, with deviations from the lower marginal value of 5.6 pp and 3.2 pp, respectively. Meanwhile, the largest differentiation between Ukraine and the Carpathian region was observed in the environmental security component. Therefore, the average value of the empirical indicator of environmental resilience in 2010-2023 was 0.598 for Ukraine and 0.388 for the Carpathian region. The average indicator for Ukraine exceeds the lower marginal threshold by 19.1 pp (in the Carpathian region - lower by 0.2 pp).

The comparative analysis of demographic security as a component of the social resilience of Ukraine and the Carpathian region confirms the thesis of disproportionate development of demographic resilience indicators. The most significant threats to the demographic security of Ukraine and the Carpathian region (in terms of distance from the upper marginal threshold) include ultra-low net reproduction rate (per woman) and high mortality rate of the population in general and children under one year of age in particular. A critical scale of external migration (labor, educational, and stationary), which leads to a decrease in the labor force and an increase in the demographic burden on the working population, is an existential challenge for the demographic security of the Carpathian region as a border area.

According to the average annual rate of change in the level of social resilience in 2010-2023, the demographic security of Ukraine as a whole and the oblasts of the Carpathian region showed a negative trend. Lvivska oblast showed the most negative trends in the weakening of demographic security every year during the study period (the average annual rate of change was -0.71%). Almost the same value of the average annual change in the empirical indicator of demographic security was recorded in Zakarpatska oblast (-0.52%), while the national average value of the weakening of demographic security was 0.56%. The main catalysts for this trend, especially in Zakarpatska and Lvivska oblasts, included external migration, which reached critical levels and eventually led to other negative demographic consequences (deformation of the age and sex structure of the population, depopulation of the territory, a significant decrease in the number of women of childbearing age, etc.). Meanwhile, a significant decrease in the fertility rate (2-fold in 2010-2023) and marriage rate (1.5-fold), and an increase in the mortality rate (1.1-fold) were the existential determinants of the weakening of Ukraine's demographic security. The average annual rate of change in the levels of demographic security in Ivano-Frankivska and Chernivetska oblasts was -0.46% and 0.4%, respectively.

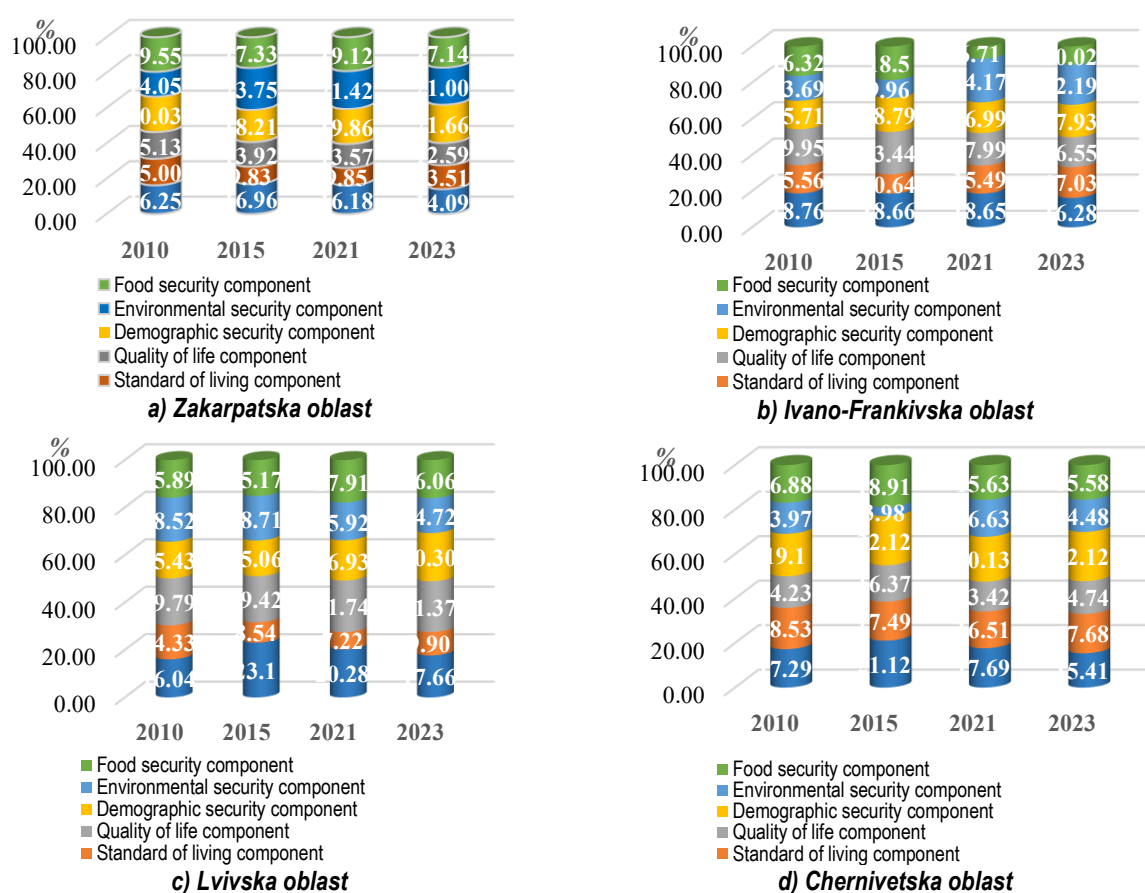
Interestingly, the average annual rates of change of other components of social resilience in Ukraine and the oblasts of the Carpathian region in 2010-2023 were positive, indicating a positive trend of strengthening environmental (except for the Zakarpatska oblast, where its weakening by 0.75% was observed) and food security (except for the national average, the change was -0.11%). Despite the increasing differentiation of the current values of the quality of life and standard of living components from the lower marginal and optimal thresholds, the average annual rates of change of these components of social resilience showed an upward trend. For example, the average annual changes in the quality of life and standard of living were 0.17% and 0.55%, respectively, for Ivano-Frankivska oblast, and 0.05% and 0.1%, respectively, for Chernivetska oblast. Meanwhile, the average annual rate of change in the quality-of-life indicator decreased by 0.23% in Zakarpatska oblast and by 0.48% in Lvivska oblast.

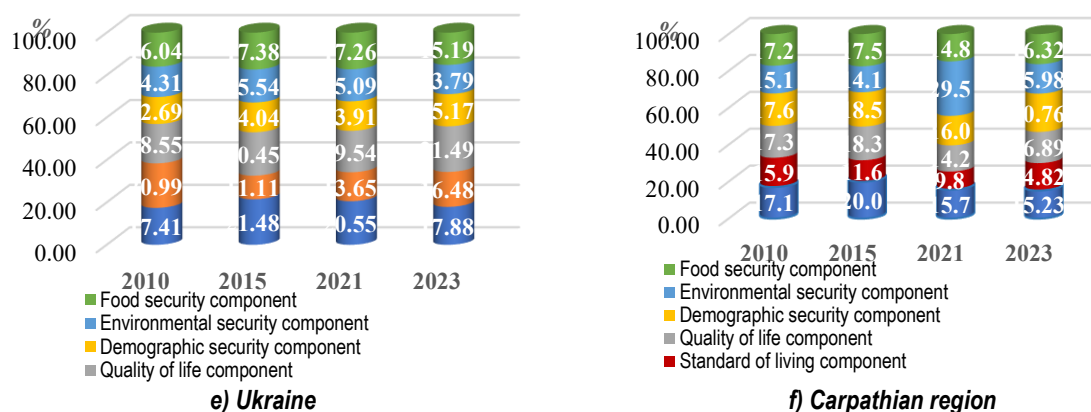
The quality of social and labor relations component had a positive dynamic of changes in average annual rates, except for the indicator for Ukraine as a whole (-0.06 %). For example, the average annual rate of change in the quality of social and labor relations in Ivano-Frankivska oblast was 1.75%, the main factor being the creation of a significant number of new jobs in the service sector and thus an increase in employment and labor productivity and a reduction in real and hidden unemployment. A significant increase in the number of individual

entrepreneurs in the IT and service sectors is also observed in the Carpathian region, which also indicates an increase in employment, especially informal and precarious employment.

The calculated weighting coefficients of the components' influence on ensuring social resilience indicate differentiated significance, which correlates with the periods of crisis and socio-economic development (Figure 1). For example, in 2010, the social resilience of Zakarpatska oblast was mostly ensured by such components as the standard of living and quality of life (weighting coefficients were 21.0% and 18.6%, respectively), while during the socio-economic and socio-political crisis (2015), by the quality of social and labor relations and quality of life (21.5% and 20.5%, respectively). It is worth mentioning that the standard of living had the greatest weighting influence on the social resilience of the region during the study period but decreased during the crisis period, while the influence of the quality of social and labor relations component increased. In 2014-2015, the weight of the standard of living component decreased from 17.8% to 11.1%, while the weight of the quality of social and labor relations component increased from 16.9% to 21.5%. A similar situation was observed in 2020-2021, during the period of the global pandemic, which had a negative impact on the development of regional economies. The weight of the standard of living component decreased from 24.5% in 2020 to 13.7% in 2021, and the quality of social and labor relations component increased to 20.6%, which is 4.6 pp more than in 2020.

Figure 1. Weight significance of the social resilience components of Ukraine and the oblasts of the Carpathian region, 2010, 2015, 2021, 2023, %





Source: compiled based on the authors' calculations

The components with the highest weight in Ivano-Frankivska oblast in 2010-2011 were the quality of life (20.0 % and 20.6 %, respectively) and demographic security (15.7 % and 16.0 %, respectively), in 2014-2015 – the quality of social and labor relations (18.7 % and 22.3 %, respectively) and the quality of life (19.1 % and 23.4 %, respectively), in 2020 – the standard of living and the quality of life (22.3 % and 22.5 %, respectively), and in 2021 – environmental security (24.2 %) and the quality of social and labor relations (18.7 %). Interestingly, the weight of food security in ensuring the social resilience of the region ranged from 15.8% to 18.5% (except for 2012-2013, when the weight was 13.2% and 14.5%, respectively).

The social resilience of Lvivska oblast in 2010-2023 was determined to the greatest extent by the weight of three components – quality of social and labor relations, standard of living, and quality of life. In 2014, the weighting coefficient of the standard of living component in the oblast was 34.5 %, and in 2020-2021, the weight of the quality-of-life component was 19.9 % and 21.7 %, respectively. Interestingly, a decrease in the weight of the quality-of-life component and an increase in the weight of the environmental security component are observed during periods of economic stability. For example, in 2011-2012, the weight of the quality of social and labor relations decreased from 19.8% to 9.0%, while the weight of environmental security increased from 7.4% to 49.4%, which is determined by the increase in capital expenditures for environmental protection. During the period of Covid-19 (2020-2021), the weight of environmental security decreased by 0.5 pp and 3.4 pp, respectively, and the standard of living by 1.1 pp and 9.6 pp, respectively, compared to 2019.

Compared to other oblasts of the Carpathian region, Chernivetska oblast had the most permanent distribution of the weight of the components' impact on social resilience in 2010-2023, apart from the environmental component, whose weighting dynamics was sigmoidal. For example, it was 13.1-14.1% in 2012-2013, 4.0% and 41.6%, respectively, in 2015-2016, and 17.2% and 13.2, respectively, in 2018-2019. During the periods of socio-economic uncertainty (2014) and the spread of the pandemic (2020) in the region, the standard of living (20.8% and 24.6%, respectively) and demographic security (16.4% and 16.8%, respectively) had the greatest impact on social resilience. Meanwhile, in 2010, the standard of living and quality of life had the greatest influence on the development and maintenance of Ukraine's social resilience (21.0% and 18.6%, respectively), while in 2015 and 2021, it was the quality of social and labor relations (21.5% and 20.6%, respectively) and quality of life (20.5% and 19.5%, respectively).

In 2023, against the backdrop of Russia's full-scale war against Ukraine, significant changes occurred in the structure of the importance of social resilience components, both at the national level and within the regions of the Carpathian area. These shifts reflect the adaptive processes triggered by military threats and socio-economic challenges. At the national level, the importance of the quality-of-life component increased to 21.49%, up from 19.54% in 2021. This rise may be attributed to the intensification of volunteer initiatives, the expansion of social services, and the provision of humanitarian aid. At the same time, there was a notable decrease in the social and labor relations component (from 20.55% to 17.88%), indicating a weakening of institutional and interpersonal ties under critical conditions. The standard of living component rose from 13.65% to 16.48%, reflecting efforts to stabilize the economic situation. Demographic security increased by 1.26 percentage points to 15.17%, possibly in response to the threat of losing human capital. Meanwhile, environmental and food security declined to 13.79% and 15.19%, respectively.

In Zakarpattia Oblast, the most significant components in 2023 were demographic security (21.66%) and environmental security (21.00%), reflecting the increasing relevance of preserving the population and natural environment as key development resources. Conversely, the quality of social and labor relations declined to

14.09%, down from 16.18% in 2021 - marking the lowest value recorded over the analyzed period. After a drop in 2015 and 2021, the standard of living component rose from 9.85% to 13.51%, while the quality of life decreased to 12.59%. In Ivano-Frankivsk Oblast, there was a notable increase in the environmental security component (22.19%) and consistently high values in demographic security (17.93%). Meanwhile, the quality-of-life component decreased from 17.99% to 16.55%, and social and labor relations dropped to 16.28%. Notably, food security, which accounted for only 6.71% in 2021, rose to 10.02% in 2023. In Lviv Oblast, the quality-of-life component remained dominant at 21.37%, showing a slight decrease compared to 2021. However, the social and labor relations component declined from 20.28% to 17.66%. At the same time, demographic security increased sharply from 16.93% to 20.30%, indicating rising concerns over population outflow and migration. For Chernivtsi Oblast, demographic security remained consistently high (22.12% in both 2015 and 2023) holding the leading position among all components. The social and labor relations component fell from 17.69% to 15.41%, while environmental security decreased from 16.63% to 14.48%. Food security remained nearly unchanged at 15.58%.

Thus, in 2023, the most notable transformations were the increased significance of demographic and environmental security, as well as quality of life, while the institutional component (social and labor relations) partially lost its weight. These shifts reflect the adaptive mechanisms of territorial communities under prolonged wartime conditions, demographic vulnerability, and the pressing need to sustain basic living conditions.

According to the results of the study, in 2010-2022, Zakarpatska oblast was in the range below social vulnerability, i.e. the loss of resilience to risks and threats. The value of the empirical indicator of social resilience was the lowest (0.391) in 2014, which is 25.9 pp lower than in 2013. In 2017-2020, the trend of increasing social vulnerability was downward, but in 2021, the empirical indicator decreased by 4.7 pp (Figure 2). The deviation of the social resilience coefficient from the lower marginal threshold ranged from -0.209 to -0.086 (Table 1). The average social resilience indicator for Zakarpatska oblast in 2010-2023 was 0.489, which is 11.1 pp and 51.1 pp less than the lower and upper marginal thresholds, respectively, and 21.4 pp and 34.7 pp less than the lower and upper optimal thresholds, respectively.

Table 1. Deviation of the current values of the composite index of social resilience from the vector of threshold values: social vulnerability aspect, 2010-2023

Thre-sholds	Oblasts	Years														
		2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	
Lower marginal	Zk	-0.092	-0.086	-0.098	-0.073	-0.209	-0.077	-0.101	-0.149	-0.133	-0.114	-0.089	-0.113	-0.174	-0.145	
	Iv-Fr	-0.127	-0.110	-0.107	-0.096	-0.075	-0.125	-0.139	-0.107	-0.079	-0.087	-0.102	-0.032	-0.104	-0.069	
	Lv	-0.148	-0.099	-0.153	-0.154	-0.095	-0.076	-0.099	-0.086	-0.119	-0.084	-0.073	-0.083	-0.148	-0.117	
	Ch	-0.115	-0.096	-0.151	-0.080	-0.053	-0.059	-0.044	-0.092	-0.089	-0.095	-0.139	-0.085	-0.150	-0.119	
Upper marginal	Zk	-0.492	-0.486	-0.498	-0.472	-0.609	-0.476	-0.501	-0.549	-0.533	-0.514	-0.488	-0.512	-0.574	-0.544	
	Iv-Fr	-0.526	-0.509	-0.506	-0.496	-0.475	-0.525	-0.538	-0.507	-0.479	-0.487	-0.501	-0.432	-0.503	-0.469	
	Lv	-0.548	-0.499	-0.552	-0.553	-0.495	-0.476	-0.499	-0.486	-0.519	-0.484	-0.473	-0.482	-0.547	-0.516	
	Ch	-0.514	-0.496	-0.550	-0.479	-0.453	-0.459	-0.444	-0.491	-0.489	-0.494	-0.539	-0.485	-0.549	-0.518	
Lower optimal	Zk	-0.195	-0.189	-0.201	-0.175	-0.312	-0.179	-0.204	-0.252	-0.236	-0.217	-0.191	-0.215	-0.277	-0.247	
	Iv-Fr	-0.229	-0.212	-0.209	-0.199	-0.178	-0.228	-0.241	-0.210	-0.182	-0.190	-0.205	-0.135	-0.206	-0.172	
	Lv	-0.251	-0.202	-0.255	-0.256	-0.198	-0.179	-0.202	-0.189	-0.222	-0.187	-0.176	-0.185	-0.250	-0.219	
	Ch	-0.217	-0.199	-0.253	-0.182	-0.156	-0.162	-0.147	-0.194	-0.192	-0.197	-0.242	-0.188	-0.252	-0.221	
Upper optimal	Zk	-0.328	-0.322	-0.334	-0.308	-0.445	-0.312	-0.337	-0.385	-0.369	-0.350	-0.324	-0.348	-0.410	-0.380	
	Iv-Fr	-0.362	-0.345	-0.342	-0.332	-0.311	-0.361	-0.374	-0.343	-0.315	-0.323	-0.337	-0.268	-0.339	-0.305	
	Lv	-0.384	-0.335	-0.388	-0.389	-0.331	-0.312	-0.335	-0.322	-0.355	-0.320	-0.309	-0.318	-0.383	-0.352	
	Ch	-0.350	-0.332	-0.386	-0.315	-0.289	-0.295	-0.280	-0.327	-0.325	-0.330	-0.375	-0.321	-0.385	-0.354	

Note: Zk – Zakarpatska; Iv-Fr – Ivano-Frankivska; Lv – Lvivska; Ch – Chernivetska.

Source: compiled based on the authors' calculations

The levels of social resilience in Ivano-Frankivska oblast were similarly below the marginal threshold, indicating the social vulnerability of the population in 2010-2023. In 2013-2014 and 2018-2019, the territory balanced at the level of the lower marginal threshold, with deviations of -0.085 and -0.081 respectively. The critical weakening of social resilience in the region was observed in 2010 (0.474), 2015 (0.475), and 2016 (0.462), which is 12.7 pp, 12.5 pp, and 13.9 pp below the lower marginal threshold, respectively. Over the period under

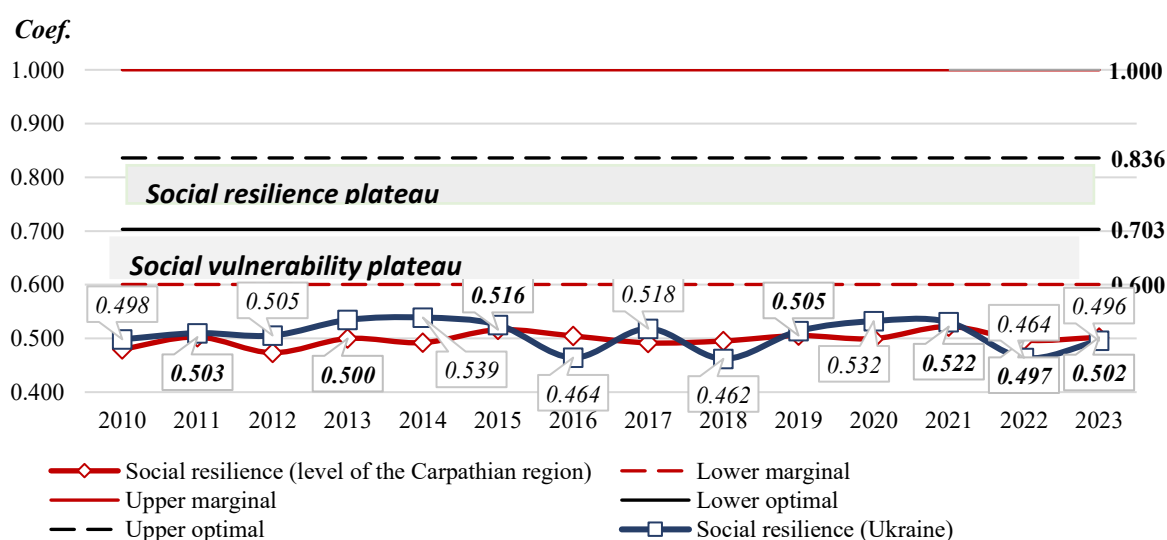
study, the average value of the empirical indicator of social resilience in Ivano-Frankivska oblast was 0.502, which is 9.9 and 49.8 pp less than the lower and upper marginal thresholds, respectively, and 20.2 and 33.4 pp less than the lower and upper optimal thresholds.

Compared to other oblasts of the Carpathian region of Ukraine, Lvivska oblast demonstrated a steady trend towards increased social resilience in 2010-2023, apart from 2012-2013 (0.447-0.448) and 2018 (0.481). The average value of the empirical indicator of social resilience in Lvivska oblast was 0.495, which is 10.6 pp and 50.5 pp below the upper and lower marginal thresholds, respectively, and 20.8 pp and 34.1 pp below the lower and upper optimal thresholds. For comparison, the empirical indicator of social resilience in Lvivska oblast in 2020 was 0.527, which is 2.8 and 1.5 pp higher than in Ivano-Frankivska and Zakarpatska oblasts, respectively.

Chernivetska oblast demonstrated the least deviations (0.92 pp) of the average social resilience indicator (0.509) from the lower marginal threshold among the oblasts of the Carpathian region. The range of deviations from the optimal thresholds was from 19.4 pp to 32.7 pp. A significant increase in social vulnerability in Chernivetska oblast was observed in 2012 (the deviation from the lower marginal value was -0.151), in 2017 (-0.092), and in 2020 (-0.139). Interestingly, Chernivetska oblast had critically low values of social resilience during the study period, indicating a loss of the region's resistance to macroeconomic instability and financial and economic risks, which led to an increase in social vulnerability, especially in terms of poverty and limited access to social goods and services.

Over the period 2021–2023, the Carpathian region of Ukraine exhibited a general trend of decreasing social vulnerability across all studied oblasts. Specifically, in Zakarpattia Oblast, the deviation of the composite social resilience index from the lower threshold deteriorated in 2022 (-0.174). A similar trend is observed for the upper threshold (from -0.574 in 2022 to -0.544 in 2023), as well as for the lower (from -0.277 to -0.247) and upper optimal thresholds (from -0.410 to -0.380), indicating a moderate reduction in social vulnerability. Ivano-Frankivsk Oblast demonstrated a slight strengthening of social resilience (Fig. 2). Although the indicators in Lviv Oblast remained within the vulnerability zone, the trend points to a gradual decrease in social vulnerability (the lower marginal deviation decreased from -0.148 in 2022 to -0.117 in 2023). Similar trends are observed in Chernivtsi Oblast, notably the decrease of the lower marginal deviation from -0.150 to -0.119 and the upper optimal deviation from -0.385 to -0.354. In 2022, a significant decrease in both indicators was observed (to 0.497 for the Carpathian region and to 0.464 for Ukraine). In 2023, a certain recovery of social resilience was noted, with the index for the Carpathian region increasing to 0.502.

Figure 2. Social resilience – social vulnerability plateau for Ukraine and the Carpathian region, 2010-2023: a compositional approach



Source: compiled based on the authors' calculations

In 2010-2023, the oblasts of the Carpathian region demonstrated a critical situation of social vulnerability of the population with a tendency to approach the lower marginal threshold. Declining living standards, disruption of the demographic balance, and poor quality of the social and labor sphere are the main triggers for the spread of social vulnerability and, consequently, the weakening of social resilience. Thus, during 2010-2023, Ukraine as a whole and the Carpathian region were in the zone of social vulnerability with an average value of 0.511 and

0.499, respectively. In 2010-2015, the trend of social resilience in the Carpathian region mirrors the national trend, with the highest value of the divergence indicator observed in 2010 (3.2 pp) and the lowest in 2010 (0.9 pp). In 2016 and 2018, the Carpathian region demonstrated higher empirical indicators of social vulnerability compared to the national indicators (4.0 pp and 3.3 pp, respectively). This trend seems to be natural, as the level of socio-economic development of the Carpathian region of Ukraine is defined as moderate compared to other economic regions of Ukraine. For example, the average GRP per capita in the Carpathian region of Ukraine in 2018 was over UAH 56,400, while Chernivetska oblast had one of the lowest figures in Ukraine (UAH 37,400). Despite the positive trend in the growth of socio-economic development indicators, the GRP of the Carpathian region was about 67% of the national average.

It is worth mentioning that the volume of capital investments in environmental protection characterized by permanent dynamics in 2016-2023 is the conceptual trigger for the increase in the divergence of indicators, for example, of the socio-ecological resilience of the Carpathian region from the national average. There was a significant increase in capital investments in Ukraine in 2019 compared to 2018 by UAH 6.2 billion or 61.4%; while in the Carpathian region, capital investments decreased by UAH 131.2 million or 20.4%. Chernivetska and Zakarpatska oblasts were characterized by a relatively low level of investment in general throughout the study period.

4. Discussions

Ensuring migration security in the system of socio-economic resilience of the territory has a complementary methodological and practical significance, which is associated with the unique characteristics of migration processes as an object of the regulation (e.g., volume, dynamics, risks for structural transformation of the economy, migration transfers, and entrepreneurial capital) and variability of the relationship between the structural characteristics of migration and the parameters of economic security, resilience, and development.

Within the framework of migration policy, the issues of the impact of migration on the economic system are not complex, dynamic, or multidimensional. In the state migration management policy, migration security is regulated in the projection of national economic development or ensuring economic resilience. Meanwhile, the migration security policy envisages the management of migration processes in such a way that their volumes are within the optimal range, exceeding which has negative consequences for the economic system and national security. It is worth distinguishing three blocks of mechanisms for ensuring migration security – (1) economic security, (2) socio-economic resilience, and (3) economic growth.

Mechanisms for ensuring migration security within the economic security block include detailed measures to counteract the decline in business activity and investment attractiveness of the territory because of macroeconomic shocks, deterioration of the business environment, etc. A set of instruments aims to regulate the pressure on the social system and infrastructure (Jia *et al.* 2022), develop a balanced labor market (Levytska *et al.* 2022), eliminate demographic imbalances, reduce social inequality (Mulska *et al.* 2023b), preserve human resources, develop human capital (Voznyak *et al.* 2021), and stabilize the financial system (Wielechowski *et al.* 2021).

Maximizing the effectiveness of the use of migration potential for the sake of ensuring the resilience of the socio-economic system is the main objective of the development and implementation of migration security mechanisms in the socio-economic resilience block. Mechanisms for the regulation of migration flows focus on ensuring economic stability through: development and enhancement of labor market competitiveness (attracting highly qualified labor force with necessary professional skills; identifying and filling labor shortages in certain industries or regions; responding to 'staff shortages' as a result of external migration depending on labor market needs; attracting highly qualified specialists) (Mulska *et al.* 2023a), increase in the attractiveness and stimulation of investment activity in the business sector (creation of new jobs, provision of benefits and various forms of support for migrant entrepreneurs) (Andersson & Siegel, 2020), the impact of migration on development, prevention of illegal migration (strengthening border control to reduce the illegal movement of people, introduction of severe penalties for illegal employment), adaptation of regional economic policy to market turbulence (Ilyash *et al.* 2022; Alpaslan *et al.* 2021), long-term monitoring of the economic situation, and adaptation of migration policy to new challenges and opportunities (Lupak *et al.* 2022).

The mechanisms of ensuring migration security in the economic growth block focus on increasing the competitiveness of the economic system, expanding factors, increasing production resources (capital, labor, innovations, technologies, intangible assets, entrepreneurial skills, business models), improving the structure of the economy through the development of high-tech industries, sectors with significant added value, and productive areas, and developing rational balances between the private and public and commercial and non-profit

sectors. Reducing regional disparities and optimizing the pace of demographic reproduction processes in the context of the migration crisis are triggers of economic development, the increase of the potential for economic recovery, and the reduction of the effects of economic stagnation (Voznyak *et al.* 2024).

The systematization of scientific approaches to the development of mechanisms for ensuring migration security as regulatory tools ensuring the controlled course of migration processes, contributes to the construction of a conceptual model of mechanisms in the projection of their ability to secure the dynamic resilience of the socio-economic system. According to the author's interpretation, the mechanisms for ensuring migration security include measures of state and local authorities to influence migration, its volume, and structural characteristics to minimize its negative impact on the security, resilience, and development of the socio-economic system. Interestingly, the current mechanisms for ensuring migration security focus on regulating migration in the context of economic security, medium-term mechanisms – on socio-economic resilience, and long-term mechanisms – on economic development. The differentiation of the mechanisms involves specifying the functions, principles, methods, and means of implementing state and regional migration and economic policies, as well as opportunities to use the potential of migration, ensuring its controllability in the security – resilience – economic growth vector.

The process of implementing migration security mechanisms depends on certain elements of the basis, in particular (1) legislative regulation (laws and regulations governing migration processes, including immigration codes, legal acts defining the rights and obligations of migrants, and rules for controlling migration flows); (2) controlling (control and monitoring) (databases, electronic identification systems, etc.); (3) international cooperation (cooperation between countries and international organizations to share information, respond to migration challenges, and coordinate security efforts); (4) HR management (training, advanced training of specialists of border and migration services); (5) risk analysis and foresight (long-term implementation of risk management, development of strategies to minimize the consequences, forecasting possible threats, and preparation for possible scenarios); (6) social and legal security of migrants (providing legal assistance and social support to migrants in difficult situations or victims of exploitation to ensure their rights and integration into society). The configuration of these elements forms the basis for the implementation of mechanisms and a comprehensive system of migration security, which contributes to the effective management of migration processes and the protection of national and migrant interests.

Conclusions and Further Research

The study confirms the hypothesis: migration security is a determinant of the country's socio-economic resilience, and its weakening is determined by a critical increase in social vulnerability, which has a permanent reverse effect on the Ukrainian economy and society in the long run.

Social vulnerability is examined from the perspective of social resilience and determining the boundaries of the system's safe existence. The calculation of thresholds of catalysts, regressors, and components was the conceptual stage of the study, which helped determining 'vulnerability zones' and 'safety margin' ranges by comparing them with the composite coefficients. Threshold vectors (lower marginal – upper marginal; lower optimal – upper optimal) are defined for each component of social resilience.

Based on the temporal-spatial approach and using the multiplicative method, a series of empirical indicators of social resilience is constructed for the oblasts of the Carpathian region of Ukraine. The study reveals that in 2010-2023, the region's oblasts demonstrated a critical situation of social vulnerability of the population with a tendency to approach the lower marginal threshold (the indicator in the Carpathian region of Ukraine was 0.499). The main triggers for the spread of social vulnerability, and thus the weakening of social resilience, included a decline in the standard of living, disruption of the demographic balance, and the poor quality of the social and labor sphere. In 2010-2015, the trend of ensuring social resilience in the Carpathian region reproduced to the national one, with the highest value of the divergence indicator in 2010 (3.2 pp) and the lowest in 2020 (0.9 pp).

The practical value of the authors' methodology for studying the vulnerability-resilience of the socio-economic system is determined by the identification of the dynamics of the composite social resilience coefficients and their deviations from the thresholds as an empirical indicator of social vulnerability. Such an approach leads to the implementation of adaptive and proactive actions and makes it possible to scientifically substantiate the strategic guidelines for indicators of strengthening social resilience, while also reducing social vulnerability in the context of the migration crisis. The testing of this approach resulted in a scientific justification of the need to regulate key indicators that ensure social resilience at an optimal level and form the basis of a proactive policy to reduce social vulnerability.

The scientific novelty of the study lies in the development and testing of a scientific and methodological approach to assessing the social vulnerability of the population through the identification of vulnerability (risk) zones, resilience reserves, and the social resilience of a territory. This approach is based on the concept of dynamic equilibrium ('homeostasis') and has enabled the identification of threshold, optimal, and critical values of catalysts and regressors across various social domains (such as the quality of socio-labor relations, living standards, quality of life, and demographic, environmental, and food security). It also determines the degree of influence of specific indicators on ensuring social stability (reducing social vulnerability) and assesses the capacity of the social system to maintain resilience over time and to withstand emerging challenges and threats.

The study of social vulnerability is important in terms of determining the boundaries of safe system functioning or identifying the degree of social resilience. A key conceptual stage of the research was the calculation of threshold values for catalysts, regressors, and components, which made it possible, through comparison with compositional coefficients, to identify 'vulnerability zones' and ranges of 'resilience reserves.

Meanwhile, special attention is paid to the limitations of the methodological approach to assessing social vulnerability in the projection of the resilience of the socio-economic system:

- 1) vulnerability indicators are selected and grouped using an expert method and are subject to discussion regarding their decomposition;
- 2) the division of indicators into catalysts and regressors is subject to discussion;
- 3) the boundaries of the marginal and optimal ranges of indicators are permanent during the study period, which does not fully reflect the cyclical and dynamic nature of socio-economic processes.

Further research is modeling the complementary causal relationship between socio-economic resilience and migration security and identifying the delayed impact of determinants on the potential for recovery of territories in conditions of instability.

Credit Authorship Contribution Statement

Authors have contributed equally to this research.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Declaration of Use of Generative AI and AI-Assisted Technologies

The authors declare that they have not used generative AI and AI-assisted technologies in the writing process before submission.

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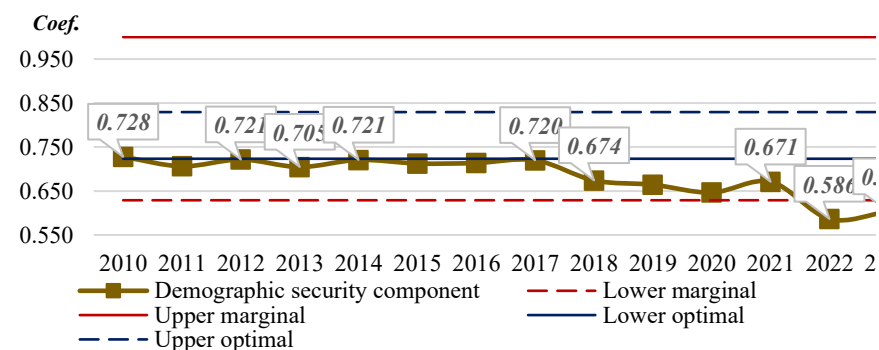
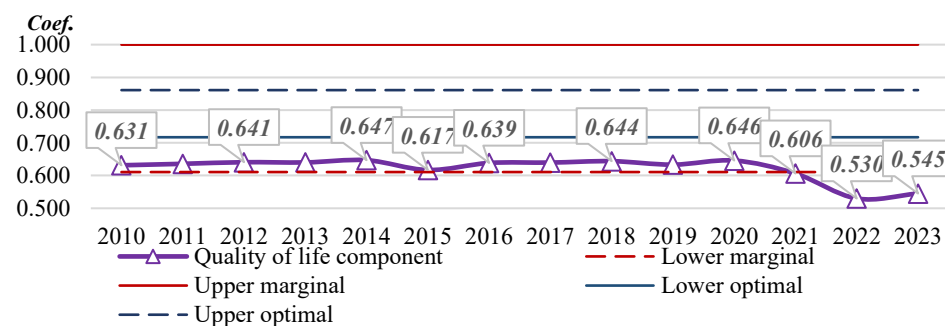
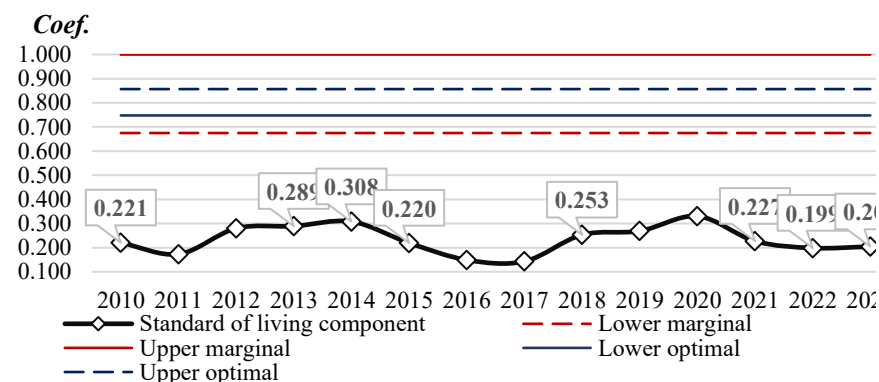
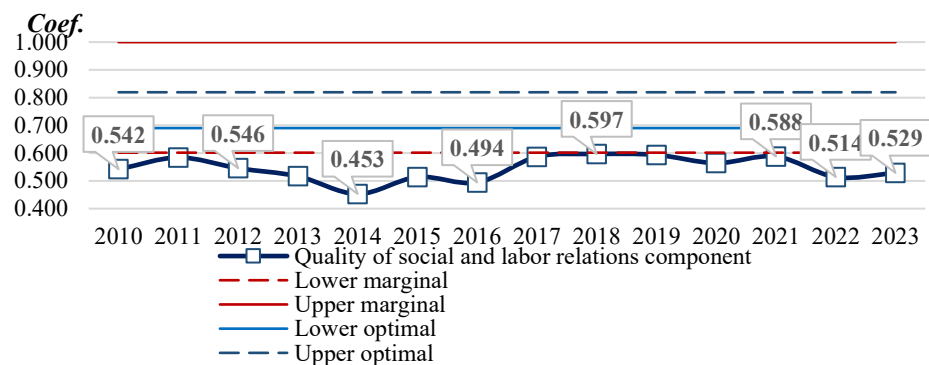
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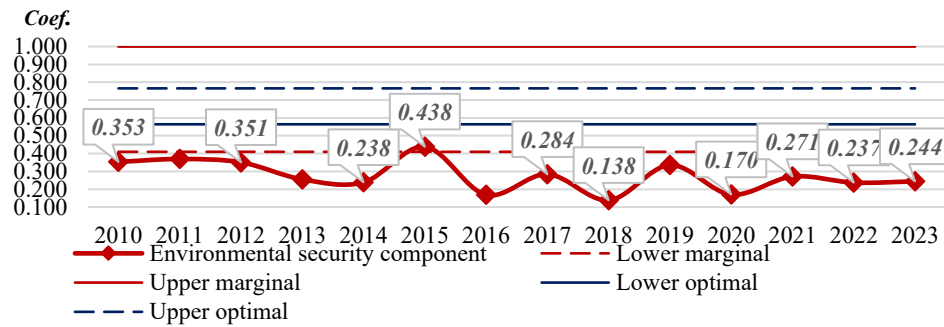
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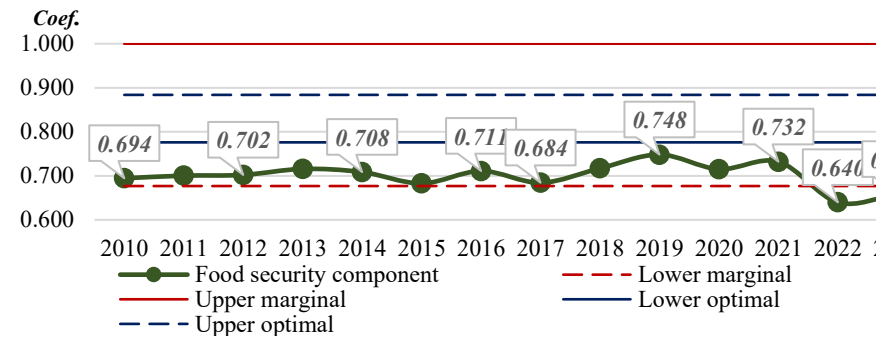
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Application 1. Social resilience – vulnerability of Zakarpatska oblast, 2010-2023: a structural and temporal approach



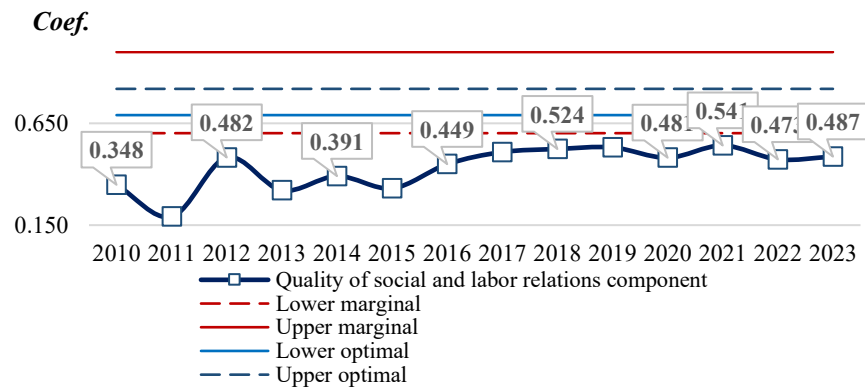


e) Environmental security component

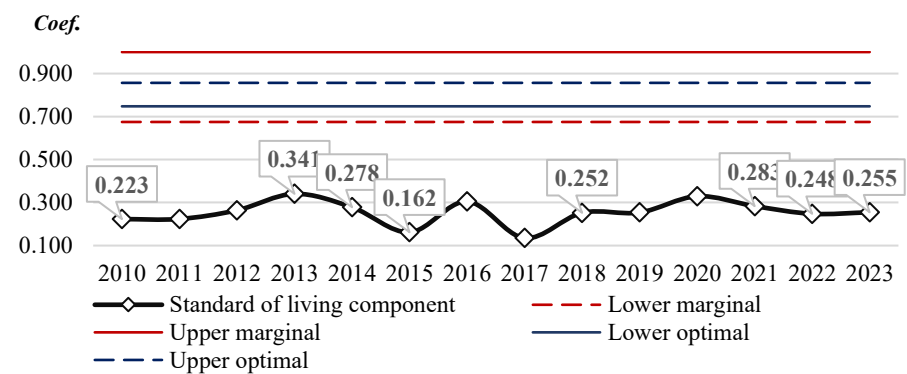


f) Food security component

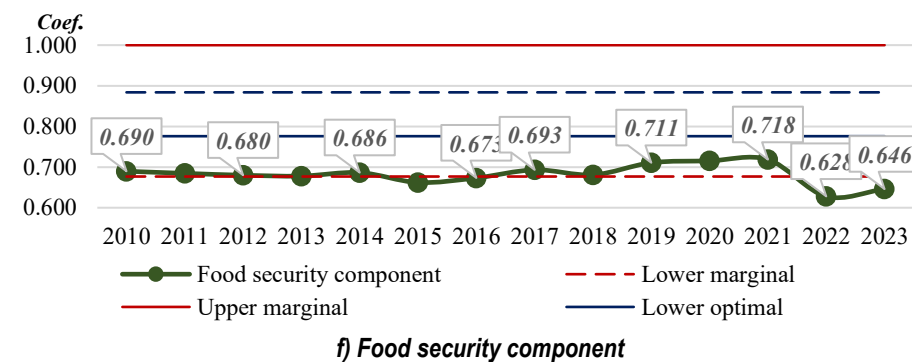
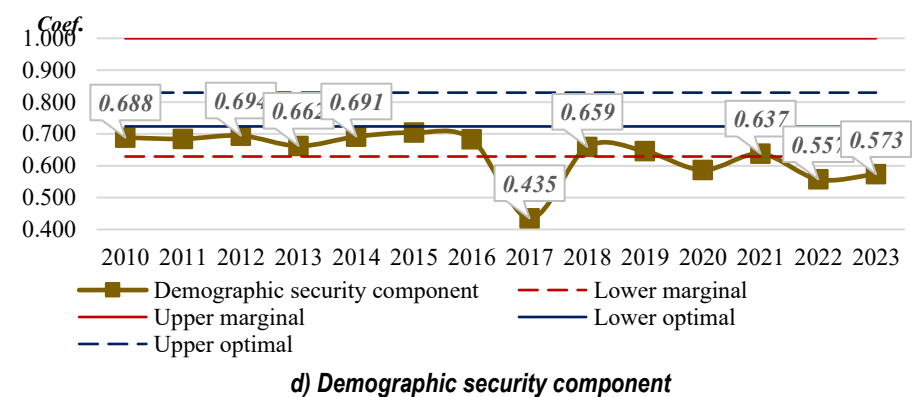
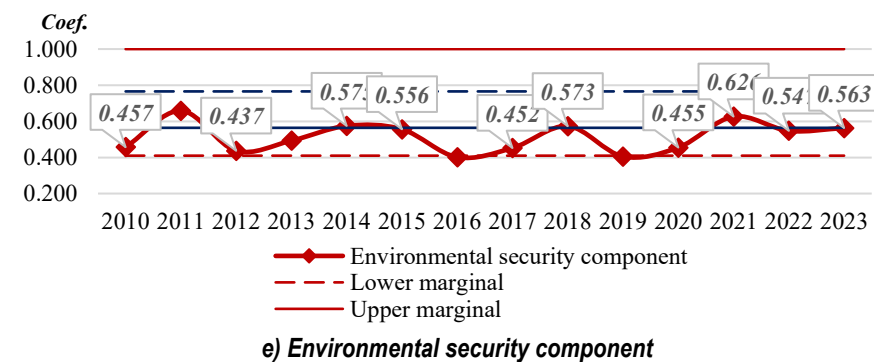
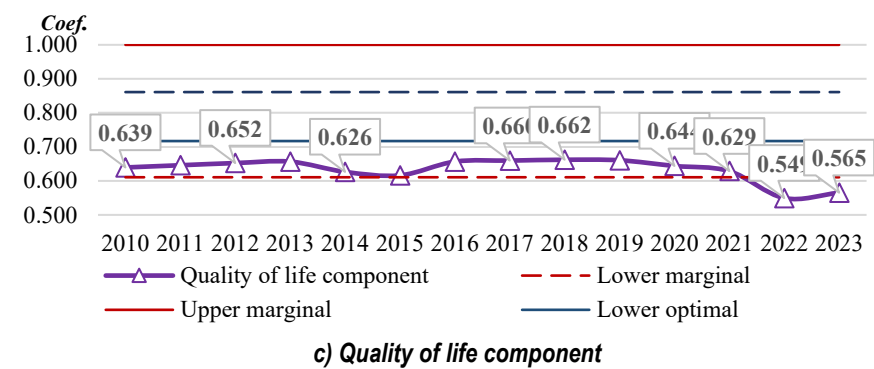
Application 2. Social resilience – vulnerability of *Ivano-Frankivska oblast*, 2010-2023: a structural and temporal approach

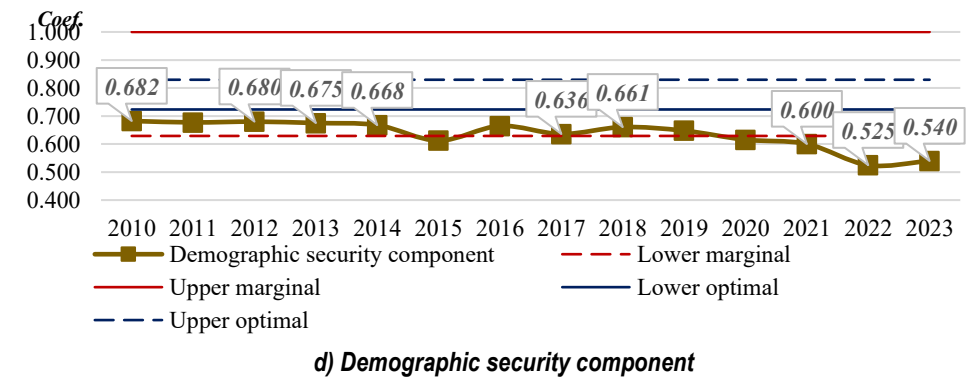
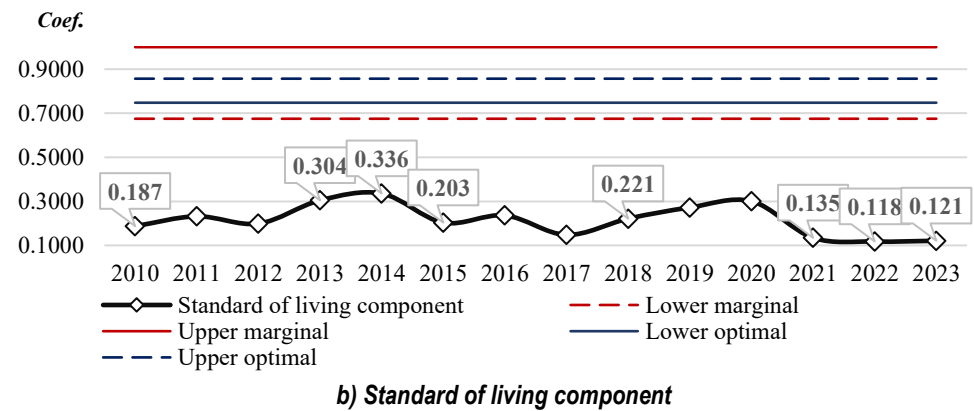
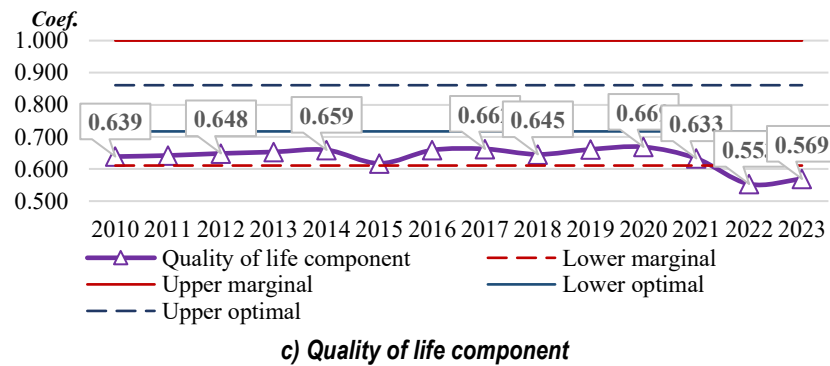
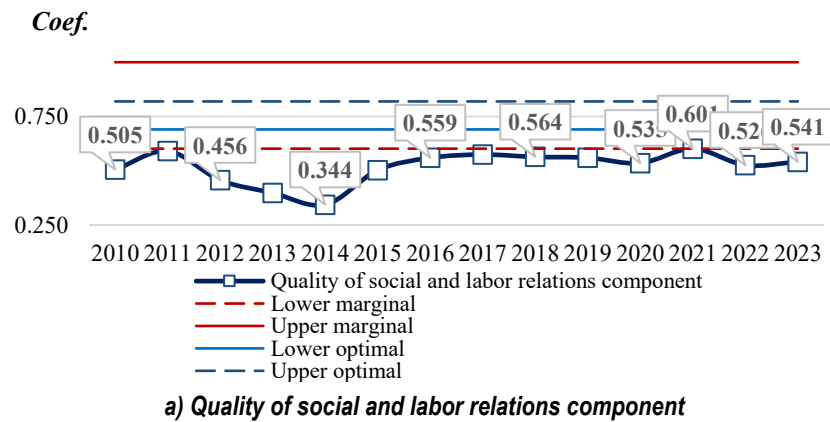


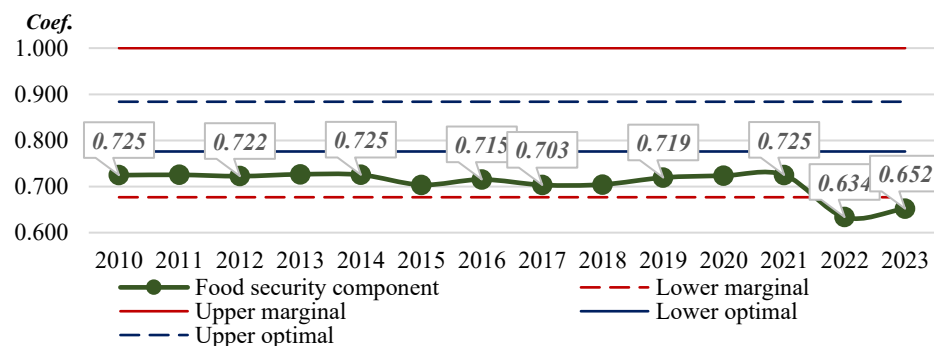
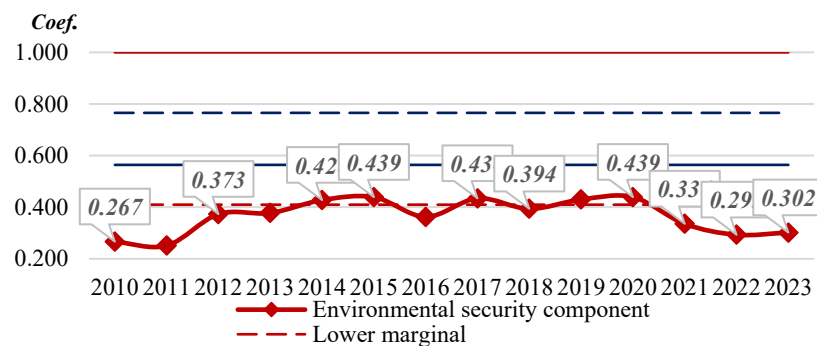
a) Quality of social and labor relations component



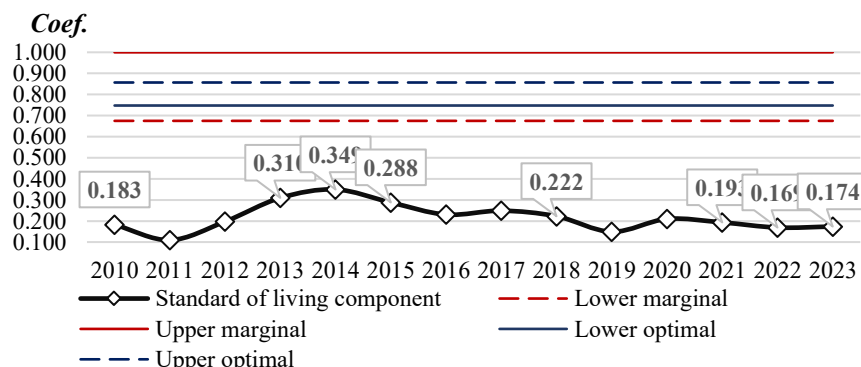
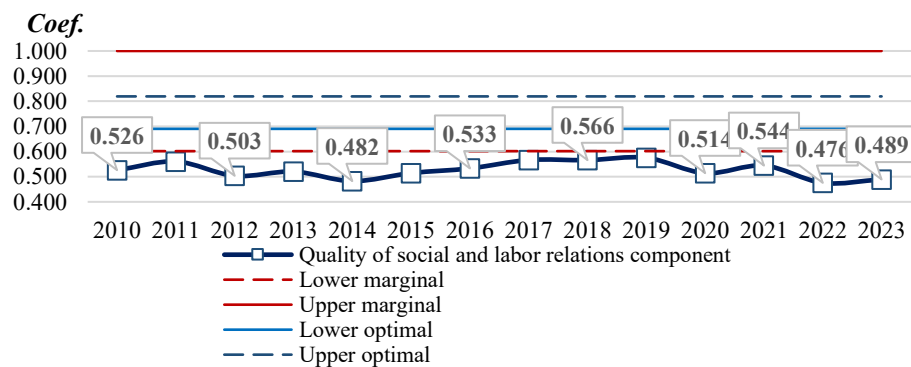
b) Standard of living component

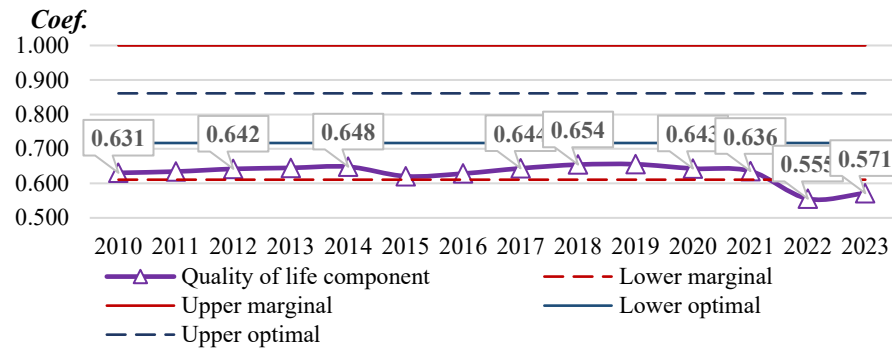


Application 3. Social resilience – vulnerability of *Lvivska oblast*, 2010-2023: a structural and temporal approach

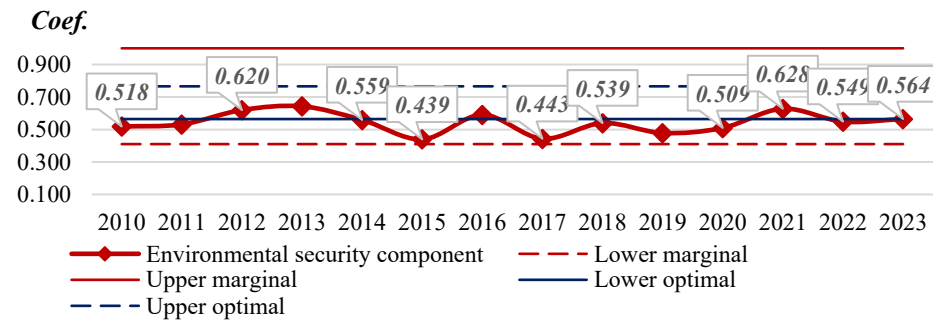


Application 4. Social resilience – vulnerability of Chernivetska oblast, 2010-2023: a structural and temporal approach

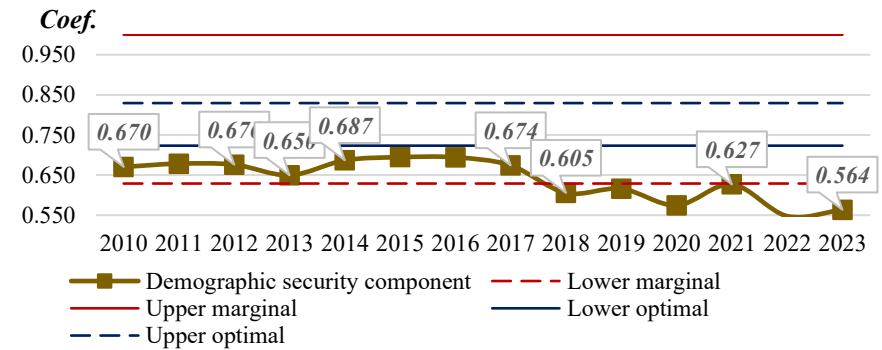




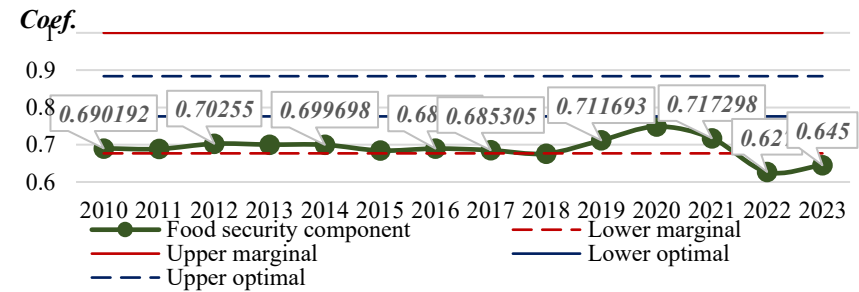
c) Quality of life component



e) Environmental security component

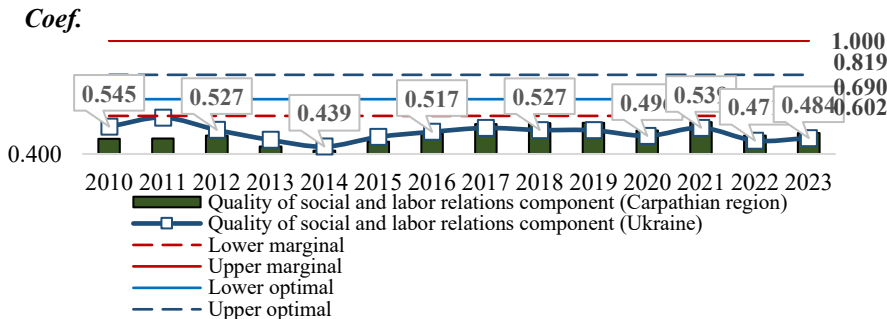


d) Demographic security component

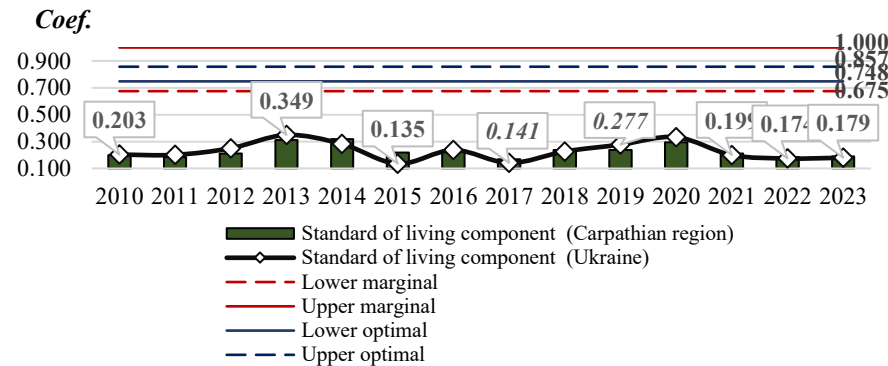


f) Food security component

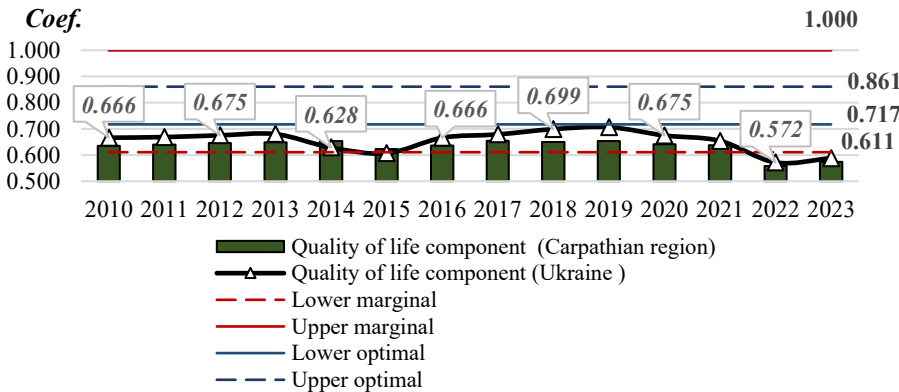
Application 5. Social resilience – vulnerability of *Ukraine and the Carpathian region*, 2010-2023: a structural and temporal approach



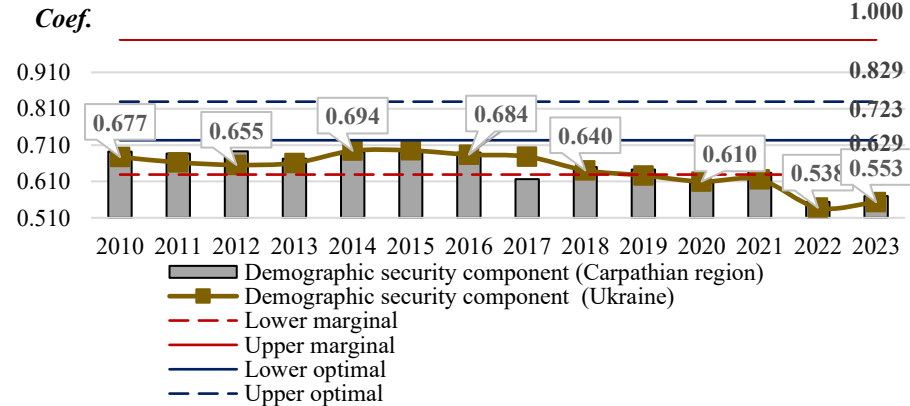
a) *Quality of social and labor relations component*



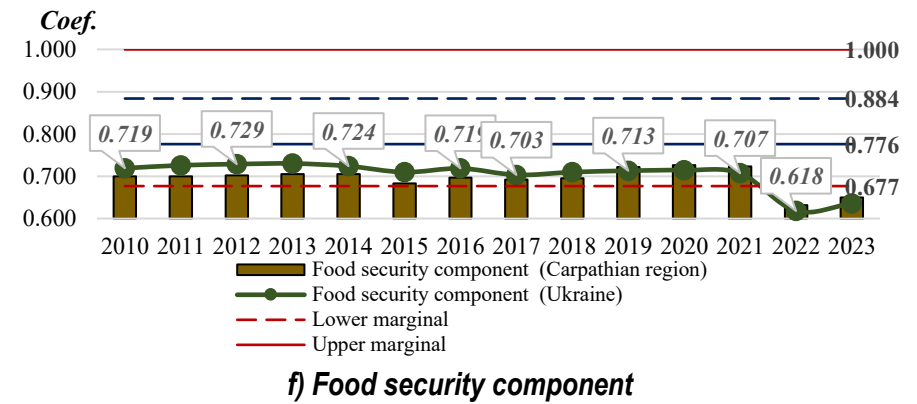
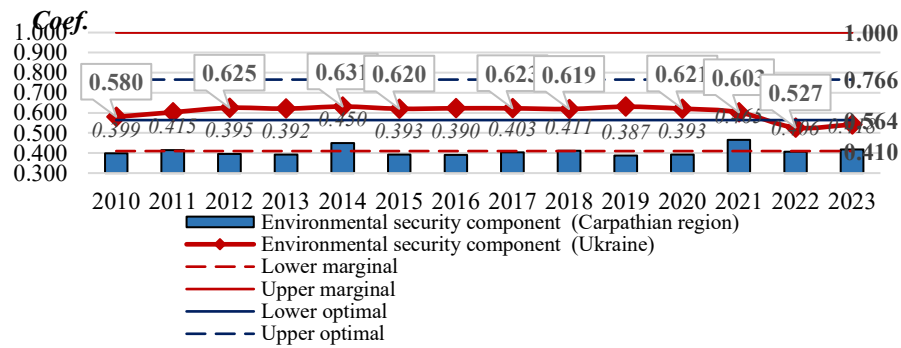
b) *Standard of living component*



c) *Quality of life component*



d) *Demographic security component*





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Impacts and Challenges of Digital Technology on Cooperatives in Bali Province

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Abstract: This study aims to explore the impacts and challenges of cooperatives that use digital technology in the Province of Bali. The relevance of this work is the demand for digitalization of cooperatives by the central government to increase the empowerment of cooperative institutions and the lack of cooperatives that apply digital technology. A qualitative approach was used, and data analysis was conducted using the semantic interpretation method by conducting in-depth interviews using a purposive sample method with 47 cooperative top management who are using digital technology. The basis of this research methodology is organizational theory in the context of digitalization. The object of this work is cooperatives that apply digital technology. Digital cooperatives which are using organizational theory were the investigated objects showing the novelty of this work. It has been found that the impact of the use of digital technology by cooperatives influences increasing business prospects, business continuity, outreach and collaboration. However, it was found that cooperative members who are using mobile cooperatives have low loyalty. The risks faced are still challenging digital cooperatives, and it is recommended that further research be conducted to find out the reasons of cooperatives that have not implemented digital technology services.

Keywords: digital technology; cooperatives; business continuity; outreach; faced risks; digitalization; digital service; collaboration.

JEL Classification: G21; O33; M15; R11; A12.

Introduction

The rapid development of technological transformation to digital transformation has brought drastic changes to society, organizations, agencies, private sector, companies and governments that should be able to be welcoming the era of society 5.0. This of course also has an impact on cooperatives as microfinance institutions. The application of technology is very important for the survival of an organization. However, research on the impact of technology on an organization is still limited.

Previous studies revealed that technology can improve profitability and values of company (Chen, Guo, and Shangguan 2022), able to encourage commercial bank resilience during crises which in turn increases financial stability (Dadoukis, Fiaschetti, and Fusi 2021), able to increase bank customer financial transactions (Carbó-Valverde *et al.* 2020), and able to improve employee skills and performance of small and medium-sized

enterprises (SMEs) (Eller *et al.* 2020). On the other hand, others showed that there are negative impacts of technology implementation including negative impact on corporate innovation performance (2021). Financial technology (fintech) also provided a negative effect on bank performance (2020) and its innovation reduced the profitability and asset quality of Chinese commercial banks in aggregate (2022). It also had a negative impact on the profitability of bank savings in Spain (2012). In addition, there are other studies that showed an ambiguous impact from the application of technology. Cámara *et al.* (2015) confirmed that there is no real evidence to conclude the positive impact of Web 2.0 technology on the operational performance of companies in Spain. Di Vaio & Varriale (2020) also stated that there is no guarantee that the adoption of blockchain technology will improve performance in the aviation industry in Italy. The majority of previous studies have analyzed companies (Kumar *et al.* 2022; Tang, Huang, and Wang 2018; Gillani *et al.* 2020; Martínez-Caro, Cegarra-Navarro, and Alfonso-Ruiz 2020; Singh, Sharma, and Dhir 2021), SMEs (Abbasi *et al.* 2021; Khayer *et al.* 2020; Denicolai, Zucchella, and Magnani 2021; Eller *et al.* 2020), banks (Ha 2022; Dadoukis, Fiaschetti, and Fusi 2021), the airport industry (Di Vaio and Varriale 2020) and external auditors (Manita *et al.* 2020).

In addition, Riaz *et al.* (2022) showed the impact of digitalization on corporate governance in Australia as improved corporate governance with transparent disclosure of information and thwart corrupt practices. Lumi (2020) found the impact of digitalization on human resource management seen from the positive and negative aspects. The positive aspects of digitalization of human resource management are revealed to have created and accelerated many changes, enhanced efficiency and effectivity by facilitating technology in every process includes recruitment, selection, training and development, performance and monitoring (Tongdhamachart & Alwi, 2023). The globalization of international connections, social networks and many other aspects affect training and forms of digital communication with digital platforms. The negative aspects of digitalization are stated to damage the essence of space and time. Moreover, organizations must allocate funds by investing more in the digitalization aspect for every innovation and every method carried out.

Cherkasova & Slepushenko (2021) found the impact of digitalization on financial performance companies in Russia. They discovered that digitalization carried out by companies has a positive effect on company operational efficiency, enabling company management to choose the right strategy in terms of digital transformation, ensuring company competitiveness and contributing to the development of digital innovation. Kiseleva (2020) then described the impact of digital transformation on potential investments in Russian cities. They found increasing digital potential to interact with public authorities, increasing e-business components through business digitization, and the implementation of electronic workflow processes (Al Maani *et al.* 2023).

Lapina (2022) further stated digitalization in the health sector as improved provision of medical care and medical services and optimized health care management. On the other hand, Matoušková (2022) showed the impact of digitalization on the business sector, whereby businesses using more digital modes can earn more revenue which is different to businesses going digitally backwards that will lose customers as they face inconvenience related to cash payments as digital modes of payments are now more preferred by customers.

Furthermore, digital technology has been found facilitating access to various types of information, helping in the development of cooperatives cooperation with customers in Russia and improving the daily life of cooperative members (Kruchinina and Ryzhkova 2020). With regards to agribusiness sector, the introduction of digital platforms helps increasing labor productivity, resource efficiency and effectiveness of cooperation between participants (Shadchenko *et al.* 2022). However, one negative side of digital cooperatives is the lack of effective legal and technical mechanisms to regulate digital cooperative information infrastructure in Russia (Budarin, Chirkov, and Magomedov 2022).

Yet, digitalization of the consumer cooperative system is an important component of the socio-economic development, culture of members, customer and producer cooperatives, as well as guidelines for ensuring the competitiveness of the country and society as a whole (Kartashov *et al.* 2022). There is also an ambiguity of the sharing economy which is found as a new form of consumer cooperatives in the context of digitalization and the need for flexible regulations in each country's economic system (Vorozheykina *et al.* 2022). Moreover, the development of digital cooperatives in Russia makes it possible to improve financial performance, develop crisis management to gain lost profits in 2020 (Nabiyeva *et al.* 2022). Financial models have also been shown in digital cooperative business for the Euro-America and Asia Pacific regions, showing a strong correlation between turnover of cooperative business structures in the Asia-Pacific region and the availability of funds for technology development (Korolev *et al.* 2022).

Rising competition for digital technology services carried out by banking financial institutions requires cooperatives to participate in increasing the application of digital technology services. Under current conditions, digitization is so important that the central government encourages the development of cooperatives through

regulations by issuing government regulations according to the Regulation of the Minister of Cooperatives and Small and Medium Enterprises of the Republic of Indonesia Number 2 of 2017 allowing the digitization of cooperatives and Government Regulation Number 7 of 2021 Article 21 paragraph 1 which confirms that: (a) cooperative empowerment is carried out through innovation and technology and Article 21 paragraph 6, (b) encouraging the improvement of cooperative innovation capabilities to improve work efficiency and cooperative competitiveness (Joko Widodo 2021).

However, the low interest of cooperatives in implementing digital technology services is the motivation for this research to be conducted. Therefore, this study focuses on a qualitative study of the phenomenology of digital cooperatives to contribute to the context of cooperative digitization. The aim of this work is to discuss the impact of cooperatives that apply digital technology and the challenges faced by using organizational theory (Quang & Duc, 2023). The importance of this work is to explore whether the results might be different from previous studies that focused on digital cooperatives. Since there are various types of cooperatives, among others includes, savings and loan, service, marketing, producer, consumer and all-business cooperatives. The contribution of this research is expected to guide the top management of cooperatives to increase the implementation of digital technology services.

Research Problem:

As for the problems of research conducted to determine the role of cooperatives in the Province of Bali, as follows:

1. The impact of implementing digital technology for cooperatives in Bali;
2. Is the application of digital technology for cooperatives able to provide services to businesses and services provided.

1. Literature Review

In the Previous study has shown the impact of digitizing SMEs on increasing employee skills, financial performance, and information technology (Eller *et al.* 2020). Meanwhile, European SMEs undergoing digital transformation showed the impact of digitalization, allocate more resources for experimentation with innovating business models and are more involved in implementing digital business strategies (Bouwman, Nikou, and de Reuver 2019) The impact of digitalization on SMEs was also shown by Takeda *et al.* (2022) in which an increase in the percentage of online sales which in turn increases digital payments. The impact of digitalization on companies can be seen in the increased skills of female employees and salary increases (Lukyanova 2021). Different things can be seen in the impact of digitalization on business-to-business organizations stated by Pagani & Pardo (2017), namely the success of using digital marketing, creating value through integration of resources, development of business networks, supporting the occurrence of new activities, new resource ties, and new actor ties. Digitalization also influences social networks updates for corporate purposes and the performance of knowledge-intensive business service. There are also impacts of digitalization on the banking sector including the existence of strategic partnerships and cooperation between banks and financial technology companies (Elsaid 2021), increased possibility for bank customers to carry out financial transactions through digital channels rather than in physical branches, accelerated digitalization of bank customers, achieved personal and social efficiency gains, increased bank productivity and efficiency (Carbó-Valverde *et al.* 2020). The impact of digitalization on manufacturing companies in Italy was shown to affect the company's export behavior (Cassetta, Meleo, and Pini 2016). Additionally, manufacturing companies in the United States and Europe experienced improved customer experience, reduced time and costs, varied service models and enhanced financial performance (Abou-foul, Ruiz-Alba, and Soares 2021). Yang *et al.* (2021) then stated that there are four main impacts of the adoption of digital technology in manufacturing companies, namely supply chain efficiency, supply chain structure, sustainability and innovation.

Wehrle *et al.* (2021) stated that digitalization affects the purchasing and supply management functions so that it encourages the development of new products at different times and forms, as well as drives the potential role of innovation. The impact of digitalization can also be seen in the service sector such as updating social networks, using social networks for corporate purposes, and having high-level training in using digital technology (Ribeiro-Navarrete *et al.* 2021). There are also other impacts such as changes in work allocation, collaboration, motivation, workload, workplace monitoring, technostress problems, the growth of online fraud, security management, the need for internet regulations, monitoring and data privacy (De', Pandey, and Pal 2020). It can be seen that the impact of digitalization on cooperatives has not been carried out. Therefore, this study was conducted by conducting a qualitative analysis of the impacts and challenges of digital cooperatives in Bali Province in welcoming the era of society 5.0.

Huang *et al.* (2022) stated that society 5.0 was proposed by the Japanese Cabinet to balance economic progress with solving social problems in Japanese society. Society 5.0 aims to put humanity at the center of innovation, leveraging the impact of technology and the results of industry 4.0 with the integration of technology to improve quality of life, social responsibility and sustainability (Carayannis and Morawska-Jancelewicz 2022).

2. Method

Several stages were used in this work. From a population of 5,380 active cooperatives in Bali Province in 2022, the first stage of sample selection was carried out using a purposive sampling method in order to obtain 4,260 active cooperatives that are still operating. The second stage of sample selection was carried out using the accidental sampling method in order to obtain a sample of 47 cooperatives that have used digital technology services. The data collection method was carried out by means of in-depth interviews conducted with the top management of digital cooperatives of 47 people from December 2022 to January 2023. The interview guide consisted of an introduction, agreement and open questions. All interviews were conducted by recording with the consent of the respondents and kept confidential to provide a code for each interview. The average time required for each interview is 45 minutes.

2.1 Research Methodology. Analysis Digital Cooperative Characteristics

Based on field observations, it was found that the majority of cooperatives that apply digital technology in Bali Province belong to the type of savings and loan cooperatives, which are 30 cooperatives, followed by 4 types of all-business cooperatives, 7 types of consumer cooperatives and 6 service cooperatives. Cooperatives using digital technology develop technological innovations by collaborating with vendors of national and local scale technology development institutions with most cooperatives located in Badung Regency. They implement digital technology based on operational and service market needs. As many as 24 cooperatives implemented digital technology during the COVID-19 pandemic and after the pandemic.

Based on the information that we have obtained from the vendor commissioner of the technology development agency of the cooperative, the characteristics of the application of digital technology are the application of technology by recording transactional activities using a computerized system, the use of the mobile collector smartphone application by field officers, availability of a control computer (server), existence of an internet network that connects one computer from one office to another and the use of a cloud-based infrastructure as a server control center. Cloud technology is the use of the internet to access applications, data or services stored or run on remote servers (Artemenko and Zenchenko 2021). Other characteristics according to vendors of digital cooperative services are 24-hour operational services in real time, mobile and browser-based services similar to internet banking that are integrated with third parties in providing services to cooperative members, digital services that are generally provided include account opening online, online loan applications, cooperative member marketplaces, online bank payment points so that they can be used to pay electricity bills, telephone, internet, water, BPJS, and motor vehicle installments. Other mobile services provided by digital cooperatives as informed to us are being able to top up OVO, GOPAY balances, and having an Application Programming Interface so that cooperative members can make QRIS payment transactions, interbank transfers, and can withdraw money using ATMs in all banks.

Table 1. Types of Digital Cooperatives in Bali Province

Type of Cooperative	Quantity
Service	6
Consumer	7
All Business	4
Savings and Loan	30
Total	47

Source: 2023

3. Research Results

Based on the conducted interviews, it was found that there are 47 people working as top management of the cooperative who have agreed to be interviewed with the majority being male comprised of 40 people and 7 women (Table 2). Based on the field findings, it is known that if women get a place to manage an organization, they become the top management of an organization. This was disclosed by RESP12 based on the results of

meetings held by the management as a form of gender equality, and in terms of educational level and competency aspects, RESP12 has been assigned as manager since 2021.

Table 2. Gender of Respondent

Gender	Quantity
Male	40
Female	7
Total	47

Source: 2023

Most respondents have an undergraduate education level of 42 people, 4 people with postgraduate education and 1 person with a diploma education (Table 3). This shows that the level of undergraduate education possessed by the top management of the cooperative has the competence to manage the organization, as is the case for higher education levels than undergraduate. The importance of the level of education will affect performance as a tool for adjusting tasks and jobs with the abilities and skills possessed by top management.

Table 3. Level of Education of Respondent

Level of Education	Quantity
Diploma degree	1
Bachelor's degree	42
Postgraduate degree	4
Total	47

Source: 2023

There are 10 respondents working as chair of the Cooperative Board, 2 people as Chairman of the Board of Cooperatives as well as General Manager, 1 person as Secretary of the Board of Cooperatives, 1 as the Deputy Chairman of the Board of Cooperatives and as 33 as manager (Table 4). The composition of the management of the cooperative consists of the Chairperson, Deputy Chairperson, Secretary and Treasurer. If the cooperative has good and large organizational development, a cooperative operational manager is appointed specifically by the management. This is certainly in accordance with the ability of institutions to provide remuneration in the form of salaries to managers. However, if this management has not been able to be carried out, then usually the Chairman of the Board also works as the Manager so that in his capacity the manager is always referred to as a manager while the capacity to establish a policy, regulations is the authority of the board, thus it is called the Chairperson of the Board. Cooperatives that have large assets generally have a Chairman and appoint one person as a manager.

Table 4. Position of Respondent

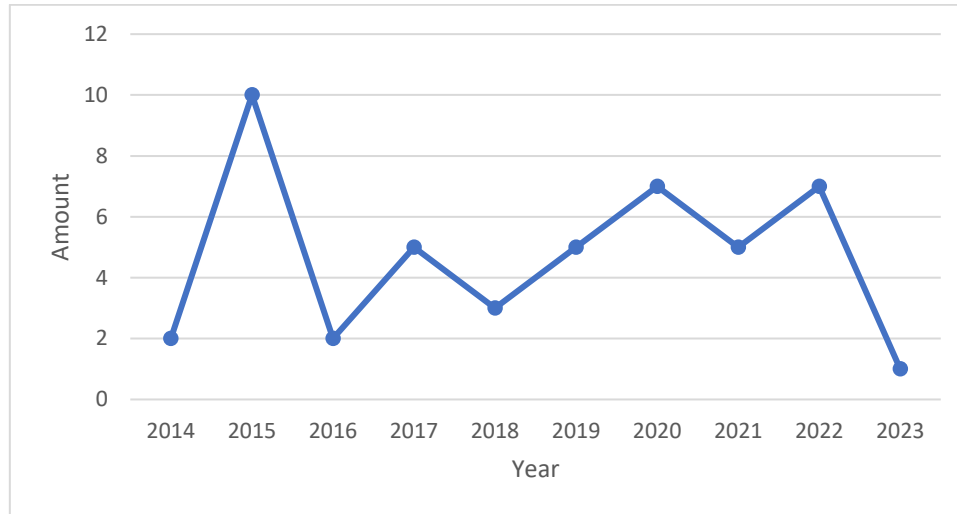
Position	Quantity
Chairman of the Cooperative Management	10
Cooperative Chairman and General Manager	2
Executive Secretary	1
Deputy Chief Executive	1
Manager	33
Total	47

Source: 2023

Based on the conducted interviews, information was obtained about the application of digital technology by cooperatives from 2014 to 2023 (Figure 1). In 2014, 2 savings and loan cooperatives applied digital technology. Subsequently, 1 service cooperative, 2 consumer cooperatives, 2 multi-business cooperatives and 5 savings and loan cooperatives implemented digital technology in 2015. In 2016, there were 2 savings and loan cooperatives that applied digital technology. There were then 1 service cooperative, 2 consumer cooperatives, 1 multi-business cooperative and 1 savings and loan cooperative that implemented digital technology in 2017. There were as many as 3 savings and loan cooperatives in 2018 that have applied digital technology and 5 of them in 2019. Furthermore, 5 savings and loan cooperatives, 1 all-business cooperative and 1 service

cooperative that have implemented this technology in 2020. In 2021, there will be 4 savings and loan cooperatives and 1 consumer cooperative that will implement digital technology. In addition, there will be 3 savings and loan cooperatives, 3 service cooperatives and 1 consumer cooperative that utilize digital technology in 2022. Ultimately, there will be 1 savings and loan cooperative that implement digital technology in 2023. It was also obtained that 15 cooperatives have collaborated with local scale digital technology development institutions while 32 others have made partnerships with third parties on a national scale.

Figure 1. Period of Digital Technology Application by Cooperatives in Bali Province



4. Discussions. Impact of Digital Cooperatives

Cooperatives that apply digital technology in operational activities and services to their members have impacts and challenges which are the main categories describing the conditions that provoke top management of cooperatives to use digital technology (Damayanti *et al.* 2022). The impact of cooperatives applying digital technology is that there are business prospects that can be developed through cooperative mobile application services, business continuity, increased range of mobile cooperative services, and collaboration with other parties. The challenge faced by cooperatives is a risk that can be avoided by cooperatives including data security for cooperative members when using mobile applications and misuse of money by employees which can be done by implementing digital technology services through collector mobile applications. The use of digital technology has provided business prospects through cooperative mobile applications for cooperative members include increased business of cooperative members through cooperative merchants, increased volume of cooperative business and the circulation of money within cooperatives.

“By using digital technology through the mobile cooperative application, our cooperative is able to help the businesses of cooperative members by providing a marketplace as well as online marketing to all cooperative members. As a result, cooperative members can make purchase transactions and direct payments online through a mobile application.” (RSP4)

“I think negatively about cooperative members because of the lack of cooperative members who are willing to take advantage of the online merchant facilities that our cooperative provides through our mobile application. This can be seen from the fact that online transactions of our members are minimal in for daily needs through merchants.” (RSP40)

“Various types of cooperative member businesses that appear in the mobile cooperative application have a positive impact on cooperatives which can be seen from the increase of cooperative business volume in each period.” (RSP15)

“Digital transactions carried out by cooperative members through the mobile cooperative application make very high cashflow, which is reflected in the increasing number of cooperative members' savings every day. Cooperative members increase their savings balance so they can use their digital wallet through the mobile cooperative application service that we provide.” (RSP5)

Mobile cooperative services provided by cooperatives have a positive impact on the sustainability of cooperative businesses so that public trust in cooperatives increased. Furthermore, mobile application users of all ages, and cooperatives innovate mobile application services to meet the needs of cooperative members.

"I had negative thoughts about the implementation of mobile cooperative services at our cooperative operational locations, because competition was quite high with other financial institution sectors. To my surprise, people's trust has increased after we implemented mobile cooperatives and we have an increase in new cooperative members." (RSP14)

"I cannot stop thinking, with the low interest of cooperative members in utilizing the mobile cooperative services that we provide. We are making every effort to motivate cooperative members. However, this application is not popular for young people, whose also called the millennial generation or generation Z." (RSP2)

"Based on my observations from the system, users of the mobile cooperative application consist of members of the cooperative who have years of birth from 1964 to 1998." (RSP31)

"After we implemented mobile cooperative services, the growth of cooperative assets has increased every year." (RSP20)

"I do not expect our asset growth to not increase, even though we have been trying to implement a mobile cooperative application service." (RSP13)

Mobile cooperative services have another positive impact by increasing the outreach of cooperatives which can be seen in the younger generation joining cooperatives which is done by meeting the needs of cooperative members and ensuring the availability of high-speed internet connections at cooperative operational locations.

"Based on the board meeting, supervisors and management of the cooperative, I was assigned to innovate mobile application services in 2020. The bonus I received for this effort increased the credibility of our cooperative, as seen from the increasing number of savings of cooperative members every day." (RSP1)

"It is hoped by the management team that the cooperative will be able to meet the needs of cooperative members by using the mobile cooperative application. However, we have to educate members because more than half of cooperative members have not used the mobile cooperative application that we have provided." (RSP28)

"I was very happy to hear what the members of the cooperative said during the annual cooperative member meeting held last year. Cooperative members said that they are very proud of cooperating and their needs are met with the availability of the cooperative mobile application." (RSP44)

"Members of the cooperative appealed to me for the cooperative to add mobile cooperative service facilities." (RSP43)

"With the availability of a high-speed internet connection, the cooperative is able to reach members through the mobile cooperative application." (RSP38)

"The availability of high-speed internet connection in the operational area of the cooperative greatly affects the outreach of mobile cooperative services by cooperative members. Since a high-speed internet connection entered the cooperative's operational area, only then were we able to implement the mobile cooperative application." (RSP3)

The impact of the use of mobile cooperatives felt by cooperatives is the creation of collaborations that can be carried out with third parties, banking financial institutions and the central government. Thus, the mobile cooperative services provided to cooperative members vary among the digital cooperatives that have been encountered.

"I cooperate with third parties including technology development agencies and banking institutions to develop mobile cooperative application service facilities. Thus, the mobile cooperative application is useful for cooperative members." (RSP45)

"I have increased cooperation with more than one banking financial institution to improve mobile cooperative service facilities. Therefore, our cooperative is the first cooperative to implement an Application Programming Interface so that it can take advantage of banking financial services. After implementing standardization of payments using the QR Code, cooperative members will enjoy the QRIS mobile cooperative service facility that is easier, faster and secure. Our mobile cooperative application can also be used to make payments between merchants using the QRAM application (QRIS Inter Merchant). Cooperative members can also withdraw their savings in our cooperative through ATMs of all banks, as well as make transfers from cooperative virtual accounts to other bank accounts." (RSP27)

"I made a breakthrough in collaboration with the central government and local governments, through a very strict selection of several stages. Finally, our cooperative has been distributing People's Business Credit since 2019. Our cooperative won a national award as the best People's Business Credit distributor in 2021 in the category of non-bank financial institutions." (RSP37)

The challenge faced by cooperatives in implementing digital services is that there are risks that can be avoided, including data security for cooperative members and misuse of money by employees.

"Cooperative members are required to enter a username and password first for every transaction made by cooperative members through mobile application and all transaction data are stored on the cloud server." (RSP 31)

"Cooperative members will receive two security transaction verifications, namely a password and One Time Password (OTP) code to maintain the confidentiality of cooperative member data when transacting using our mobile application. Our password has a number that is always changing so that it is not easily misused by other parties. There is also an OTP code which is a secret code. Cooperative members will receive notifications via the Telegram application after the transaction through the mobile cooperative is successful." (RSP32)

"I think negatively about the security of cooperative members' data with the rise of hackers at banking financial institutions and skimming at regional banks." (RSP47)

"I had negative thoughts about the misuse of cooperative members' money by employees more than once. However, the use of mobile collectors can minimize the occurrence of misused money since every transaction made by cooperative officers in the field will generate automatic notifications via Telegram application." (RSP27)

"The aim of our cooperative is to implement mobile cooperative services in order to minimize mistakes made by employees on purpose. Mistakes made by cooperative employees will certainly affect the credibility and provide bad image of the cooperative in society." (RSP47)

"Mobile cooperative application makes it very easy for cooperative members to transact online and it minimizes misuse of members' money which is generally carried out by cooperative employees." (RSP42)

This research contributes to findings related to the impacts and challenges of cooperative digitization. It was found firstly that the impact of the digital cooperatives increased cooperative business prospects. This is in accordance with the findings of Verkijika (2018) that all e-commerce giants in Cameroon have increased business prospects. Yang *et al.* (Yang, Fu, and Zhang 2021) then showed that the use of digital technology affects the prospects and business strategies of manufacturing companies. Matoušková (2022) also stated that digitalization has an impact on business prospects. Farah *et al.* (2018) and Bhatiasavi (2016) supported this finding by stating that business prospects affect the use of mobile banking. This is also in agreement with the finding of Chopdar *et al.* (2018) who have found that business prospects affect the use of mobile shopping. However, the research findings of Slade *et al.* (2015) claiming digital technology has no impact of business prospects.

The second impact of digital cooperatives is increasing business sustainability. Digital financial technology influences the sustainability of use (Artemenko and Zenchenko 2021). Mobile application service innovation uses QR codes according to Dudin *et al.* (2021), which are codes used to make payments such as in e-commerce systems as a form of digital technology application services. Carayannis & Morawska-Jancelewicz (Carayannis and Morawska-Jancelewicz 2022) then stated that society 5.0 and industry 5.0 have an effect on the

sustainability of higher education. Hospital business continuity is also claimed to be influenced by digital technology, big data and artificial intelligence (Benzidia, Makaoui, and Bentahar 2021). Yang *et al.* (2021) further revealed that the use of digital technology affects supply chain sustainability. However, the research findings of Mathess & Kunkel (2020) have debated the effect of digitalization on business sustainability.

The third impact of digital cooperative is the enhancement of the outreach of cooperatives. This is in accordance with the finding of Errol S. van Engelen (2019) who stated that if information and communication technology is implemented effectively to provide innovative financial services to poor people living in developing countries, it will increase their outreach. It was also stated that the development of digital financial technology will increase the availability, quality and outreach of financial services (Artemenko and Zenchenko 2021). This is also supported with the claim that innovative practices are urgently needed so that microfinance institutions can better serve the poor (Mia and Chandran 2016). The research findings of Alam *et al.* (2018) further showed that the advantages of digital technology will help create stronger community relations with a wider outreach to people and business groups. Voorrips *et al.* (2012) declared that mobile financial services significantly enhance the operational outreach of microfinance institutions. Similar view was expressed by Kigen (2011) that many microfinance institutions realized an increase in transaction volume as a result of the introduction of mobile banking. Srivastava (2013) also claimed that mobile banking in India serves as a powerful tool for increasing financial inclusion. Thus, banking services can reach untouched populations. However, financial institutions in Cameroon are more focused on generating profits, rather than reaching the poorest of the poor in society (Shu and Oney 2014) and Lopatta *et al.* (2017) stated that broad outreach has no effect on a sustainable economic and financial system.

The fourth impact of digital cooperative is collaboration with various parties, from the private sector, central government to local governments. Advances in information technology are the main foundation for conducting e-collaboration that connects suppliers with international customers (Bryan Jean, Sinkovics, and Kim 2014). The use of technology influences supply chain collaboration to achieve integration with organizational partners (Wu and Chiu 2018). Similarly, it was expressed by Alsaad *et al.* (2018) that collaboration is the key word for getting value from information technology in the supply chain. Implementation of e-collaboration among SMEs found to facilitate collaborative supply chain success enabling organizations to gain competitive advantage (Chan, Chong, and Zhou 2012). However, van den Broek & van Veenstra (2018) revealed that big data collaboration needs to balance innovation that must comply with data protection regulations in the European Union and there are several considerations for implementing integrated communication and collaboration technology among 50 countries (Silic and Back 2016).

The challenges faced by digital cooperatives are the risks faced including security and privacy issues which are obstacles for providers, designers and developers of online banking services (Alkhatib and Alaiad 2016). The development of digital technology also influences risks reduction, costs in the financial sector and ensuring security in the use of financial technology (Artemenko and Zenchenko 2021). The results of the study by Ejidys *et al.* (2019) confirmed that the most important factor that forms trust in technology is the perceived level of security. In addition, a lack of understanding and concern for data security and privacy can prevent SMEs from realizing business value (Perdana *et al.* 2022). Thus, user security and privacy are critical to the adoption of mobile banking applications in Lebanon (Merhi, Hone, and Tarhini 2019). However, Hwang & Choi (2017) showed that organizations that have low innovation will negatively affect the security of information systems. It is suggested that there is a need for the availability of regulations set by the government relating to digital financial transactions provided by cooperatives, the availability of procedure manuals for implementing digital services in cooperatives and the availability of high-speed internet connections to implement digital technology services.

Conclusions

This study explored the impacts and challenges posed by cooperatives that implement digital technology in the Province of Bali. By using accidental sampling method, it was found that 47 cooperatives were willing to be interviewed. It has been found that cooperatives that implement digital services consist of service, consumer, multi-business and savings and loans cooperatives. The impact of digital technology implemented by cooperatives in the Province of Bali was found to have an impact on increasing business prospects, business continuity, the range of mobile cooperative services that can be carried out especially for all-business and service cooperative types. The existence of collaboration was found as another impact for all types of cooperatives that were the respondents of this study. There are also risks that come from internal and external cooperatives as challenges faced by all types of cooperatives.

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Credit Authorship Contribution Statement

Surya Dewi Rustariyuni: Conceptualization, Investigation, Methodology, Project administration, Software, Writing – original draft, Supervision, Data curation, Validation, Writing – review and editing.

M. Pudjihardjo: Conceptualization, Investigation, Methodology, Project administration, Software, Writing – original draft, Supervision, Data curation, Validation, Writing – review and editing.

Full M. Umar Burhan: Conceptualization, Investigation, Methodology, Project administration, Software, Writing – original draft, Supervision, Data curation, Validation, Writing – review and editing.

Dias Satria: Conceptualization, Investigation, Methodology, Project administration, Software, Writing – original draft, Supervision, Data curation, Validation, Writing – review and editing.

Declaration of Competing Interest

The authors state that no competition for financial interests or personal relationships could influence the work reported in this paper.

Declaration of Use of Generative AI and AI-Assisted Technologies

The authors declare that they have not used generative AI and AI-assisted technologies during the preparation of this work.

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The Effectiveness of AI Chatbots in Business

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Abstract: Against the backdrop of digital business transformation, the present article delves into the efficacy of AI chatbots as a mechanism for enhancing sales on social media platforms. The relevance of this study is underscored by the rapid expansion of e-commerce and the imperative to refine marketing channels to sustain competitive advantage within the digital landscape. The purpose of the research is to quantify the chatbots' influence on key business metrics and to form an integral effectiveness index of their implementation. The methodology employed involves the calculation of an Integral Efficiency Index (IEI) through the application of weighting factors, normalization of business indicators to unify their scale, and the utilization of quantitative analysis alongside mathematical modeling techniques to interpret the results obtained. The study findings reveal that the use of AI chatbots leads to a 67% increase in sales, a 55% increase in qualified leads, and a 61% increase in staff productivity. The Integral Efficiency Index stands at 56.825%, signifying a substantial degree of synergy among the various components of efficiency. This study indicates that chatbots effectiveness is contingent upon the technology utilized and their integration within a company's operational processes. The developed IEI methodology facilitates a quantitative evaluation of chatbot implementation efficacy while also identifying growth areas for further technological interventions. The scientific novelty of the study lies in the development and testing of an integral index of AI chatbot effectiveness for a comprehensive assessment of the impact of technology on business processes.

Keywords: digital marketing; integral performance index; sales conversion; lead qualification; integration; productivity improvement.

JEL Classification: C61; D49; M39; A12.

Introduction

Against the backdrop of current landscape of digital communication, AI chatbots have evolved into a pivotal component of business strategies, revolutionizing customer interactions and enhancing sales efficacy through social media platforms. The rapid development of artificial intelligence and its seamless integration into communication channels unveil novel opportunities for enterprises of all sizes, facilitating a personalized approach to each client. As Mahdavi *et al.* (2023) elucidate, the use of AI chatbots has demonstrated remarkable effectiveness across diverse domains, including healthcare, education, and e-commerce, owing to their capacity to analyze extensive datasets and provide relevant answers in real time.

The integration of AI chatbots into social networks creates a new paradigm of interaction with customers, elevating communication to a qualitatively new level. According to a study by Li *et al.* (2023), chatbots that simulate friendly interactions substantially enhance customer engagement and brand loyalty, which directly impacts sales and conversion rates. Tailored recommendations, prompt responses to inquiries, and proactive engagement with prospective customers are emerging as competitive advantages for enterprises that incorporate AI solutions into their marketing strategies.

The scientific novelty of this research lies in developing a comprehensive Integral Efficiency Index for evaluating AI chatbot impact on key business metrics. Our approach integrates multiple dimensions of effectiveness into a cohesive analytical framework, enabling data-driven implementation decisions. The study's importance is highlighted by the rapidly expanding global AI chatbot market. Our research bridges gaps in existing literature by establishing a standardized methodology for evaluating chatbot performance across various business contexts.

An indispensable dimension of integrating AI chatbots within social networks lies in their capacity to gather and analyze data pertaining to user behavior, thereby facilitating the development of precise predictive models and tailored recommendations. As Leung (2023) underscores, the integration of AI and machine learning in social media enhances the efficacy of business processes and engenders novel opportunities for market analysis, as well as the customization of products to align with the preferences of the target audience.

The purpose of this study is to quantify the impact of AI chatbots on key business metrics and form an integral index reflecting the effectiveness of their implementation in sales through social networks. To accomplish this purpose, the following tasks were delineated: 1) analyze the current state and emerging trends in the use of AI chatbots within social media platforms; 2) identify the principal business metrics that characterize the effectiveness of AI bot implementation; 3) develop and validate a mathematical model for calculating the Integral Efficiency Index (IEI); 4) investigate the impact of various factors on the effectiveness of AI chatbots in the context of sales through social networks; 5) formulate recommendations for optimizing the use of AI chatbots to enhance sales performance.

1. Literature Review

An analysis of the scientific literature reveals a growing interest among researchers in the implementation and evaluation of the efficacy of AI chatbots across various business sectors, particularly within the context of social networks and e-commerce. Scholars are devoting considerable attention to examining the impact of AI technologies on customer interaction processes, fostering loyalty, and increasing conversion rates, as well as devising methodologies for assessing the effectiveness of such innovations.

Melnik *et al.* (2022) underscore the paramount significance of ensuring that digital business tools adhere to regulatory requirements to foster sustainable entrepreneurship and mitigate corruption risks. Expanding upon this idea, Alazzam *et al.* (2023) assert that the development of digital platforms, particularly those incorporating AI chatbots, necessitates the creation of comprehensive information models that duly consider both technological aspects and legal compliance imperatives within the framework of global digitalization. This underscores the emergence of a holistic paradigm that encompasses not only the technological dimensions but also the regulatory and legal considerations of implementing AI solutions.

The psychological aspects of chatbot effectiveness are explored in a variety of complementary studies. For instance, Lin and Wu (2023) investigate the psychological mechanisms underlying the formation of relationships between consumers and brands through the strategic use of chatbots on social media platforms.

The authors underscore that the success of chatbots is largely contingent upon their capacity to create an emotional bond with users, which subsequently evolves into a sustained relationship with the brand. Notably, this theory is significantly enriched by Kim and Hur (2024), who enhance our comprehension of emotional factors and delve into specific elements that elicit users' empathy towards AI chatbots. They discovered that perceptions of

chatbots' competence and empathy profoundly influenced users' willingness to persist in their interactions and engage in purchasing behaviors.

It is worth mentioning that their findings resonate with those of Mei *et al.* (2024), who analyze the behavioral parallels between AI chatbots and humans, affirming that a pronounced degree of imitating human conduct markedly enhances user trust and interaction efficacy. Concurrently, alongside the psychological dimensions, the tangible influence of chatbots on business performance is explored in a number of studies. Kushwaha *et al.* (2021) investigate AI chatbots' impact on customer experience within the B2B sector, finding a substantial enhancement in the quality of customer interactions and a notable reduction in response times to inquiries. Similar findings, albeit within the B2C sector, were drawn by Rana *et al.* (2024), who showed that chatbots significantly improve user experience across all stages of the sales funnel.

The findings of Linina *et al.* (2022) corroborate our research, revealing that effective AI chatbot implementation significantly enhances consumer satisfaction across Baltic markets through personalized interactions and prompt response times. Additionally, Radionova *et al.* (2019) emphasizes the critical role of digital communication tools in establishing meaningful customer relationships within online dimensions, further supporting our assertion that AI chatbots represent a pivotal component of contemporary sales strategies.

Although concentrated on distinct market segments, both studies converge in their conclusion that AI technologies significantly enhance the quality of customer experience. In this context, Krishnan *et al.* (2022) and Fan (2023) examine the strategic dimensions of implementing chatbots. Accordingly, while Krishnan *et al.* (2022) focus on quantitative metrics and hold that organizations utilizing chatbots exhibit superior customer retention and sales conversion rates, Fan elaborates on this notion by positioning chatbots as a fundamental component of social media marketing strategies.

Current research highlights the strategic value of AI chatbots for modern businesses. An important ethical of the use of chatbots is revealed by Liu (2023), who the privacy issues associated with the of chatbots on social networks. The author notes that the collection and analysis of user data allow for the creation of highly personalized offers, but at the same time researchers underscore the strategic significance of AI chatbots for contemporary enterprises. An essential ethical dimension of utilizing chatbots is elucidated by Liu (2023), who examines the privacy concerns associated with using chatbots on social media platforms. The author observes that the aggregation and analysis of user data facilitate the crafting of exceptionally tailored offerings; however, this practice simultaneously raises serious questions regarding the safeguarding of personal information.

This ethical dilemma stands in stark contrast to Awad and Moosa (2023) pragmatic perspective, which focuses primarily on the cost-effectiveness of integrating AI technologies. This viewpoint underscores their pivotal role in optimizing business processes and minimizing operational expenditures. Our research endeavors to fill these gaps by developing an Integral Efficiency Index (IEI) that takes into account key business metrics and their relative significance across various business types.

2. Materials and Methods

2.1 Research Procedure

The initial stage of the research procedure entailed a comprehensive analysis of the prevailing state and emerging trends regarding the utilization of AI chatbots within social networks. To this end, statistical data was gathered from leading analytical sources, including Smartbot (2024), Dashly (2025), Reuters (2025), and Freshworks (2024), which elucidate chatbots' key performance indicators across diverse business contexts. At the second stage, the principal business metrics were discerned that most accurately characterize the effectiveness of implementing AI bots: sales growth, enhancement of qualified leads, improved conversion rates, return on investment, efficiency in lead qualification, and increased staff productivity. The third stage involved the evaluation and normalization of the obtained indicators for their subsequent incorporation into an integral index. The fourth stage comprised an expert assessment of the weighting coefficients attributed to each indicator, considering their relative significance within business processes. The concluding stage of the study encompassed the computation of the Integral Efficiency Index (IEI) employing the developed mathematical model, alongside the interpretation of the obtained findings.

2.2 Sample Formation

The study sample included statistical data regarding the efficacy of AI chatbots within social networks, sourced from reputable analytical entities for the years 2024-2025. In particular, data from Smartbot (2024) was analyzed to assess sales growth following the deployment of AI bots across corporate social channels. Metrics pertaining to the enhancement of qualified lead generation and the increase of conversion rates were derived from Dashly

(2025). Data on high ROI and lead qualification efficiency were produced based on research conducted by Cardillo (2024). Furthermore, statistics on the escalation of online sales in the United States during the 2024 holiday season were provided by Reuters (2025) and Salesforce. Freshworks (2024) contributed valuable data regarding user preferences in their interactions with chatbots. The sample also incorporated forecast data concerning the anticipated growth of the global AI chatbot market (Cardillo, 2024).

2.3 Methods

The study employed a diverse array of analytical methodologies to assess the effectiveness of AI chatbots in social media sales. The principal methodological framework was the computation of the Integral Efficiency Index (IEI), a metric that facilitates the synthesis of various business indicators taking into account their relative significance. The formula for calculating the IEI is articulated as follows:

$$IEI = \frac{\sum_{i=1}^n (w_i x_i)}{\sum_{i=1}^n w_i}$$

where:

- x_i — value of the i -th indicator (in percent);
- w_i — weight coefficient of this indicator's significance;
- n — number of indicators;
- $\sum w_i = 1$ (or normalized during calculation).

The weighted evaluation method allowed considering the different importance of individual indicators for the overall effectiveness of AI bots. The weighting method was employed, which was based on an analysis of each indicator's relative impact on the overall business result. A method of normalizing indicators was employed to bring them to a single evaluation scale, which ensured the correctness of further aggregation.

For statistical analysis and interpretation of results, descriptive statistics and correlation analysis methods were used, which made it possible to identify relationships between individual performance indicators. The benchmarking method was used to compare the effectiveness of using chatbots by companies of various sizes, from small businesses to large corporations.

2.4 Tools

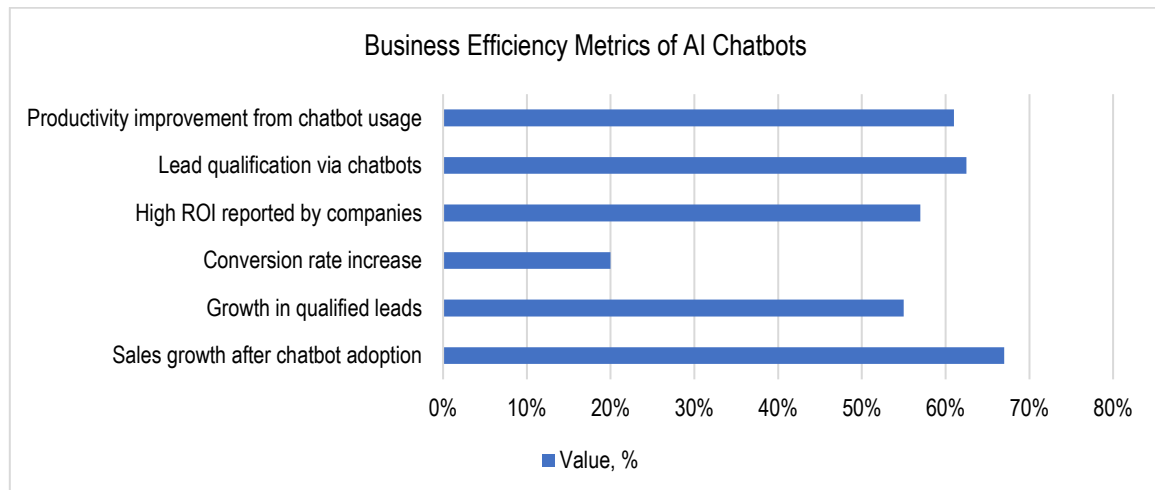
The study employed analytical tools to process and visualize statistical data. To compute the Integral Efficiency Index (IEI), Microsoft Excel was used, enabling the execution of essential mathematical calculations and the generation of tables with results.

3. Results

In the context of digital business transformation, AI chatbots have emerged as a pivotal instrument for automating customer service and an effective catalyst for enhancing sales on social networks. The integration of chatbots enables enterprises to facilitate instantaneous interactions with potential clients, substantially expediting the sales cycle and increasing conversion rates. According to Smartbot (2024), more than 67% of companies reported a marked increase in sales following the implementation of AI bots within their social media channels.

The chatbots' effectiveness is substantiated by the improvement of key business metrics. In this light, Dashly (2025) observes that 55% of enterprises experienced an increase in the volume of high-quality leads attributable to bots, while 20% noted an escalation in conversion rates. The integration of artificial intelligence facilitates the customization of communication strategies tailored to specific audiences and contexts. The automated collection of data, coupled with the anticipation of user needs, transforms a chatbot into a responsive and proactive sales tool. The key business metrics of AI chatbots that were used in calculating the composite index as illustrated in Figure 1.

Figure 1. Business Efficiency Metrics of AI Chatbots

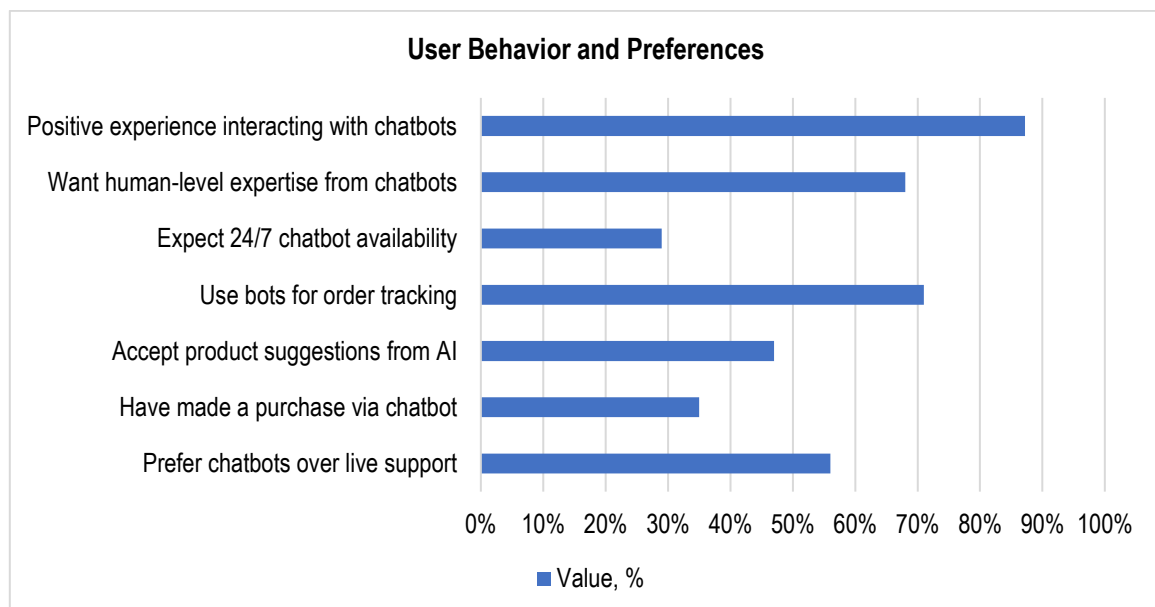


Source: developed by the authors based on Dashly (2025), Shrivastava (2024)

The use of AI bots across social networks such as Facebook, Instagram, and WhatsApp yields increasingly noticeable outcomes. Meta is actively integrating AI features into its messengers, thereby enhancing audience engagement and diminishing the costs associated with customer acquisition (Reuters, 2025). According to Salesforce, the implementation of chatbots on social media resulted in a 4% surge in online sales in the United States alone during the 2024 holiday season, a period when the market is particularly attuned to the efficacy of sales channels. While AI bots in social networks represent a technological trend, they also serve as an economically justified tool.

In addition to directly influencing profitability, chatbots optimize response times, increase customer satisfaction, and facilitate the scaling of services without necessitating the recruitment of additional personnel. Freshworks (2024) cites data indicating that 71% of users favor engaging with chatbots to obtain prompt information regarding their orders. As illustrated in Figure 2, the preferences of social media users indicate a growing trend towards interactions with AI chatbots during online purchasing experiences.

Figure 2. User Behavior and Preferences



Source: developed by the authors based on Dashly (2025), Shrivastava (2024)

The global AI chatbot market is experiencing robust growth, with projections indicating an increase from \$15.6 billion in 2025 to \$46.6 billion by 2029 (Cardillo, 2024). This expansion can be attributed to the rapid advancements in natural language processing (NLP) technologies, as well as the surging popularity of integrated communications within social media platforms. Companies that have already adopted chatbot solutions are not

only reducing operational costs but also securing a competitive edge by facilitating continuous engagement with their customers. The integration of chatbots effectively addresses the challenges of multi-channel marketing. In numerous enterprises, customers interact simultaneously across platforms such as Instagram Direct, WhatsApp, and Facebook Messenger, and owing to AI algorithms, these requests can be synchronized.

The segment of small and medium-sized enterprises deserves particular consideration. These entities possess the remarkable ability to scale their operations with minimal expenditure. For such organizations, as noted by Dashly (2025), a chatbot transcends mere automation; it emerges as survival tool within a fiercely competitive digital landscape. Streamlining the sales process, mitigating the "losses" of potential customers, and increasing response speed is critically important for small businesses.

In conclusion, it is worth emphasizing that the effectiveness of AI chatbots depends on technology and integration with the company's business processes. Based on customer behavioral analysis, we achieve significantly better results. In the coming years, chatbots will become not an option, but the standard for sales on social networks, and those that adapt these solutions today. In conclusion, it is imperative to underscore that the efficacy of AI chatbots is contingent upon technology and its seamless integration with the company's operational processes. Businesses that build an implementation strategy grounded in the analysis of customer behavior realize markedly superior outcomes. In the forthcoming years, chatbots will transition from being an optional tool to an essential standard for sales on social networks, and those companies that embrace these solutions today will shape the future of the market.

In the context of digital transformation of the companies that sell via social networks, it is imperative to reasonably assess the viability of investments in artificial intelligence. The development of an integral efficiency index (IEI) allows for a generalized assessment based on key business metrics that exert a direct influence on the company's financial and operational performance. The use of weighting coefficients within the IEI model enables to adjust the overall impact of each factor according to its real weight in making management decisions.

The integrated model includes six key metrics: sales growth, qualified lead growth, conversion improvement, high return on investment (ROI), lead qualification efficiency, and staff productivity growth. Data obtained from sources Shrivastava (2024), Dashly (2025), and Cardillo (2024) were normalized and correlated with appropriate weights. The outcomes of calculating AI chatbots' integral efficiency index by key business metrics are presented in Table 1.

Table 1. Integrated Weighted Index of AI Chatbot Efficiency Based on Key Business Metrics in Social Commerce (2024–2025)

No.	Indicator	x_i (%)	w_i (%)
1	Sales growth	67	0.25
2	Qualified leads growth	55	0.20
3	Conversion rate increase	20	0.10
4	High ROI	57	0.15
5	Lead qualification via chatbots	62.5	0.15
6	Productivity improvement	61	0.15
Total			1.00

Source: calculated by the authors

The indicators incorporated in the IEI calculation encompass the principal functional dimensions of chatbots within the digital sales ecosystem: ranging from the generation of initial demand to the realization of financial outcomes. The sales growth metric accounting for 67% illuminates the direct chatbot's influence on sales volume, while the increase of qualified leads accounting for 55% reflects the effectiveness of automated primary audience segmentation.

The productivity index of 61% demonstrates the degree of workload redistribution from personnel to AI agents, facilitating operational savings while preserving service quality. The IEI model is fundamentally built on weighted normalization, which offers a balanced assessment of each indicator's impact within the overarching performance framework. Modifying the coefficients or integrating new metrics, such as average response time or the extent of personalization, enables the IEI recalibration to account for emerging bot architectures, be they rule-based, hybrid, or neural network.

Due to the ability to change weighting factors depending on industry specifics or business scale, this model shows sufficient flexibility in application. In small businesses, productivity may carry more weight, while in large corporations the emphasis shifts to ROI and lead quality. The IEI model's adaptability makes it an effective

tool for analytical assessment in terms of digital business transformation. The calculations are performed as follows and the obtained values are recorded in Table 2.

Table 2. Final IEI Calculation Based on Weighted Business Metrics of AI Chatbot Implementation

Indicator	$x_i(\%)$	w_i	$w_i x_i$
Sales growth	67	0.25	16.75
Qualified leads growth	55	0.20	11.00
Conversion rate increase	20	0.10	2.00
High ROI	57	0.15	8.55
Lead qualification via chatbots	62.5	0.15	9.375
Productivity improvement	61	0.15	9.15
Total IEI	—	1.00	56.825

Source: calculated by the authors

The integral performance index, derived from key business metrics, elucidates the overarching effectiveness of integrating AI chatbots in the field of social sales. The indicator of 56.825% signifies a pronounced synergy among the constituent components of effectiveness, including increased productivity, enhanced lead generation, improved ROI, and increased conversion rates. It is imperative to underscore that the remarkable sales growth of 67% not only reflects a short-term impact but also serves as compelling evidence of chatbots' strategic influence on business model's comprehensive transformation.

A well-founded weighting of indicators makes it possible to form an objective and balanced assessment that takes into account both financial aspects (ROI, sales) and operational aspects (productivity, lead qualification). The combination is especially valuable for management decisions in small and medium-sized enterprises, where resources are limited and efficiency must be maximized without large-scale investments.

The IEI index indicates a high, but not limitless, level of effectiveness of implementing AI chatbots in sales via social networks. The indicator indicates that most key business metrics, including 67% sales growth, 62.5% lead qualification improvement, and 61% productivity improvement, illustrate a consistent and favorable impact stemming from the implementation of chatbots. However, at 20%, conversion rates remain comparatively underdeveloped.

The IEI methodology provides the opportunity to quantitatively assess the impacts across diverse domains for further technological or strategic interventions. Its practical value is evidenced in the analytical endeavors of marketing teams, the assessment of digital investments, and change management within CRM systems.

4. Discussions

The study elucidated that AI chatbots markedly enhance the efficacy of sales through social networks. This assertion is substantiated by the research conducted by Milan *et al.* (2023), which illustrates how the integration of AI technologies in social marketing amplifies customer engagement and elevates conversion rates. Our findings align with the conclusions of Pratika (2023), who posits that the use of artificial intelligence in social media marketing fosters increased sales and enhances customer loyalty. Nonetheless, Ocal (2023) maintains that the ethical implications surrounding the utilization of AI in social media raise concerns among users, potentially limiting chatbots' effectiveness. Our study confirms the findings of Redondo *et al.* (2023) that AI technologies allow for the identification and adaptation of communication strategies tailored to diverse user profiles. Zappavigna's (2023) research confirms that leveraging AI for social media data analysis significantly enhances message targeting, a finding that resonates with our results regarding the increasing the lead qualification efficiency. Sufi (2023) underscores the promise of social media analytics powered by AI in discerning factors that influence consumer behavior, a notion that is reinforced by our research. As stated by Roche *et al.* (2023), a holistic approach for the integration of AI into business processes guarantees the optimization of customer interactions, which is consistent with our conclusions regarding comprehensive performance assessment. Greenfield and Bhavnani's (2023) observations regarding the potential hazards of excessive automation in communications support our recommendations for a balanced approach to implementing AI chatbots. Ortina *et al.* (2023) assert that digital advancement necessitates effective public administration, a claim that is in line with our findings on the imperative for a strategic framework in utilizing AI technologies. Alazzam *et al.* (2023) emphasizes the significance of developing information models for e-commerce within the global digitalization context, a perspective that aligns with our methodology for establishing an integral efficiency index. Thus, AI chatbots are indeed a key element in contemporary social media sales strategies, but their full use

requires a comprehensive approach to assessing effectiveness, alongside careful consideration of the ethical dimensions of user interaction.

Limitations

Despite the integrity of the research undertaken, there exist limitations regarding the universality of the developed Integral Efficiency Index (IEI) across diverse industries and varying business scales. The established weighting factors may vary depending on the market's specifics and the target demographics, necessitating further methodology's adaptation to suit specific business contexts. It is noteworthy that the study predominantly relied on statistical data from 2024-2025, which may not fully reflect long-term trends in the evolution of AI technologies within social networks. A comprehensive analysis of the AI chatbots' effectiveness should encompass both large corporations as well as small to medium-sized enterprises to ensure the study rigour.

Recommendations

Drawing upon the conducted research, the following directions for further inquiry are delineated:

1. Examine the influence of psychological factors on the perception of AI chatbots across diverse consumer segments, with the aim of formulating more effective communication strategies within social networks.
2. Expand the methodology for assessing the effectiveness of AI chatbots, taking into account industry specifics and the scale of enterprises.
3. Conduct longitudinal studies to assess the impact of AI chatbots on customer loyalty and the customer lifecycle, thereby elucidating the long-term implications of communication automation.
4. Delve into the ethical dimensions of employing AI in social networks, particularly regarding personal data protection and the transparency of user interactions.

Conclusions and Further Research

Therefore, the integration of AI chatbots into social media sales emerges as a key factor for enhancing business efficiency within the framework of digital transformation. The analysis revealed that the utilization of AI bots substantially increases sales volumes (by 67%), elevates the number of qualified leads (by 55%), and augments staff productivity (by 61%). The developed integral efficiency index (IEI) with a value of 56.825% indicates a pronounced level of synergy among the diverse facets of chatbot influence on business processes. The incorporation of weighting factors facilitates an objective evaluation of the effectiveness of AI technology implementation, considering the relative significance of various business indicators.

The study findings confirm that organizations, strategically incorporating AI chatbots into their marketing paradigms, derive significant competitive advantages through enhanced customer interactions, elevated conversion rates, and optimized business processes. The effectiveness of AI bots is contingent upon technological aspects and their integration with business operations and overarching corporate strategy. To maximize efficiency, it is imperative to strike a harmonious balance between automation and a personalized approach to customer engagement, while also considering the ethical implications of employing AI within social media platforms. Prospective avenues for research should encompass an exploration of the ramifications of integrating generative AI and augmented reality technologies on the effectiveness of customer interactions in social networks, as well as the formulation of specific methodologies for evaluating effectiveness across diverse industries and business scales.

Credit Authorship Contribution Statement

Sergiy Spivakovskyy: Conceptualization, Validation, Project administration.

Alina Danileviča: Investigation, Writing – review and editing, Methodology.

Volodymyr Samchuk: Writing – original draft, Software.

A. S. Fomin: Formal analysis, Data curation.

Kostyantyn Milonushkin: Supervision, Visualization.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Declaration of Use of Generative AI and AI-Assisted Technologies

The authors declare that they have not used generative AI (a type of artificial intelligence technology that can produce various types of content including text, imagery, audio and synthetic data).

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Behavioral and Experimental Economics and Financial Behavior: A Cross-Country Comparative Study

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Abstract: One of the key objectives of financial literacy studies is to translate financial knowledge into positive financial behavior. Thus, appropriate financial choices and sound decisions can be made. However, this translation is hindered by psychological factors. This study examines the factors that influence financial behavior in both theoretical and practical contexts through the lenses of behavioral and experimental economics. This research seeks to examine the financial behaviors of university students in Romania, Türkiye, and Ukraine, as well as the factors affecting them from this perspective. The data were analyzed using multiple regression and the Mann-Whitney U. The findings revealed that Turkish students' financial behavior level is higher than their counterparts in Romania and Ukraine. It was found that having financial knowledge improves positive financial behavior. The results indicate a potential relationship between the financial behavior level and the principles of behavioral and experimental economics. It was concluded that rational decision-making, along with trust, can foster positive financial behavior. This study may motivate educational authorities to implement financial education, as it underscores the beneficial impact of financial knowledge on financial behavior. Given that the research highlights the importance of trust, it could assist market makers in fostering sustainable market trust.

Keywords: financial behavior; financial literacy; behavioral economics; experimental economics.

JEL Classification: D14; G53; D91; C90; A14.

Introduction

Financial behavior and attitude are two important elements for an individual because they measure the potential for change in financial well-being, forming the basis for financial health. Financial behavior involves individuals displaying appropriate behaviors on different financial issues. To be in a good financial situation, individuals need to manage money, credit, and debt well, save for long-term goals such as retirement, and exhibit desired consumer behaviors (Joo, 2008). A higher level of financial literacy is positively associated with both long-term and short-term financial planning and financial management behavior (Henager & Cude, 2016). Financial knowledge has a significant impact on financial behavior (Robb & Woodyard, 2011). Knowledge of financial issues such as credit, savings, and investments can increase responsible financial behavior. Financial literacy is beneficial as long as it enables effective financial decisions. Thus, individuals with financial literacy can make effective financial decisions for themselves and their families and ensure their economic security and well-being, promoting social welfare and development (Hilgert *et al.* 2003). For example, the study by Sabri *et al.* (2021) concluded that financial knowledge and behavior contribute to the increased financial well-being of Malaysian youth. Research by Perry and Morris (2005) indicated that consumers' behavior about saving, budgeting, and controlling their spending depends partly on their perceived control over outcomes, knowledge, and financial resources. Perceived control and its relationship to reported financial management behavior significantly impact responsible financial management behavior, both directly and indirectly. This suggests that individuals will not fully utilize their knowledge or financial resources unless they feel they control their financial situation. While knowledge and income are important, individuals who believe that financial outcomes are dependent on luck or external factors are less likely to take action to manage their finances.

Contributions of financial literacy and behaviors to individuals and society are possible if they are mostly positive financial behaviors. However, financial behaviors vary depending on the psychological attitudes of individuals. Psychological, emotional, and cognitive factors affect individuals' investment decisions (Yürekli & Yılmaz, 2021). For example, in stock markets, individuals' decision-making behaviors cannot be given effectively due to psychological factors, especially cognitive biases such as overconfidence, overoptimism, and loss aversion (Gärling *et al.* 2009). In addition to personal factors such as future time perspective, financial risk tolerance, conscientiousness, and emotional stability factors, cognitive factors, including knowledge of finance and investing, perceptions of task relevance, feasibility, and complexity, are psychological factors that affect individuals' decisions. These psychological factors that affect financial behavior have been analyzed in economics with behavioral approaches. Behavioral economics combines economics and psychology to investigate the irrational behaviors of individuals (Hershey *et al.* 2007). Behavioral economics emerged as a response to neoclassical economics, drawing heavily from behaviorism and related doctrines such as verificationism and operationalism. The emergence of behavioral economics was a reaction to neoclassical economics, which argued that cognitive and affective factors were not influential in human behavior (Angner, & Loewenstein, 2007). In addition to behavioral economics' objections to neoclassical economics and its examination of irrational behavior in human behavior, experimental economics, which began in the 1940s and developed later, has begun to examine human behavior in simplified and pure forms by imitating what is encountered in markets under controlled laboratory conditions. Samuelson (2005) argues that economic theories and experiments can be combined to benefit both. More importantly, experiments can be useful in identifying behavior that the theory cannot explain, and observations can force the theorist to rethink.

1. Conceptual Framework

The finance literature presents two views on how investors process information. The standard finance view suggests that investors make decisions based on the efficient market hypothesis, while the behavioral finance approach assumes that individuals are not rational and make their decisions based on intuitive, cognitive, and emotional factors (Ricciardi, 2008). In addition, the view that people are fundamentally rational has always been opposed. The classical economics approach assumes rational choice to maximize a utility function without cognitive limitations, self-control problems, or social preferences. However, this is based on the view that economics is independent of psychology. In 1955, Nobel Prize winner Herbert Simon argued that people do not always seek optimization but instead rely on a series of basic rules that act as a satisfactory process. This hypothesis introduced the concept of bounded rationality and, in a way, formed the basis of the understanding of behavioral economics (Pech & Milan, 2009). Behavioral Economics combines psychology and economics and differs from the classical economic model because it has three important limitations. First, humans have bounded rationality due to limited cognitive abilities. Second, humans make choices not in their best interest in the long run, showing limited willpower. Third, humans often try to help others, pursuing limited personal interests. This shows that behavioral factors complement economic theory (Mullainathan & Thaler, 2000). The economic thought behind the behavioral economics approach can be traced back to Adam Smith and continued through economists like Fisher and Keynes in the 1930s. However, this approach has faced significant resistance within the field of economics literature. A key issue is its reliance on a single theory to determine and predict potential behaviors (Thaler, 2016). The concept of bounded rationality, along with related studies, highlights that individuals often make limited decisions influenced by their senses and emotions, which prevents them from being entirely rational. In this context, behavioral economics focuses on decision-making behaviors, particularly those related to people's psychological structures and their economic implications. It investigates the essential factors that guide individuals in their decision-making and analyzes the economic consequences of the resulting data. A study on decision-making processes within the framework of behavioral economics was conducted by Dold (2023). The author highlighted the limitations of preference-purification and opportunity-based approaches, arguing that an agency-centric approach - focusing on the decision-making process - provides a promising methodological and normative alternative. By adopting a pluralistic approach that integrates criteria such as well-being, opportunity, and autonomy, policymakers and citizens can better understand the trade-offs among different approaches. Balawi and Ayoub's (2023) study suggests that nudge interventions are cost-effective, behaviorally focused tools that have been successfully applied across various economic sectors. These interventions demonstrate greater practical value than traditional behavioral economics models. The authors also emphasize that a behavioral economics approach, which considers cognitive biases and bounded rationality, highlights the significance and effectiveness of nudges in public policy.

On the other hand, in the early 1940s and 1950s, economists began to be interested in the fact that laboratory experiments could be helpful in the studies of economic science. In this context, three different understandings emerged. The first is market experiments, in which Edward Chamberlin focused on neoclassical economic price predictions. The second is experimental studies that test the behavioral effects of non-competitive game theory. The third is experimental economics studies focusing on simpler environments where the only uncertainty is external random events (Davis & Holt, 2021). Experimental economics studies have an important place in economic studies, especially in recent years, and have determined the parameters that guide individuals' financial decisions in the laboratory environment. The results of laboratory studies serve as empirical pre-tests of economic theory before using field data tests. For example, when examining market price formation, when possible and applicable, data obtained from controlled experiments are used to test hypotheses resulting from random observations. When economic theories examine behavioral tendencies, experiments conducted within the scope of experimental economics are suitable for testing the validity of such theories. It provides a more disciplined model than models created to examine field data (Smith, 1976). Especially as psychology and economics have gained common areas of study in this field, experimental economists have been able to integrate experimental results into a comprehensive model instead of ignoring the trust in a rational model. Experimental economists have recognized that psychological processes can create consistent and predictable constraints on decision-making, particularly as collaboration among researchers increases (Ariely & Norton, 2007). Psychologists have been conducting experiments with humans for over a century, which means that researchers in experimental economics can glean valuable insights from the experiences and findings of psychologists (Bonetti, 1998). In addition, new AI-based studies are being conducted in the field of artificial experimental economics. Wang *et al.* (2025) explored the application of large language models (LLMs) in experimental economics. They demonstrated that the practical strategies they proposed could enhance experimental outcomes. Their work emphasizes the significance of design, reproducibility, and the generalizability of LLM-based experiments.

This research aims to compare the financial behavior levels of university students in three different countries (Romania, Türkiye, and Ukraine) from a behavioral and experimental economics perspective. In addition to comparing the financial behavior levels across countries, students' gender, work experience, family financial support, financial knowledge, and financial choice and decision are included in the examination. This research integrates behavioral economics, experimental economics, and financial behavior both theoretically and practically, which is uncommon in literature. While there is significant literature on each area, this type of research will make a substantial contribution to the field. In the research, the interpretive analysis of human behavior from the perspective of psychology and economy of behavioral and experimental economics is combined with the analytical analysis of financial behavior studies. Thus, theoretically and practically, a comparative analysis was carried out using the data, including Romania, Türkiye, and Ukraine. The first section of this research is the introduction. The importance of financial behavior and its relationship with psychology are analyzed. In addition, the introduction section draws a theoretical framework for experimental and behavioral economics and financial behavior. The literature review constitutes the second section of this research and examines the definition, theoretical studies, and applications in these research areas. The third section is the data and methodology, in which variables, econometric analysis method, and data analysis are presented. The fourth section explains the descriptive results of the research with tables. The fifth section is the discussion, in which the results are compared with the literature and interpreted. The sixth section is the conclusion section. In this section, the contribution of the study and recommendations are expressed. The last section mentions the limitations related to the study.

2. Literature Review

If financial literacy leads to sound financial behavior, it has a significant impact (Stolper & Walter, 2017). In this sense, the OECD's (2024) definition includes all the mechanisms financial literacy should have, from financial knowledge acquisition to financial well-being. The OECD begins its definition with knowledge and understanding of financial concepts. Then, it mentions the skills and attitudes that will put this knowledge and understanding into practice. It emphasizes that putting it into practice is to make effective decisions. At the end of all qualifications, participation in economic life and individual and social well-being are the main goals. While many definitions of financial literacy exist, the OECD presents a comprehensive definition, emphasizing the transformation of financial literacy into behavior that fosters a welfare effect. Financial literacy should contribute to positive financial behavior. For example, de Bassa Scheresberg's (2013) research found that high financial literacy levels reduce high cost borrowing and increase savings. This result shows that financial literacy translates into informed

decisions and positive financial behaviors. Grohmann's (2018) study on the financial literacy of the middle class in Bangkok showed that middle-class participants with higher financial literacy were more likely to use a wide range of financial services and have assets other than savings accounts. He also stated that there is a causal relationship between financial literacy and financial behavior.

Many studies in Türkiye aim to determine the level of financial literacy of university students, but few are directly related to financial behavior. Different results have been reached in studies related to financial behavior. Yılmaz and Kaymakçı (2021) concluded that a higher level of financial literacy contributes to financial behavior in high school students. Özen (2021) concluded that a high level of financial knowledge and appropriate financial behavior fosters a positive perception of the private pension system, indicating that financial knowledge can promote a favorable attitude towards long-term saving. Additionally, Alkaya and Yağlı's (2015) study of university students revealed that 78.4% exhibited positive financial behaviors, while the debt rate among participants was 31.9%. In their study, Yılmaz and Sevim (2021) evaluated university students' financial behavior score average as sufficient, at 61.58%. Doğanay Payziner (2017) found that interest in financial literacy and spending-related behaviors was low. Gürbüz and Yılmaz (2023) concluded that financial literacy, peer influence, and self-control positively impact investment behavior. On the other hand, there are some of the studies related to financial behaviors in Romania. In their study on young people over 18 in Romania, Alexandra *et al.* (2020) found that their interest in saving has increased. However, the study conducted by Nițoi *et al.* (2022) on financial literacy in Romania concluded that only 8% of the population has basic financial knowledge, while only 6% of the population has advanced financial knowledge. Only 0.3% of the participants could answer all the questions correctly. In their study, Stoian *et al.* (2021) concluded that financial literacy can shape young adults' risk aversion behavior and investment preferences. There are also studies on financial behavior in Ukraine, but they are not as numerous as in Romania and Türkiye. However, there are still studies that provide important results. For example, Polishchuk *et al.* (2023), in their study of Ukrainian individuals in Ukraine and Poland, concluded that Ukrainians in both countries tend to control finances, build up cash reserves, focus on short-term planning, keep savings outside the formal financial system and show low trust in investment vehicles, while Ukrainians in Poland tend to avoid consumer loans more and have a more diversified investment portfolio. Kharchenko (2011) concluded that financial literacy has no direct effect on saving and suggested that financial literacy may indirectly affect saving by affecting wealth. In their survey on retirement among Polish and Ukrainian students, Płonka *et al.* (2020) found that 61.8% of Poland and 33.5% of Ukrainian students considered old-age security an important or critical issue. In addition to these studies, Namiassenko (2025) examined the post-war development process of Ukraine through the lens of development and behavioral economics. In this economic strategy study, he proposed the creation of clusters based on economic regions to promote regional development. This approach is rooted in corporate governance principles and aligns with the goals of sustainable development.

On the other hand, in addition to behavioral economics examining the behavior of individuals using psychology, experimental economists test the behavior of individuals in a laboratory environment. One of these is the trust game experiment used by experimental economists to understand trust behavior. In this experiment, the relationship between the sender and the receiver is examined in this experimental study. For example, in their laboratory experiment on the trust game, Sapienza *et al.* (2013) found that the amount sent depends not only on the sender's expectation of the receiver's trustworthiness but also on their preferences, with beliefs significantly correlated with the amount sent only when subjects sent more than 25% of their initial donations. In the trust game, players infer their opponents' behavior from their behavior. In their meta-analysis, Johnson and Mislin (2011) suggested that small changes in the experiment could lead to significant changes in the measured trust behavior. They also suggested that subjects would send less money if they received random payments. The other counterpart was a simulated confederate and would pay less if the return rate was low and the sample was a student group. Samson and Kostyszyn (2015) investigated the effect of cognitive load on trust in a trust game experiment and found that a secondary task that occupied some of the cognitive resources (cognitive load) reduced the amount of trust that participants had in their interaction partners. When cognitive resources were limited, participants' behaviors were more impulsive. Marantz and Plonsky (2025) assessed different computational methods to predict human decisions related to textually described lottery picks. The findings indicated that large language models (LLMs), especially GPT-4o, surpassed hybrid models that integrate behavioral theories.

3. Materials and Methods

3.1. Data Collection Methodology

This study is based on a survey conducted among university students from Türkiye, Romania, and Ukraine. The researcher developed the survey questions for the research purpose by reviewing the literature (Lassar *et al.* 2005; Gutter & Copur, 2011; Dew & Xiao, 2011). The survey form was created using the Google survey tool, and the survey link was shared with university students in Türkiye, Romania, and Ukraine via e-mail. The survey was initially sent to students' email addresses from September 1 to September 30, 2024. Due to insufficient participants, it was resent from October 1 to October 30, 2024. The expected number of participants was not reached, but an attempt was made to obtain as much participation as possible. Thus, 579 surveys from Romania, Türkiye, and Ukraine were obtained. 561 surveys were included in the statistical analysis after outliers were excluded from the total participants (Romania: 191, Türkiye: 197, Ukraine: 173). The Social and Human Sciences Research Ethics Committee of Balıkesir University granted permission for the survey on 03/05/2024, with the decision number 2024/04.

3.2. Independent Variables

Independent variables were designed in 6 categories: Gender, working experience, family financial support, prior knowledge of individual financial issues, informed decision-making, and trust behavior. The gender variable was compared within and between countries and investigated whether there were gender differences in positive financial behavior levels. Working experience was added to the survey as a variable where individuals establish financial connections with the outside world. Thus, the effect of individuals' money-making experiences on positive financial behaviors was investigated. Prior knowledge of individual financial issues refers to acquiring financial education or any other means of financial issues beforehand, and the relationship between prior knowledge of financial issues and positive financial behaviors was investigated. The survey question on informed decision-making asked individuals about their conscious thinking and decision-making behaviors on the products they purchased, and individuals were asked to evaluate themselves on this issue. Thus, whether there was a relationship between informed decision-making and positive financial behaviors was tested. In addition, this question measured the financial behavior level of individuals who believe they make informed decision-making in their rational self-interest based on rational analysis. Thus, it aimed to test the rationality concept of classical and behavioral economics in terms of financial behavior. The question on trust behavior investigated whether there was a relationship between individuals' trust behaviors in money transactions and their financial behaviors. Since it was necessary to explain this question to the participants face to face to make the explanation more understandable, this question was applied to a separate group of fifty Turkish students. The relationship between the answers to this question and positive financial behavior was evaluated within fifty people.

3.3. The Dependent Variable

A total of 14 financial behavior questions were asked. Yes/no answers were requested to these questions. Each positive financial behavior was evaluated as 1 point to obtain the total score for positive financial behavior. Therefore, the maximum positive financial behavior score that could be obtained was 14. Financial behavior questions included individual financial issues such as comparing prices, exchanging ideas with friends about prices, saving money for emergencies and long-term goals, comparing products, having a written budget, product quality, expense cutting, monitoring expenses, following financial news, paying bills, following personal financial affairs, having an investment account, and spending according to personal budget.

3.4. Analysis Methodology

Multiple linear regression was employed to examine the relationship between the overall positive financial behavior score and the independent variables for statistical evidence.

The equation for the multiple linear regression model is as follows:

$$y_i = +\beta_0 + \beta_1 x_{i1} + \beta_2 x_{i2} + \dots \dots \beta_{p-1} x_{ip-1} + \varepsilon_i \quad (1)$$

$$\varepsilon_i = y_i - \hat{y}_i \quad (2)$$

y_i is the dependent variable. β_0 represents the constant, which is the predicted value of Y when all $X_n = 0$. X_n is the explanatory variable. i represents an individual in the data sample. β_p is the coefficients of the regression. Each explanatory variable has β_n , the magnitude of change in the mean of y when X is larger by one unit, and

represents a slope concerning X_n (Eberly, 2007). ε represents the residual or the error of the regression, which is the difference between the observed and predicted value (Tranmer & Elliot, 2008).

Before determining whether there is a statistical relationship between the dependent and independent variables, the assumptions of multiple linear regression were tested to ensure a reliable and valid analysis. In this context, scatter plots were used for the linearity assumption to test whether the relationship between dependent and independent variables was linear. Skewness and kurtosis values were used for normality analysis. Since the acceptable range of kurtosis and skewness values is between -1 and +1 (Hair *et al.* 2022), values between -1 and +1 were accepted as valid for normally distributed data. Multicollinearity was tested between independent variables. A correlation value of less than 0.8 was accepted as an indicator of no multicollinearity (Field, 2009, pp. 224). In addition, Tolerance and VIF values were used to test whether independent variables had a high correlation. Multicollinearity exists if VIF is greater than 5 and lower than 0.1, The tolerance is greater than 10 and lower than 0.2, also multicollinearity is observed (Kim, 2019, pp. 559). It was considered that the VIF value was less than 10, and the Tolerance value was greater than 0.20. The Durbin-Watson value between 1 and 3 was considered because values less than 1 or greater than 3 cause concern. Cook's distance, a measure of the overall influence of each observation, was used to evaluate the effect of independent variables on the regression, and it was observed whether or not it took a value of greater than 1 because values greater than 1 cause problems for regression analysis (Field, 2009, pp. 217-221). The statistical significance of the ANOVA value was used to evaluate the null hypothesis test.

In order to include the data in the regression, each independent variable was coded as 0 and 1 (Dummy variable). Independent variables coded as 0 were determined as the reference category, and the contribution of other independent variables in the regression to the dependent variable was evaluated according to this data. In the gender group, "female"; in the nationality group, "Ukraine"; in the work experience group, "no work experience"; in the group having pre-knowledge about personal finance, "no pre-knowledge about personal finance"; in the group having sufficient knowledge when making decisions "not having sufficient knowledge" categories were determined as reference categories and their numerical values were coded as 0. Table 1 shows the description of the explanatory variables in the regression analysis:

Table 1. Description of the Explanatory Variables in the Regression Analysis

Variables	Definition
Male	Dummy variable, equal to 1 and 0 female
Romania	Dummy variable, equal to 1 and 0 Ukraine
Türkiye	Dummy variable, equal to 1 and 0 Ukraine
Working experience (yes)	Dummy variable, equal to 1 and 0 no working experience
Family support (yes)	Dummy variable, equal to 1 and 0 no family support
Pre-knowledge on finance (yes)	Dummy variable, equal to 1 and 0 no pre-knowledge on finance
Informed decision-making (yes)	Dummy variable, equal to 1 and 0 no informed decision-making

Source: the author's own elaboration

4. Result

4.1. Assumption Analysis of Multiple Linear Regression

The Enter method was used for regression analysis, and assumptions were tested. According to the results of the analysis, all assumptions were met. When the correlation between the variables was examined, no correlation value was greater than 0.80. This showed that there was no multicollinearity between the variables. While the maximum correlation value between the variables was between Türkiye (-.529) and Romania, the lowest was between having work experience and making rational decisions (.002). In addition, the maximum and minimum VIF values were 1.525 and 0.656, respectively. The maximum and minimum Tolerance values were .972 and .656, respectively. None of the predictor variables are multi-collinear. Durbin_Watson value was 2.073. Cook's distance value is greater than 1, between .000 and .0017. The standard residual value was a maximum of -2.744 and a minimum of 2.130. The regression was statistically significant ($F = 9.707$, $p < .001$); thus, the null hypothesis was rejected. The scatter plot indicated a linear relation between explanatory and dependent variables. The skewness value was -.437, and the kurtosis value was .206, indicating that the data showed a normal distribution.

4. 2. Descriptive Results

Table 2 displays the descriptive statics of the sample. Although the participation rates differ in gender, the number of participants from each country is almost equal. 34% of the participants are from Romania, 35.1% from Türkiye and 30.8% from Ukraine. 31.6% of the participants have working experience, while Turkish students have the least working experience (17.3%). Romanian and Ukrainian students have more than twice the working experience of Turkish students. 82.4% of the students receive financial support from their families. Turkish students receive more support from their families than those from other countries (90.9%). 44.9% of the students state that they have prior knowledge about personal finance, while Türkiye has the least prior knowledge (26.9%). Romania and Ukraine have almost equal percentages in this regard. 75.0% of the participants stated that they make informed decisions by evaluating all the information and options when making financial decisions.

Table 2. Descriptive statics of the sample

Variables	Romania		Türkiye		Ukraine		Full Sample	
	n	%	n	%	n	%	n	%
Gender								
Female	127	66.5	154	78.2	126	72.8	407	72.5
Male	64	33.5	43	21.8	47	27.2	154	27.5
Working experience								
Yes	76	39.8	34	17.3	67	38.7	177	31.6
No	115	60.2	163	82.7	106	61.3	384	68.4
Family support								
Yes	135	70.7	179	90.9	148	85.5	462	82.4
No	56	29.3	18	9.1	25	14.5	99	17.6
Pre-knowledge on finance								
Yes	98	51.3	53	26.9	101	58.4	252	44.9
No	93	48.7	144	73.1	72	41.6	309	55.1
Informed decision-making								
Yes	165	86.4	130	66.0	126	72.8	421	75.0
No	26	13.6	67	34.0	47	27.2	140	25.0

Source: the author's own elaboration

Table 3 shows the result of financial behavior scores. The rate of participants comparing products and prices and exchanging ideas with their friends on this issue is over 80%. However, the percentage of Ukrainian students making price comparisons is lower than the other two countries (64.2%). They also exchange ideas about prices with their friends for less (69.9%). Although there is no significant difference, the percentage of students saving for emergencies (72.2%) is higher than that of long-term savings (68.4%). While the percentage of participants making a monthly written budget has the lowest percentage among financial behavior scores (18.7%), Ukrainian students' monthly written budgeting is lower than Romania and Türkiye (11.0%). A considerable percentage of students fully pay their monthly bills (92.7%). This financial behavior area has the highest percentage among all behaviors. Turkish students score less in this area than other countries (89.8%). While 31.0% of the participants reported following the financial news, the highest score in this area belongs to Ukrainian students (52.6%). The lowest score in this regard belongs to Turkish students, with 18.8%, while the score percentage of Romanian students is 24.1%. There is no significant difference between countries, with 27.5% of students reporting that they have an investment account. More than 85% of students spend according to their budget. Romanian students have the highest score in this regard (94.8%).

This study also investigated the relationship between trust and positive financial behavior. First, trust was investigated. For this purpose, a two-stage survey was applied to a sample group of 50 participants. In the first phase, each participant was asked to assume that they were given 100 Turkish Liras (TL) and had the option of giving or not giving some or all of this money to someone they did not know (person B). They were explained that if they chose to send, the amount they sent would be tripled and given to person B. After receiving the money, person B could send some or all of it back or none of it. Under these conditions, they were asked how much of

the 100 TL they would prefer to send to person B. In addition, it has been explained that Person B, who receives the money, will have the same options, and the sending and receiving money process will continue for 10 rounds.

Table 3. Descriptive statics of financial behaviors

Items	Romania		Türkiye		Ukraine		Full Sample	
	n	%	n	%	n	%	n	%
Comparing prices before purchasing	172	90.1	176	89.3	111	64.2	459	81.8
Exchanging ideas with friends about prices	167	87.4	183	92.9	121	69.9	471	84.0
Saving money for a long term	130	68.1	139	70.6	115	66.5	384	68.4
Comparing products and their prices	163	85.3	174	88.3	155	89.6	492	87.7
Always strive for quality products	138	72.3	108	54.8	93	53.8	339	60.4
Making a monthly written budget plan	43	22.5	43	21.8	19	11.0	105	18.7
Making an effort to reduce expenses	131	68.6	129	65.5	124	71.7	384	68.4
Constantly monitoring expenses	129	67.5	166	84.3	120	69.4	415	74.0
Following financial news	46	24.1	37	18.8	91	52.6	174	31.0
Paying bills on time	181	94.8	177	89.8	162	93.6	520	92.7
Following my personal financial affairs closely	157	82.2	151	76.6	144	83.2	452	80.6
Having an investment account	52	27.2	57	28.9	45	26.0	154	27.5
Spending according to a personal budget	181	94.8	170	86.6	147	85.0	498	88.8
Saving for emergencies	138	72.3	143	72.6	124	71.4	405	72.2

Source: the author's own elaboration.

In Table 4, the descriptive analysis of the survey results for the first phase shows that the participants mostly sent half of their money. 34% of the participants preferred to send 50 TL, while the rate of those who preferred to send 30 TL and above was 82%. Only 12% of the participants preferred to send 30 TL or less, while three participants (6%) preferred to send money.

In the second phase, participants were asked to assume that person B received the money that person A sent 90 TL and that this amount was tripled to 270. They were explained that they could return some or all of the money, or they could not return it. Under these conditions, they were asked how much of the 270 TL they would prefer to return to person A. According to the survey results, it was observed that 60% (30 people) of the participants preferred to return money between 90 and 150 TL. Only one person reported they would not return any money, while seven participants (14%) reported they would prefer to return it all.

Table 4. Descriptive statics for trust behavior

	100								270						
	0	10	20	30	40	50	100	0	60	90	120	150	180	210	270
n	3	3	3	8	7	17	9	1	4	11	8	11	7	1	7
%	6	6	6	16	14	34	18	2	8	22	16	22	14	2	14

Source: the author's own conception

In Table 5, the participants' choices are grouped into two. Each group is divided into two categories. The 100 TL group was divided into two categories: those who sent 50 or less and those who sent more than 50 TL. The group 270 TL was divided into two groups: those who sent 120 TL or less and those who sent less than 120 TL. While the percentage of those sending less than 50 TL is 82% (41), 18% (9) of the participants preferred to send money more than 50 TL. The percentage of those sending less than 120 TL is 48% (26), while 52% of the participants (26) preferred to send more than 120 TL.

Table 5. Descriptive statics of the sample on trust behavior

N	100				270			
	≤ 50		> 50		≤ 120		> 120	
Variables	N	%	n	%	n	%	n	%
	41	82.0	9	18.0	24	48.0	26	52.0

Source: the author's own elaboration.

Table 6 represents multiple regression analysis. The multiple linear regression was conducted to predict positive financial behavior, as the independent variable, from gender, nationality, working experience, family support, pre-knowledge on finance, and informed decision-making as the predictors. This analysis resulted in a significant regression equation, $F(7, 553) = 9.707, p < .001, R^2 = .109$. All of the predictors explain the variance between the explanatory variables (10.9%). Students predicted positive financial behavior (y) is equal to $8.131 + 0.307(\text{Romania}) + 0.694(\text{Türkiye}) + 0.487(\text{Male}) - 0.173(\text{Working experience\_yes}) - 0.484(\text{Family support\_yes}) + 0.893(\text{Pre-knowledge on personal finance\_yes}) + 1.067(\text{Informed decision-making\_yes})$. The findings indicated that gender, Türkiye, having pre-knowledge on personal finance, and having informed decision-making were significant positive predictors of positive financial behavior. The result also showed that family support was significant negative predictor of positive financial behavior.

The individual explanatory predictor variables indicated that gender ($\beta = .096, t = 2.355, p < .05$), Türkiye as a nationality predictor ($\beta = .146, t = 2.946, p < .01$), family support ($\beta = -.081, t = -1.712, p < .1$), having pre-knowledge on personal finance ($\beta = .196, t = 4.602, p < .001$), having informed decision-making ($\beta = .204, t = 4.939, p < .001$) were significant predictors, but Romania ($\beta = .064, t = 1.320, p > .05$) and having working experience ($\beta = -.036, t = .740, p > .05$) were not.

To find whether there is a statistically significant difference between Türkiye and Romania in terms of positive financial behavior, Ukraine, the reference category, was added to the model, and Romania was removed from it as the reference category. It is indicated that Türkiye ($\beta = .081, t = 1.654, p < .1$) was a significant predictor, but Ukraine ($\beta = -.064, t = -1.320, p > .05$) was not compared to Romania in the nationality group.

Table 6. Multiple Linear Regression Analyses

Variables	B	Standard β Coefficients (Beta)	t	Prob.
Constant	8.131		21.145	.000
Male	.484	.096**	2.355	.019
Romania vs Ukraine	.307	.064	1.320	.187
Türkiye vs Ukraine	.694	.146***	2.946	.003
Türkiye vs Romania	.387	.091*	1.654	.099
Working experience_yes	-.173	-.036	-.740	.460
Family support_yes	-.484	-.081*	-1.712	.087
Pre-knowledge on finance_yes	.893	.196***	4.602	.000
Informed decision-making_yes	1.067	.204***	4.939	.000
R		.331		
R-squared		.109		
S.E. of regression		2.15569		
Sum squared resid		2569.784		
F (for change in R ²)		9.707***	.000	
Prob (F-static)			.000	
Durbin-Watson stat		2.073		
N. observation		561		

Source: the author's own elaboration.

* $p < .1$, ** $p < .05$, *** $p < .01$.

Table 7 shows the Mann-Whitney U test results. Since the number of participants for each group was low, the Mann-Whitney U test was applied as a non-parametric test. The Mann-Whitney U test was run to examine the difference in test scores between those who want to give 50 TL or less and those who want to give more than 50 TL in terms of positive financial behavior level. The finding showed a significant difference between the two groups, $U = 109.500, Z = -1.914, p = .057$. The mean rank for the group that gave 50 TL or less was 23.67, while the mean rank for the group that gave more than 50 TL was 33.83. This result suggests that the participants' trust behavior significantly affect positive financial behavior levels. The Mann-Whitney U test was also conducted to find possible differences between those who want to give back 120 TL or less and those who want to give back more than 120 TL in terms of positive financial behavior level. The finding showed no statistically significant

difference between the two groups, $U = 296.000$, $Z = -.314$, $p = .754$. The mean rank for the group that gave back 120 TL or less was 26.17, while the mean rank for the group that gave more than 120 TL was 24.88. The participants' trust behavior regarding giving money back does not significantly affect positive financial behavior.

Table 7. Mann-Whitney U test results for difference between trust and positive financial behaviors

N	100		270	
	≤ 50	> 50	≤ 120	> 120
N	41	9	24	26
Mean rank	23.57	33.83	26.17	24.88
Std deviation	3.23224		3.23224	
U	109.500		296.000	
Z	-1.912		-.314	
P	0.57*		.754	

Source: the author's own elaboration.

* $p < .1$

5. Discussion

This study aims to compare various factors of behavioral economics, experimental economics, and financial behavior and determine whether there is a relationship between them. To achieve this, the study is conducted among university students from Romania, Türkiye, and Ukraine. It investigates explicitly the concept of trust in financial behavior and experimental economics, alongside the idea of rational human beings in classical and behavioral economics. Initially, it identifies positive financial behavior and compares it with certain socio-demographic characteristics. The main finding regarding financial literacy level is that all three countries have a medium level of financial behavior. The average score of countries in 14 financial behavior questions was 9.36 (66.4%). This score indicates a medium level of financial behavior (Chen & Volpe, 1998). Romania, Türkiye, and Ukraine have a medium level of positive financial behavior with average scores of 67.8%, 67.14%, and 64.28%, respectively. The average of three countries having a very low rate (18.7%) for creating a monthly written budget plan indicates that budget planning remains an issue for students. While the average investment account is also low at 27%, this rate can be seen as relatively high when considering students. This survey question includes crypto accounts alongside stocks and bonds. The presence of a crypto account, which has become common these days, might have contributed to the increase in the investment account rate.

This research concluded that males have a higher level of positive financial behavior than females, with a positive β coefficient of .096, indicating males' more contribution to the regression. Although this study only examined the financial behavior dimension of financial literacy, the result also concluded that there is a statistically significant difference between males and females in terms of financial literacy level, with males having higher financial behavior and literacy levels (Gutter & Copur, 2011; Er *et al.* 2014; Borden *et al.* 2008; Tinghög *et al.* 2021; Yürük, 2023; Güz & Poyraz, 2024). This result contradicts the result of Mireku *et al.* (2023).

There was a statistically significant difference between nationality groups regarding positive financial literacy levels. It was concluded that Turkish students have higher positive financial behavior than Ukrainian students. The statistically significant difference was at the 0.01 alpha level, with $\beta = .146$. Turkish students have a higher level of positive financial behavior than Romanian students, with a low probability and a positive β coefficient of .081 at the 0.01 alpha level. Although no statistically significant difference was observed between Romanian and Ukrainian students, with a positive β coefficient of .64, the contribution of Romanian students to the regression is more significant than that of Ukrainian students. The study also found that working experience does not affect positive financial behavior. This result aligns with the study by Mireku *et al.* (2023), which found that working experience was not a significant factor influencing students' financial behavior. The result showed that family support has a very low negative impact on financial behavior with a negative β coefficient of -.081 at the 0.087 alpha level. Khalisharani *et al.* (2022) found that pocket money and family income did not affect students' financial behavior. It was observed that pre-knowledge of individual financial issues significantly affected positive financial behaviors. It contributes to the regression at the 0.001 alpha level with a positive β coefficient of .196, indicating high probability. This result shows that receiving financial education in schools or gaining knowledge on financial issues through individual efforts positively affects financial behavior and financial literacy (Kaiser & Menkhoff, 2017; Wagner, 2019). Basic financial literacy acquired at home and in school enables individuals to manage their personal finances effectively (Koskelainen *et al.* 2023). On the other hand, it was

concluded that making informed choices and sound financial decisions affects positive financial behaviors. The level of positive financial behavior among students who believe they make conscious decisions based on adequate information regarding their financial choices and decisions was higher than that of those who feel they do not make such decisions. Regression analysis indicated a high probability and a positive β coefficient of 0.081 at the 0.01 alpha level. As individuals' rationality increases, the likelihood of rational decisions also rises. Individuals' experience, knowledge, and attitudes toward digital financial platforms, as well as digital products and services, reduce behavioral biases and financial errors. This leads to rational, safe, profitable, and informed financial decisions (Kumar *et al.* 2023). Individuals who are financially savvy tend to make better financial decisions. (Fong *et al.* 2021). Financial education, a subfield of economic education, provides competence in decision-making. Economic and financial education can assist students in decision-making situations. Rationality is the main characteristic of making sound economic decisions (Loerwald & Stemann, 2016). Although it may not seem possible for students to evaluate every alternative in the market and make the most rational choice and decision through financial education, financial education's contribution to making sound financial decisions should always be considered, and appropriate financial education programs should be provided to society.

This research also investigated the concept of trust from the perspective of experimental economics and compared it to the level of financial behavior. The study was conducted in two phases. In the first stage, the first group (Group A) sent an average of 47.2 TL to the second group (Group B) (assuming that each individual was given 100 TL). In the second stage, Group B sent an average of 144 TL to Group A (assuming each individual had a maximum of 270 TL). The first group sent less money than average, while the second sent more. Although this study cannot analyze the statistical relationship between the two groups, while trust may have been a compelling factor for the first group, reciprocity was a more compelling factor for the second group. Brühlhart and Usunier (2012) examined the effect of altruism in their trust game experiment. They concluded that there was no significant negative relationship between the monetary transfers of the first group and the transfers of the second group. According to the statistical analysis performed after dividing each group into two in terms of mean, a significant relationship was found between trust and positive financial behavior in the first stage. This result suggested that positive financial behavior tends to decline as risky behaviors increase. It indicates that emphasizing trust and minimizing risk can positively impact financial behavior. In the second stage, no statistically significant results were obtained, although trust behavior was increased. However, this result did not support the assumption that individuals always act solely in their interests. They can make decisions that are at least partly guided by their understanding of trust. Fisher and Montalto (2011) suggest that a low-risk tolerance is associated with a decrease in the probability of saving. Those who are not willing to take any financial risk, have limited money, and cannot afford to risk losing it may have such financial behavior.

Conclusions and Further Research

The gender gap in financial literacy remains an issue. Closing this gap requires enhancing women's access to financial education. The essence of this study's findings suggests a potential relationship between financial behavior and experimental as well as behavioral economics assumptions concerning the parameters investigated. It is understood that informed decision-making and trust influence financial behavior. While this study does not establish a causal relationship between financial behavior and certain concepts within behavioral and experimental economics, it is crucial to acknowledge that positive financial behavior may enhance trust in monetary relationships and facilitate informed decision-making. Although the findings are derived from self-assessments by students regarding their decision-making processes, the significance of positive financial behavior should not be underestimated. Although individuals are not entirely rational, as suggested by behavioral economics, the results affirm that individuals exhibit rationality in their assessments, consistent with traditional economic principles.

The research has significant implications. It concluded that pre-knowledge of financial issues positively influenced financial behavior, highlighting the importance of financial education for sustainable financial literacy. This finding may prompt education authorities to prioritize financial education and encourage policymakers to develop new strategies. The findings related to trust may offer incentives for market makers to foster sustainable market trust. The significant link between informed and positive financial behaviors may inspire private and public policies to enhance consumer awareness about their choices and decisions. In addition, this research may contribute to new research on this subject by investigating the possible relationships between behavioral and experimental economics and financial behavior.

This study is notable for its integration of behavioral economics, experimental economics, and financial behavior approaches across three different countries. While most previous research focuses on financial

behavior, financial literacy, experimental economics, and psychological factors in isolation, only a few studies examine financial decision-making processes within both theoretical and experimental economics frameworks. Additionally, this study considers the differences among countries in its analysis. By incorporating socio-demographic factors such as gender, work experience, family financial support, financial knowledge, and financial preferences, it provides a more comprehensive understanding of the determinants of financial behavior. This cross-country comparative analysis also helps identify the cultural and social influences that shape financial decisions. As a result, the study offers practical insights for policymakers, educators, and financial institutions aiming to enhance financial well-being and promote responsible financial decision-making at both individual and societal levels.

Limitations

This study has several limitations. While the total number of participants was sufficient for analysis, the number of participants per country was not sufficient for a valid and more comprehensive statistical analysis. This situation restricted a more detailed analysis. A more comprehensive survey could have been implemented to determine positive financial behaviors, but the challenge of recruiting participants through an online survey constrained the survey's independent variables. Despite these limitations, the research provides significant contributions.

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Credit Authorship Contribution Statement

Kutlu Ergün: Conceptualization, Investigation, Methodology, Project administration, Software, Formal analysis, Writing – original draft, Supervision, Data curation, Validation, Writing – review and editing, Visualization, Funding acquisition.

Declaration of Use of Generative AI and AI-assisted Technologies

The author declares that he has not used generative AI and AI-assisted technologies during the preparation of this work.

Declaration of Competing Interest

The author declares that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper

Declaration of Research and Publication Ethics

The Social and Human Sciences Research Ethics Committee of Balıkesir University approved this research on May 3, 2024, with decision number 2024/04. With this approval, this research complies with research and publication ethics.

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Drivers of the Smart Green Economy in Rural Settings: An Empirical Study on Local Wisdom, ICT, and the Mediating Role of Entrepreneurship

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Abstract: This study provides local governments with critical insights into the role of Micro, Small, and Medium Enterprises (MSMEs) in advancing smart green economies within smart villages, particularly through the lenses of local wisdom, Information and Communication Technology (ICT), and entrepreneurship. Drawing on a sample of 142 MSME participants, the study employs Partial Least Squares Structural Equation Modeling (PLS-SEM) to analyze the relationships among key variables. Findings reveal that the interplay between local economic practices, ICT adoption, and entrepreneurial capacity significantly influences the development of a smart green economy. Notably, integrating indigenous knowledge with digital technologies emerges as a pivotal driver of economic transformation. Local wisdom and knowledge shape products and services' unique character and cultural value, helping communities stand out and grow their economies. When people in these communities use digital tools, especially the internet, in their businesses, it opens up new opportunities and encourages innovation. Still, having strong entrepreneurial skills is key. They do not directly drive the economy, but they help connect traditional wisdom and modern technology in ways that make growth possible. It demonstrates the importance of blending traditional heritage with innovation to create a thriving, sustainable future for rural areas.

Keywords: smart green economy; MSMEs; local wisdom; ICT; entrepreneurship mediation.

JEL Classification: O33; L26; L86; R58; D83.

Introduction

The rapid growth of internet access is transforming rural communities across Indonesia, paving the way for digital and smart village initiatives, reshaping local economies and lifestyles. These efforts align with the United Nations' Sustainable Development Goal 9, emphasizing the need for infrastructure and innovation tailored to local contexts (Iskandar, 2020). Indonesia's rich cultural diversity and natural resources make it an ideal setting for integrating indigenous knowledge into modern development strategies. Increasingly, the country's economic progress is linked to preserving and using local wisdom (Indrawan, 2018). A landmark moment came in 2017:

Lamahu Village in Gorontalo launched a digital command center using Android technology. This pioneering step laid the foundation for smart village programs, including four pilot villages in Yogyakarta between 2017 and 2018.

One standout initiative was the smart green economy program in Kulon Progo Regency (Santoso et al., 2019). Indonesia's rising Information and Communication Technology (ICT) Development Index has played a crucial role in supporting these innovations. As interest in smart village research grows, so does the number of digital village projects and startups.

Early studies have focused on building conceptual models (Ella & Andari, 2018). In Bogor Regency, the local government has prioritized sports and tourism development from 2018 to 2023, as outlined in the 2019 Development Planning Deliberation. In response to economic recovery needs, authorities have also focused on strengthening small and medium-sized enterprises (SMEs) through training, financial support, and digital innovation, especially via e-commerce platforms (Nugroho Himawan et al., 2024). SMEs are vital to Indonesia's economy, driving growth in both urban and rural areas (Herlinawati & Machmud, 2020). In Bogor Regency, village-level economic recovery is a strategic priority. One promising approach involves integrating micro-enterprises with tourism under a smart village framework. These villages thrive on active community participation, blending technology with creativity. Success depends on digital literacy and collaboration among government bodies, private companies, universities, and media outlets. Crucially, local wisdom remains at the heart of these efforts, supporting sustainable economic practices (Sukawati, 2017), environmental stewardship (Vitasurya, 2016), and the preservation of cultural heritage (Rudwiarti et al., 2021).

Entrepreneurs in these settings need a broad skill set, from production and finance to marketing and strategic planning (Aryani, 2019; Onojaefe & Leaning, 2007). This study uses the Regional Innovation System (RIS) framework to explore how regional policies and market-driven capabilities can foster innovation and competitiveness (Samara et al., 2023). Effective decision-making in this context requires adapting technologies and business strategies to fit local conditions (Carayannis et al., 2022). This study aims to fill a gap in understanding how digital tools, especially ICT, interact with entrepreneurship and local wisdom to build smart green economies. Using Structural Equation Modeling (SEM), the study provides a practical framework for regional policy and strategic planning, enabling the identification of strengths and areas for improvement. Ultimately, this study provides a comprehensive look at how entrepreneurship, ICT, and local products contribute to village-level economic growth. It emphasizes the importance of flexible, forward-thinking strategies in supporting sustainable rural development. The findings will be relevant to researchers, policymakers, business owners, and community members. Focusing on the Kemang sub-district in Bogor Regency, the study highlights the importance of integrating local wisdom with digital innovation to empower micro, small, and medium-sized enterprises in developing smart village economies.

1. Literature Review

1.1. A Theory of Local Entrepreneurship

The development of small businesses is deeply influenced by the local environment in which they operate. This "milieu" shapes the opportunities available and how entrepreneurs connect with their communities. One of the key ingredients in this process is social capital. The relationships and trust that allow entrepreneurs to build, grow, and sustain their ventures. Whether formal (e.g., business associations) or informal (e.g., community ties), entrepreneurial networks act as vital channels for sharing knowledge, resources, and experiences. However, these networks are only as strong as the businesses within them. When entrepreneurs actively participate, innovate, and contribute, they help the network evolve, creating a feedback loop where the business and the network grow together. This idea is captured in the "reversed arrow" concept: businesses do not just benefit from the network; they also shape it. However, the arrival of large commercial players, such as national retail chains or department stores, can disrupt this dynamic. While these entities may bring jobs and consumer options, they often pose a threat to smaller, locally rooted businesses. The impact is especially visible in urban areas, where small shops along major streets may be forced to close, leading to job losses and weakening local entrepreneurial fabric.

Understanding the overall effect of these changes is complex. On one hand, consumers enjoy more choices and potentially lower prices. On the other hand, the unique value of local businesses is often more attuned to community needs but is diminished. Consumer preferences play a big role here. Many people favor well-known national or global brands, influenced by broad marketing campaigns and standardized offerings that overlook local nuances. It may be due to a lack of awareness about the quality and diversity of local products or the perception that local businesses cannot compete. In contrast, when local entrepreneurs collaborate in drawing on shared cultural and economic values. They can reinforce regional economies and spark growth. Their success

depends on their ability to innovate and respond quickly to changing market demands. As Julien (2007) notes, the future of local business competitiveness lies in adaptability and creativity.

1.2. Open Innovation in SMEs

The National Innovation System (NIS) has been the go-to framework for understanding how innovation happens within countries. However, as globalization continues to blur cultural and strategic boundaries, there is growing interest in Regional Innovation Systems (RIS). These offer a more localized lens, focusing on how specific regions foster innovation and economic growth by tapping into their unique contexts and strengths (Samara et al., 2023). Open Innovation (OI) has emerged as a powerful strategy in this landscape. Rather than keeping innovation efforts strictly in-house, OI encourages companies to collaborate with external partners in sharing ideas, technologies, and resources to boost their creative capacity (Bigliardi et al., 2021). This approach is especially valuable for small and medium-sized enterprises (SMEs). These businesses often operate with limited resources, making it harder to innovate independently. By engaging in open innovation, SMEs can tap into broader networks, learn from others, and bring in fresh perspectives that help them grow and stay competitive (Herlinawati & Machmud, 2020; Prima Lita et al., 2020; Tosida et al., 2022). As Prasanna et al. (2019) point out, adopting open innovation is not just a nice-to-have; it is essential for survival in today's fast-moving global market. SMEs that embrace this model tend to be more open to risk, more focused on customer needs, and better at adapting their business models. They also understand the importance of working with their communities and building strong partnerships, recognizing that innovation thrives in collaboration.

1.3. Information and Communication Technology, Local Wisdom, and Entrepreneurship

Information and Communication Technology (ICT) plays a transformative role in rural economies, as a bridge connecting local businesses to broader national and global markets (Maja et al., 2020). By improving communication, lowering transaction costs, and providing access to market insights, ICT helps entrepreneurs start, grow, and scale their ventures (M Del Giudice & Straub, 2011; Tosida et al., 2022). Entrepreneurs benefit from ICT in several meaningful ways:

- **Boosted Motivation and Awareness:** Digital interactions among entrepreneurs foster a sense of community and influence, increasing awareness of available tools and their potential. It leads to quicker responses to market changes and more agile business strategies (Chen et al., 2015; Hartanto et al., 2021; Jayawinangun et al., 2024).
- **Better Communication and Coordination:** ICT makes sharing information and coordinating with suppliers, customers, and partners easier. It reduces uncertainty and improves the chances of business success.
- **Smarter Decision-Making:** With access to digital tools, entrepreneurs can gather and analyze data more effectively, helping them make informed decisions and innovate with confidence (M Del Giudice & Straub, 2011).

In this study, ICT is viewed through its practical use in small and medium-sized enterprises (SMEs), including computers, internet access, websites, and online platforms for marketing and sales. These technologies are seen as key drivers of entrepreneurial activity. While mobile phones and internet access are becoming more common, challenges remain. Infrastructure gaps and differences in digital literacy still affect how evenly ICT benefits are distributed across regions and local communities. The cultural values and traditions embedded in communities continue to shape entrepreneurs' businesses. These values influence behaviour, promote sustainable practices, and strengthen the social fabric of local economies (Aryani, 2019). By combining the power of ICT with the richness of local wisdom, rural areas can foster more inclusive and sustainable entrepreneurship. This synergy offers a promising path forward for communities seeking to thrive in a digital age without losing their cultural identity.

1.4. Smart Green Economy

The economic dimension plays a vital role in shaping and sustaining smart villages. One of the most promising approaches to rural development is the creative economy, especially when it is rooted in local wisdom. This kind of economy not only boosts income and creates jobs but also improves rural communities' overall quality of life (Faridha, 2022; Widyanti et al., 2022). In Indonesia, for example, innovations inspired by local traditions have helped small and medium-sized enterprises (SMEs) improve their marketing performance (Indrawan, 2018). Entrepreneurs in rural areas often draw on their cultural heritage, traditional knowledge, and local resources to create unique products that stand out in the market (Muchson et al., 2023). A great example is

agro-tourism, which blends agriculture with tourism and has positively impacted social, economic, and environmental dimensions (Widyanti et al., 2022). Using local wisdom strategically, especially in tourism branding, can bring broader economic benefits, such as increased GDP, expanded international trade, and more foreign investment (Utomo et al., 2023). The success of smart village initiatives depends heavily on each village's unique resources and potential. That is why there is no one-size-fits-all model; each smart village must be shaped by its political, economic, social, and cultural context (Zavratnik et al., 2018).

As Davidenko et al. (2018) highlight, economic growth in smart villages is marked by diversity in different types of businesses, strong human capital, and well-managed budgets. The smart green economy is one of the core pillars of the smart village concept, alongside smart mobility, smart environment, smart people, smart living, and smart tourism (Santoso et al., 2019). This framework is innovation and entrepreneurship, which drive economic transformation. This study builds on existing literature to define and measure three key variables: (i) Local wisdom (Juliana Jaya et al., 2020; Sukawati, 2017), (ii) Information and Communication Technology (ICT) (Meirelles, 2020; Singh et al., 2018; STATEC, 2013), (iii) Entrepreneurial ability (Aryani, 2019; Onojafe & Leaning, 2007). These variables are operationalized using composite indicators, which are detailed in Table 1 of the study.

Table 1. Hierarchical component of the studied constructs or variables

First-order	Number of Indicators	High-order
Uniqueness	3	Local Wisdom
Communication Bridge	3	
Local culture concept	2	
Balance with the environment & religious values	3	
Infrastructure & Technology	21	Smart green economy
Social	13	
Economy	12	

On the basis of the theoretical framework and insights derived from the literature review, the following hypotheses are proposed to guide the empirical investigation:

Hypothesis 1 (H1): Information and Communication Technology (ICT) positively affects entrepreneurship.

Hypothesis 2 (H2): Local wisdom positively contributes to entrepreneurial development.

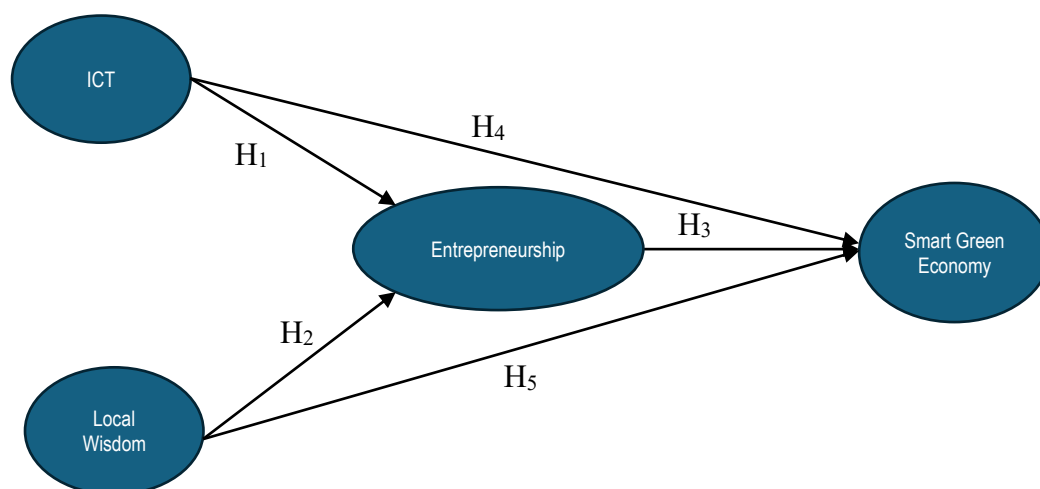
Hypothesis 3 (H3): Entrepreneurship positively affects the development of a smart green economy.

Hypothesis 4 (H4): ICT positively affects the advancement of a smart green economy.

Hypothesis 5 (H5): Local wisdom positively impacts the smart green economy.

These hypotheses collectively form the basis for the structural model illustrated in Figure 1, which conceptualizes the interrelationships among ICT, local wisdom, entrepreneurship, and the smart green economy.

Figure 1. Research Framework



2. Materials and Methods

2.1. Study Location and Participants

This study was conducted in Kemang District, located in Bogor Regency, Indonesia. The selection of Kemang District, particularly Tegal Village, was based on its notable strengths in gender-based micro-enterprises and local wisdom. In 2020, Tegal Village was awarded second place in the Program to Increase the Role of Women towards Healthy and Prosperous Families (P2WKSS) in West Java Province, recognizing its achievements in promoting micro-enterprises and initiatives grounded in gender sensitivity and local cultural values (Andria et al., 2022). A total of 142 respondents participated in the survey. The sampling process employed non-probability techniques, specifically convenience and snowball sampling, to recruit participants. These methods were deemed appropriate given the study's exploratory nature and the research's localized context.

Table 2. Result of Demography Profile of Respondents (n = 142)

Characteristic	Category	Frequency	Percentage
Gender	Male	47	33.1
	Female	95	66.9
Age	20 – 29 years old	31	21.8
	30 – 39 years old	48	33.8
	40 – 49 years old	30	21.1
	50 – 59 years old	26	18.3
	60 years old and above	7	4.9
Education	Elementary school	60	42.3
	Junior high school	35	24.6
	Senior high school	40	28.2
	Bachelor and postgraduate	7	4.9
Type of business	Food & Beverages	79	55.6
	Fruit & Vegetables	17	12
	Grocery	16	11.3
	Service	9	6.3
	Fashion	4	2.8
	Fisheries	4	2.8
	Handicraft	4	2.8
	Beauty	3	2.1
	Other	6	4.2

Table 2 presents the demographic characteristics of the study participants. The sample comprised 66.9% female and 33.1% male respondents. Participants' ages ranged from 20 to 85 years, with a mean age of 40.12 years and a standard deviation of 12.17. For analytical purposes, participants were categorized into age groups: 20–29, 30–39, 40–49, 50–59, 55–64, and 65–69. The 30–39 age group represented the largest proportion of respondents, accounting for 33.8% of the sample. In terms of educational background, most participants had attained primary school education. Regarding business type, the sample was predominantly engaged in food and beverage enterprises, indicating a concentration of entrepreneurial activity within this sector.

Drawing on a sample of 142 MSME participants, the study employs Partial Least Squares Structural Equation Modeling (PLS-SEM) to analyze the relationships among key variables. Findings reveal that the interplay between local economic practices, ICT adoption, and entrepreneurial capacity significantly influences the development of a smart green economy.

3. Results

3.1. Evaluation of Measurement Model

3.1.1. Construct Validity and Reliability

The repeated indicator approach aims to build the higher-order constructs in this study. This method involves creating a second-order latent variable that includes all the indicators from its related first-order constructs

(Sarstedt et al., 2019). In simpler terms, it means combining several related dimensions into a broader concept. Two key constructs, local wisdom and smart green economy, were treated as second-order constructs: (1) Local wisdom was broken down into four dimensions: (i) Uniqueness, (ii) Local culture, (iii) Regional communication, (iv) Harmony with environmental and religious values. Smart green economy included three dimensions: (i) Social, (ii) Economic, and (iii) infrastructure & technology. To represent these constructs, all the indicators from the first-order dimensions were reused at the second-order level. For example, each indicator served two roles: (i) as a measure for its specific dimension and (ii) as a contributor to the broader second-order construct. This dual role helped shape the outer model, which defines how indicators relate to their constructs. Meanwhile, the inner model included path coefficients, essentially weights that link the first-order constructs to the second-order ones. To ensure the reliability of each indicator, the study checked how strongly each one loaded onto its respective construct.

A loading value of 0.60 or higher was considered acceptable for exploratory research (Hair et al., 2019). Indicators that did not meet this threshold were removed individually, with the model recalculated each time. For instance, the “unique 3” indicator from the uniqueness dimension was excluded because it did not meet the reliability criteria. The results of the following validity and reliability assessments: Internal Consistency Reliability: Measured using Composite Reliability (CR) coefficients, most constructs demonstrated CR values above the recommended threshold of 0.70, except for the uniqueness dimension. Convergent Validity: Evaluated through the Average Variance Extracted (AVE), most constructs achieved AVE values above 0.50, except for the local wisdom construct. Discriminant Validity: Assessed using the Fornell-Larcker criterion, which was satisfactory for all multi-item constructs except for Frequency of Social Media Use. In this case, the square root of AVE (0.71) was lower than its correlation to the Intention to Use Social Media construct (0.75). Despite this exception, the cross-loadings matrix (see Table 3) revealed that indicators loaded more strongly on their respective constructs than on others, thereby providing additional support for the discriminant validity of the final measurement model.

Table 3. Result of Construct Validity, Reliability, and Convergence Validity

Construct	Cronbach's Alpha	rho_A	Composite Reliability	Average Variance Extracted (AVE)
Balance with the environment and religious values	0.845	0.864	0.905	0.761
Communication bridge	0.836	0.836	0.901	0.753
Economy	0.970	0.970	0.973	0.752
Entrepreneurship	0.744	0.745	0.837	0.562
ICT	0.905	0.907	0.925	0.639
Infrastructure & Technology	0.985	0.986	0.986	0.775
Local Wisdom	0.858	0.883	0.886	0.451
Local culture concept	0.801	0.816	0.909	0.833
Smart green economy	0.988	0.988	0.988	0.649
Social	0.970	0.971	0.973	0.738
Uniqueness	0.625	0.630	0.842	0.727

Table 3 presents the results of this study's validity and reliability assessments. Internal consistency reliability was evaluated using Composite Reliability (CR) coefficients, with most constructs demonstrating CR values above the recommended threshold of 0.70, except for the uniqueness dimension. Convergent validity was assessed through the Average Variance Extracted (AVE), where most constructs achieved AVE values exceeding 0.50, although the local wisdom construct fell below this benchmark. Discriminant validity was examined using the Fornell-Larcker criterion, which was satisfactory for all multi-item constructs except for the Frequency of Social Media Use. In this case, the square root of its AVE (0.71) was lower than its correlation to the Use Social Media construct (0.75), indicating a potential issue. Nevertheless, the cross-loadings matrix, also shown in Table 3, demonstrated that all indicators loaded more strongly on their intended constructs than on others, providing additional evidence supporting the discriminant validity of the final measurement model.

3.2. Evaluation of Structural Model

The structural model was assessed through path coefficients and their statistical significance, as presented in Table 4. These estimates were derived using 5,000 bootstrap resampling iterations to ensure robustness and reliability. A key metric in evaluating the structural model is the coefficient of determination (R^2), which reflects the

model's predictive power. This study used R^2 (R-squared) to measure how well the predictor variables explain the variance in a particular outcome, or endogenous construct. Simply put, R^2 tells us how much change in one variable can be explained by changes in others. The values range from 0 to 1, with higher numbers indicating stronger explanatory power. According to Chin's guidelines (Hair et al., 2019): (i) An R^2 of 0.67 or higher is considered substantial, (ii) Around 0.33 is moderate, (iii) Near 0.19 is weak. In this study's path analysis, one key finding stood out: entrepreneurship did not significantly influence the smart green economy construct. It might seem surprising initially, but it makes more sense when we look at the sample. Most business actors involved were small-scale enterprises, many earning below the regional minimum wage. Because of their limited economic output, their overall contribution to the regional economy and, by extension, to the smart green economy framework was relatively minor. It suggests that while entrepreneurship is important, its impact on broader economic transformation may depend heavily on the scale and capacity of the businesses involved.

Table 4. Results of Coefficient Determination, Multicollinearity, and Hypothesis Testing

Path Analysis		Beta	t-stat	Sig.	R^2	VIF	Decision
H1	ICT -> Entrepreneurship	0.569**	11.191	0.000	0.324	1.479	Supported
H2	Local wisdom -> Entrepreneurship	-0.002	0.027	0.979		1.034	Not Support
H3	Entrepreneurship -> Smart green economy	-0.050	0.545	0.000	0.275	1.514	Not Support
H4	ICT -> Smart green economy	0.361**	4.717	0.586		1.034	Not Support
H5	Local wisdom -> Smart green economy	0.347	5.229	0.000		1.034	Supported

Table 4 presents the results of hypothesis testing using structural equation modelling, examining the relationships among ICT, local wisdom, entrepreneurship, and the smart green economy. Hypothesis H1, which posits that ICT influences entrepreneurship, is supported with a strong and significant path coefficient ($\beta = 0.569$, $t = 11.191$, $p < 0.001$). It suggests that ICT plays a vital role in fostering entrepreneurial activity, explaining 32.4% of the variance in entrepreneurship ($R^2 = 0.324$). The variance inflation factor (VIF) of 1.479 indicates no multicollinearity issues. In contrast, H2, which examines the influence of local wisdom on entrepreneurship, is not supported. The path coefficient is almost negligible ($\beta = -0.002$), with a t-value of 0.027 and an insignificant p-value of 0.979, indicating that local wisdom does not contribute meaningfully to entrepreneurial development in this context.

Similarly, H3, which assesses the effect of entrepreneurship on the smart green economy, is also not supported. Despite a coefficient of $\beta = -0.050$ and a t-value of 0.545, the reported p-value is 0.000, which appears to be a reporting error. Given the low t-value, the relationship is statistically insignificant, suggesting that entrepreneurship does not significantly drive the development of a smart green economy in this model. Nevertheless, the model explains 27.5% of the variance in the smart green economy ($R^2 = 0.275$), with a VIF of 1.514. H4 explores the direct impact of ICT on the smart green economy. Although the path coefficient is moderately strong ($\beta = 0.361$) and the t-value is 4.717, suggesting significance, the reported p-value of 0.586 contradicts this and leads to the hypothesis being rejected. This inconsistency indicates a potential reporting error and warrants further clarification. Lastly, H5, which tests the relationship between local wisdom and the smart green economy, is supported. The results show a significant and positive effect ($\beta = 0.347$, $t = 5.229$, $p < 0.001$), suggesting that incorporating local cultural values contributes positively to building a smart green economy. All VIF values across the model are below 5, indicating that multicollinearity is not a concern.

Table 5. Result of Effect Size (f-square)

Path	f^2	Sig.
ICT -> Entrepreneurship	0.464	0.000
Local wisdom -> Entrepreneurship	0.000	1.000
Entrepreneurship -> Smart green economy	0.002	0.873
ICT -> Smart green economy	0.119	0.043
Local wisdom -> Smart green economy	0.161	0.030

In addition, Table 5 presents the f^2 effect sizes, which assess the impact of exogenous constructs on endogenous variables within the model. The results indicate that the effect of ICT on entrepreneurship is large, while the effects of both ICT and local wisdom on the smart green economy are moderate. These findings

suggest that ICT is particularly influential in fostering entrepreneurial activity. In contrast, though meaningful, their and local wisdom's contributions to the smart green economy are comparatively less pronounced. Furthermore,

Table 6. Result of Predictive Relevance (Q-square)

Construct	SSO	SSE	Q ² (=1-SSE/SSO)
Entrepreneurship	568.000	418.235	0.264
ICT	994.000	484.184	0.513
Local Wisdom	426.000	210.882	0.505
Smart green economy	426.000	146.614	0.656

Table 6 reports the Q² values, which measure the model's predictive relevance using the blindfolding procedure. All constructs exhibit Q² values greater than 0.50, except for entrepreneurship, demonstrating high predictive relevance. These results indicate the model's strong predictive accuracy, supporting its overall goodness-of-fit.

4. Discussion

In recent years, the concept of a smart green economy has gained traction as a strategic framework for promoting sustainable development, particularly in rural areas. This approach integrates three key elements: Information and Communication Technology (ICT), local wisdom, and entrepreneurship to create a dynamic system that supports economic growth, strengthens community resilience, and fosters inclusive development. ICT catalyzes innovation and connectivity, enabling rural populations to access vital information, markets, and resources previously out of reach (Anuyahong et al., 2023). It enhances communication, reduces transaction costs, and opens new avenues for business development, especially for small and medium-sized enterprises (SMEs), which benefit from global market access and cost-effective operations (Kurniawati & Chairunisa, 2023; Sianipar, 2022; Syamruddin & Yunita, 2024). Local wisdom, encompassing cultural, ecological, and social knowledge passed down through generations, adds depth and relevance to economic activities. It includes traditional practices and community-based solutions that are well-adapted to local conditions. Combined with modern technologies, it guides the development of context-sensitive and sustainable economic systems (Mardianti et al., 2022; Suriani et al., 2024; Wahyuddin et al., 2022).

Entrepreneurship plays a pivotal role by transforming ideas into action, empowering individuals to leverage ICT and traditional knowledge to create unique products and services that reflect their community's identity and values (Stevy et al., 2023). The synergy among ICT, local wisdom, and entrepreneurship forms the foundation of a smart green economy tailored to rural needs. This interconnected model enhances economic vitality, promotes environmental sustainability, and strengthens social cohesion (Mardhatillah et al., 2024). Initiatives such as agro-tourism, rooted in local traditions, have positively impacted economic, social, and environmental dimensions (Mwanza, 2022). Several enabling conditions must be met to make this model effective, including robust digital infrastructure, widespread technology adoption, digital literacy and skills training, and a supportive innovation ecosystem comprising tech firms, research institutions, and policy frameworks (Mardhatillah et al., 2024). In regions facing challenges like population decline and underinvestment, ICT can serve as a strategic tool for regeneration by attracting investment and improving quality of life (Manlio Del Giudice et al., 2012; Paulussen et al., 2011). For SMEs, ICT facilitates access to global markets, supports innovative business models, and fosters resilience and sustainability (Brenner, 2018).

Moreover, ICT-driven collaboration among businesses strengthens the entrepreneurial ecosystem, creating conditions conducive to innovation and adaptability during economic fluctuations (Lama et al., 2024). Communities embracing digital technologies can harness data analytics and digital platforms to understand market dynamics and consumer behaviour better, thereby improving their competitive edge (Manlio Del Giudice et al., 2012; Paulussen et al., 2011). This capability supports informed decision-making, efficient resource allocation, and agile responses to evolving demands. Technology adoption also enables enterprises to streamline operations, diversify revenue sources, and personalize services to enhance customer engagement (Brenner, 2018). A technology-oriented environment promotes continuous learning and skill acquisition, equipping individuals and organizations to confidently navigate future challenges (Mardhatillah et al., 2024). The widespread adoption of ICT fosters innovation and collaboration, allowing diverse teams to capitalize on their strengths and drive sustained economic growth (Manlio Del Giudice et al., 2012; Paulussen et al., 2011).

To fully unlock the transformative potential of ICT, local wisdom, and entrepreneurship in building smart green economies, stakeholders should invest in digital infrastructure aligned with local cultural and environmental

contexts, provide accessible and culturally relevant digital skills training, and design ICT applications that integrate traditional knowledge (Mwanza, 2022). Encouraging partnerships among technology companies, local enterprises, and community organizations is essential, as is implementing policy measures that protect indigenous intellectual property while fostering innovation and knowledge sharing (Mardhatillah et al., 2024). Striking a balance between preserving local wisdom and embracing digital innovation can lead to smart green economies that are both technologically advanced and culturally grounded. However, realizing this potential requires overcoming persistent barriers such as limited funding, inadequate infrastructure, and insufficient capacity-building efforts (Lama et al., 2024). By cultivating a collaborative and innovative culture, smart villages can become models of sustainable rural development, attracting talent and investment, improving public services, and enhancing the overall quality of life for their residents (Mukti et al., 2022; Yusrizal et al., 2024).

Conclusions

To foster the development of a smart green economy, this study underscores the critical role of small and medium-sized enterprises (SMEs) in integrating information and communication technologies (ICTs) with local knowledge. The findings reveal that products and services embedded with local cultural values, such as distinctiveness, heritage, and regional identity, serve as key drivers of smart economic growth. ICTs are increasingly central to business operations, enhancing efficiency, connectivity, and innovation. Notably, entrepreneurial talent does not directly influence the smart green economy; rather, it functions as a mediating factor that facilitates the effective utilization of ICT and local knowledge. Emerging evidence suggests that strategic investments in ICT infrastructure, particularly the expansion of broadband access in rural and underserved areas, are necessary to stimulate entrepreneurial activity and enhance economic dynamism. In countries like Indonesia, which possess a rich tradition of cultural preservation and a vibrant SME sector, the proposed framework for advancing the smart green economy holds significant potential for regional development. This approach can catalyze innovation and inclusive economic growth by synergizing traditional knowledge systems with modern digital technologies.

However, the successful implementation of this smart green economy model hinges on two essential components: entrepreneurial competence and institutional support. Entrepreneurs must possess a nuanced understanding of local market dynamics and cultural practices, alongside the ability to harness ICT tools to enhance their business operations. Bridging the gap between traditional business practices and digital transformation may require targeted interventions, such as mentorship initiatives and specialized training programs. Simultaneously, government support is indispensable in enabling SMEs to thrive within this evolving economic landscape. Policy measures that promote infrastructure development, facilitate access to finance, and enhance digital literacy are vital. Through such support, the framework can unlock the full potential of local wisdom-based enterprises, foster sustainable economic growth while safeguard cultural heritage.

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Credit Authorship Contribution Statement

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Roni Jayawinangun: Conceptualization, Investigation, Methodology, Project administration, Formal analysis, Writing – original draft, Writing – review and editing.

Jumadil Saputra: Investigation, Methodology, Software, Formal analysis, Data curation, Validation, Writing – review and editing, Visualization.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Declaration of Use of Generative AI and AI-assisted Technologies

The authors declare that they did not use generative AI and AI-assisted technologies during the preparation of this work.

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The Role of Digital Technologies in Creating Competitive Advantages of Modern Entrepreneurship

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Abstract: Digital technologies have become a key factor in transforming entrepreneurship and strengthening its competitiveness in the current global instability and growing competition. Digitalization is especially important for countries that are undergoing post-crisis recovery and integration into the European space, where it forms new mechanisms for economic growth, opens access to new markets, and optimizes business processes. The aim of this article is to assess the impact of digital technologies on the creation of competitive advantages of enterprises in Moldova, Romania, Ukraine, Poland, and Germany using an econometric approach.

The research methodology is based on a panel data model for 2019–2024 considering fixed effects. The model includes five independent variables: the level of digitalization, the number of innovations, the share of R&D spending, export orientation, and enterprise size.

The modelling results showed that R&D has the strongest positive impact ($\beta=8.70$), followed by digitalization ($\beta=0.52$), and innovation ($\beta=0.31$). The highest average competitiveness was recorded in Germany (3.62), the lowest - in Poland (3.27), while Ukraine has a consistently positive dynamic.

The developed model confirms the importance of comprehensive digital transformation for ensuring long-term market advantage. Further studies may expand the model, considering industry specifics, digital environmental friendliness, sustainability, and regional characteristics of the countries of Central Asia, the Balkans, and the Baltics.

Keywords: digital transformation; enterprise potential; innovation-driven competitiveness; export-oriented SMEs; panel data econometrics; sustainable economic growth.

JEL Classification: M10; O33.

Introduction

Digital technologies have become a key factor in the transformation of modern entrepreneurship and the basis for the creation of its competitive advantages. They change the logic of economic growth, resource management and interaction with customers. Digitalization is especially important for countries that are in a state of post-crisis recovery and integration into the European space, such as Ukraine, Moldova or Romania, where it serves not only as a means of increasing efficiency, but also as a tool for adapting to global competition. In view of limited resources, an unstable environment and growing demands for innovation, digital tools enable maintaining flexibility, improving the quality of management decisions and entering foreign markets. However, in many enterprises, digital transformation still remains fragmented, inconsistent and often limited to basic automation. The lack of a strategic vision for digital development and the low level of research and development (R&D) investment limit long-term competitive advantages. There is also significant international variability in the effectiveness of digitalization, which increases the need for quantitative analysis of its effectiveness in comparison.

In addition, the study focuses on enterprise potential as an integral indicator that reflects digital maturity, innovation, institutional capacity, and scalability. Innovation is defined based on quantitative data on new products, processes and digital solutions that enterprises integrate to improve efficiency. These elements establish the core of competitiveness and correspond to the strategic priorities of sustainable entrepreneurship (SDG 8, 9).

Recent studies confirm that digital technologies contribute not only to profit, but also to the creation of social and environmental value (Gregori and Holzmann 2020). Digital resilience allows peripheral communities to quickly integrate into sustainable development models (Tim *et al.* 2021). Innovative entrepreneurship and the circular economy are recognized as prerequisites for long-term social progress (Manea *et al.* 2021). Digital solutions are creating new trajectories of sustainable entrepreneurship for countries in the Global South (Contreras and Dornberger 2023). At the same time, the creation of competitive advantages requires the integration of digital tools into business models and financial systems (Prokopenko *et al.* 2024). This approach enhances the adaptability of enterprises to the challenges of the global environment and accelerates innovation processes. Therefore, digitalization is becoming strategically important for enterprises in countries with economies in transition.

This context arises the problem of determining the real economic effect of digital technologies for enterprises in different countries. Despite numerous theoretical studies, there is still a lack of empirical estimates that would substantiate the relationship between digitalization, innovation, the size of enterprises, their export activity and competitiveness. This problem has led to the need to build an econometric model for a comprehensive assessment of the relationships between these variables.

The aim of the study is to determine the impact of digital technologies on the creation of competitive advantages of enterprises in an international context. The aim involved the fulfilment of the following research objectives:

- conduct a review of academic literature on the digitalization of business;
- collect, structure, and present data on enterprises in five countries for 2019–2024;
- build an econometric model for assessing competitiveness taking into account digital and innovation factors;
- conduct a comparative analysis of results between countries with different levels of digital maturity;
- draw conclusions and provide practical regarding digital strategies.

The object of the study is the economic behaviour of enterprises in the context of digital transformation. The subject of the study is the impact of digital technologies on competitive advantages. The hypothesis of the study is that digital technologies in combination with innovations and export orientation create a stable advantage in the market. The study combines the methods of econometric modelling, international comparison, statistical analysis, and content analysis of academic literature.

The academic novelty of the study is the complex combination of digital, innovative, and organizational factors in a single quantitative model. The study is the first that assesses the digital maturity of enterprises in the context of competitiveness in Ukraine, Moldova, Romania, Poland, and Germany. The proposed model is universal and can be used for other countries and sectors of the economy. The practical significance of the study

is the possibility of applying the results to develop digital transformation strategies, determine investment priorities in digital solutions, and develop policies to support small and medium-sized businesses (SMEs).

1. Literature Review

Recent studies confirm that digital technologies are increasingly penetrating sustainable business strategies, changing approaches to value creation (Fuerst *et al.* 2023). George *et al.* (2021) consider digital innovation as a tool to address climate challenges by rethinking business models. Baran and Berkowicz (2021) propose the concept of digital platforms as laboratories for sustainable innovation, where companies experiment with new products. Fernandes *et al.* (2022) add that digital entrepreneurship operates in complex digital ecosystems, where adaptation is a critical condition for competitiveness. Satalkina and Steiner (2020) analyse the digital economy as an element of national innovation systems, emphasizing an interdisciplinary approach.

Guandalini (2022) conducts a systematic literature review calling for standardization of approaches in the study of digital transformation. Lichtenthaler (2021) introduces the concept of digitainability that emphasizes the interdependence of digitalization and sustainable development as megatrends of the 21st century. Del Río Castro *et al.* (2021) argue that the implementation of the Sustainable Development Goals is only possible if there is a digital breakthrough in business practices.

Khanh *et al.* (2023) deepen the technical dimension by describing the impact of future 6G technologies on the digital entrepreneurship infrastructure. This approach brings digital strategy closer to technological foresight, which is relevant for countries with transformational economies. In general, agreement among the authors on the need for digital adaptation to remain competitive is growing.

Man *et al.* (2025) emphasize that the combination of digital technologies and proper intellectual property management can greatly increase the speed of sustainable innovation so that the enterprises keep competitive positions even in a long-term perspective and their intangible assets remain secure. According to Zheng and Zhou (2025), business model innovation holds a mediating effect on the firm-level digital transformation and competitive advantage in manufacturing, implying that technological absorption should be consistent with product value chain value redesign. Li (2025) offers a synthesis of research study on the business model innovation in terms of digital technology that clarifies significant gaps and directions in managing the integration of digital tools and strategic planning. Omidvar *et al.* (2025) combine innovation in the business model with corporate social responsibility illustrating how, in the digital age, the SMEs can excel through a combination of technological goals and social purpose. Zaman *et al.* (2025) examine the mediating effect of digitalization management in revealing that competent provisions of the control of digital efforts improve the extent and magnitude of digitalization performance. Jang and Lee (2025) discuss the relationship between digital entrepreneurial orientation, technology absorptive capacity, and digital innovation, and they establish that the combinations of these skills enhance the performance of the business. Lastly, Huang and Tang (2025) pay attention to the strategic positioning of digital platforms that disclose their ability to act as integrative infrastructures to promote enterprise-wide digital transformation strategies and develop sustained competitiveness.

At the same time, there is a gap between normative visions of digitalization and the real limitations of its implementation. Earlier studies mainly focus on qualitative or conceptual aspects of digital transformation. However, quantitative assessment of the effect of digital factors remains underdeveloped. In this context, our study fills the gap by proposing an econometric model for analysing the impact of digital changes on competitive advantages. The integration of international data allows considering both common and specific determinants of digital efficiency of enterprises. So, the proposed approach develops the ideas of previous researchers, combining strategic vision with practical measurability.

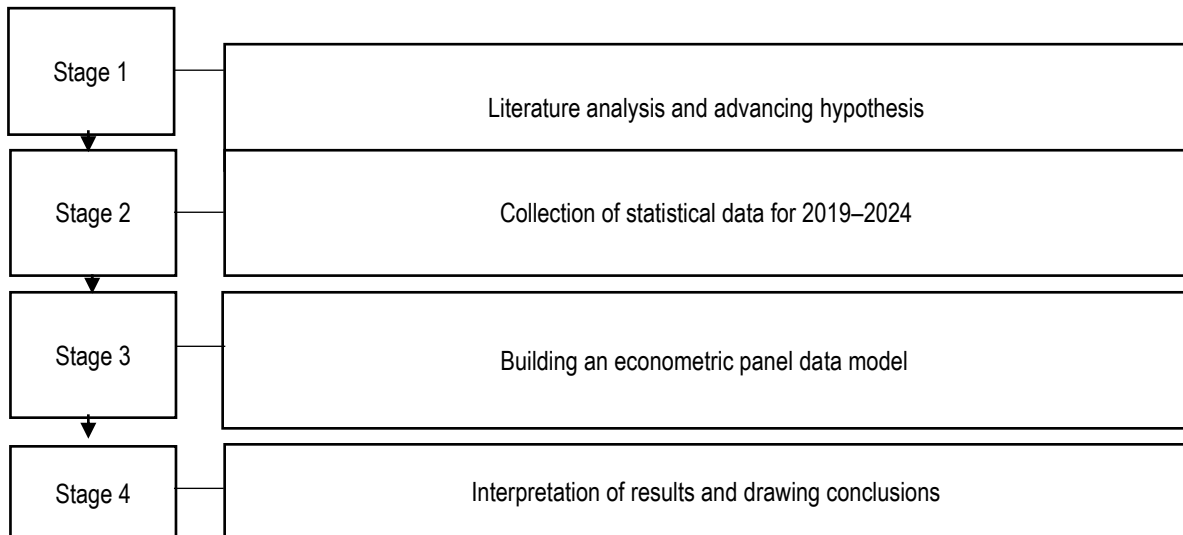
Therefore, the reviewed academic literature forms a holistic background for understanding the role of digital technologies in the strategic development of entrepreneurship. They demonstrate the interdisciplinary nature of digital transformation and its connection with sustainable innovation. However, most studies focus on the conceptual or technological level, neglecting the applied economic assessment of digital effects. There are insufficiently developed empirical approaches that can quantitatively measure the impact of digitalization on the competitiveness of enterprises in the international dimension. There is also a lack of models that consider the specifics of transformational economies, institutional barriers and asymmetries of digital access. This justifies the need for further research with an emphasis on quantitative analysis, international comparability and political aspects of digital modernization of business.

2. Methods

2.1. Research Design

The research included four stages, which ensured a logical sequence of data collection, processing, and analysis. The basis of the study was panel data on enterprises from five European countries. All stages are presented in the figure 1 below, which summarizes the methodological logic of the study.

Figure 1. Research Stages



Source: develop by the author.

The first stage identified key factors influencing the impact of digitalization on business. The second stage included the formation of an open-source database. The third stage involved the calculation of a model using regression analysis. The fourth stage provided for the comparison of results between countries and their generalization. This structure enabled combining quantitative methods with applied analysis. The procedure ensured the reliability and validity of the findings.

2.2. Sampling

Five countries were selected for the analysis, including Moldova, Romania, Ukraine, Poland, and Germany. The countries have different levels of digital maturity for the purpose of a comparative analysis. The period 2019-2024 covers transformational changes, including pandemics and crises. Small and medium-sized enterprises were selected as the most sensitive to digital changes. The main indicators are digitalization, innovation, R&D, exports, company size. Data sources include Eurostat, World Bank, national statistical offices, and industry surveys (Deloitte 2023; European Commission 2024; Gartner 2023; International Monetary Fund 2023; International Telecommunication Union 2023; McKinsey & Company 2023; National Bureau of Statistics of the Republic of Moldova 2024; OECD 2023; Polish Central Statistical Office 2024; PwC 2023; State Statistics Service of Ukraine 2024; Statista 2024; United Nations Conference on Trade and Development 2023; World Bank 2024; World Trade Organization 2023).

2.3. Research Methods

The methodological basis is a regression model with fixed effects. The model assesses the impact of digital factors on the competitiveness of enterprises. The dependent variable is the integrated index of competitive advantages. Independent variables: DIGI (digitalization), INNOV (innovation), R&D, EXPORT, SIZE. The model is as follows:

$$Y_{it} = \beta_0 + \beta_1 \cdot DIGI_{it} + \beta_2 \cdot INNOV_{it} + \beta_3 \cdot R\&D_{it} + \beta_4 \cdot EXPORT_{it} + \beta_5 \cdot SIZE_{it} + \mu_i + \varepsilon_{it} \quad (1)$$

where:

- Y_{it} - competitiveness index of enterprise i in year t ;
- β_0 - constant (baseline level of competitiveness without the influence of variables);
- $DIGI_{it}$ - level of digitalization (implementation of CRM, ERP, AI, e-commerce);

- β_1 - impact of digitalization on competitiveness;
- $INNOV_{it}$ - number of innovative products or processes implemented in the enterprise;
- β_2 - effect of innovative activity on competitive advantages;
- $R\&D_{it}$ - share of R&D spending (% of total spending);
- β_3 - impact of R&D on the level of competitiveness;
- $EXPORT_{it}$ - share of exports in the structure of enterprise revenues;
- β_4 - effect of export orientation on competitiveness;
- $SIZE_{it}$ - size of the enterprise (number of employees);
- β_5 - marginal effect of scale of the enterprise;
- μ_i - fixed effect, which takes into account permanent differences between enterprises;
- ε_{it} - random error.

The model identifies how the combination of digital tools, innovations, and foreign economic activity shapes the competitive positions of enterprises in different countries. This approach enables a comparative analysis between countries with different levels of digital maturity and economic development. At the same time, the model takes into account the effect of the scale of the enterprise, which is especially important for countries with a dominance of small businesses.

The following hypotheses were advanced in the study:

Hypothesis 1 - increasing the level of digitalization of the enterprise significantly increases its competitiveness;

Hypothesis 2 – R&D investment and development have the strongest effect among all factors;

Hypothesis 3 - innovations are a key mediator between digitalization and performance;

Hypothesis 4 - export orientation enhances the effect of digital transformations;

Hypothesis 5 - the impact of the scale of the enterprise is positive, but marginal.

So, the model quantifies which digital development factors provide competitive advantage to enterprises in an international context. It is suitable for testing strategic scenarios, comparing countries and industries, and predicting the effects of future digital investments.

2.4. Instruments

The Python language with the Statsmodels library was used for calculations. Tables were created in Pandas and formatted for publication. Visualizations were performed in Matplotlib. Primary data were processed in Excel for aggregation and verification. Cross-validation ensured the stability of the results. Analytical interpretations were based on theoretical approaches and practical data.

3. Results

The article provides an empirical analysis of the relationship between digital technologies and enterprise competitiveness in five European countries. The study is based on panel data for 2019–2024. The analysis covers Moldova, Romania, Ukraine, Poland, and Germany. The main goal is to identify key determinants of competitive advantage in the context of digital transformation. The study uses variables reflecting digital maturity, innovation level, R&D investment, export orientation, and enterprise size. A fixed effect econometric model was built to assess the impact of these variables. Table 1 illustrates the initial parameters by country and year, while Table 2 summarizes the results of the regression estimation.

Input data show significant international differences in the levels of enterprise digitalization. The highest average values are observed in Germany (0.83) and Poland (0.78). These countries have a developed digital infrastructure and stable institutional practices to support innovation. Ukraine and Romania demonstrate moderate rates of digitalization, with active development of online services and Enterprise Resource Planning (ERP) solutions. In Moldova, digitalization indicators are lower (0.45–0.55), but positive dynamics are observed every year. Regarding innovation, the highest average values are recorded in Germany (8.1) and Poland (7.4), while they fluctuate within 3–5 in Moldova and Ukraine. R&D spending have the greatest variation. In Germany, they reach 7–8% of total expenditures, while in Ukraine and Moldova they are about 2–3%. The share of exports in total revenues is significantly higher in Poland and Romania. Moldovan enterprises are mostly focused on the domestic market, which limits the effects of scaling. Enterprise sizes are largest in Germany (average value over 400 people), smallest in Moldova (about 100 people).

Table 1. Input Data

Country	Year	DIGI	INNOV	R&D	EXPORT	SIZE	Competitiveness
Moldova	2019	0.52	8	0.05	0.18	264	4.24
Moldova	2020	0.31	2	0.06	0.57	435	2.69
Moldova	2021	0.41	5	0.05	0.41	302	3.11
Moldova	2022	0.67	3	0.04	0.59	180	2.59
Moldova	2023	0.82	7	0.02	0.13	437	3.82
Moldova	2024	0.53	5	0.03	0.22	493	3.25
Romania	2019	0.37	8	0.01	0.55	469	4.05
Romania	2020	0.56	6	0.05	0.19	240	3.38
Romania	2021	0.81	2	0.04	0.56	400	2.54
Romania	2022	0.46	5	0.05	0.58	237	3.16
Romania	2023	0.63	9	0.03	0.18	394	4.43
Romania	2024	0.74	1	0.05	0.56	90	2.23
Ukraine	2019	0.85	9	0.05	0.27	97	4.62
Ukraine	2020	0.70	8	0.03	0.38	276	3.97
Ukraine	2021	0.37	3	0.06	0.38	304	2.69
Ukraine	2022	0.56	3	0.01	0.42	101	2.20
Ukraine	2023	0.64	4	0.07	0.22	286	3.07
Ukraine	2024	0.87	7	0.03	0.18	115	3.65
Poland	2019	0.67	9	0.02	0.33	157	4.24
Poland	2020	0.84	7	0.07	0.24	332	4.30
Poland	2021	0.56	4	0.03	0.25	247	2.49
Poland	2022	0.43	3	0.03	0.22	364	2.46
Poland	2023	0.49	8	0.06	0.28	491	4.23
Poland	2024	0.47	1	0.03	0.59	269	1.93
Germany	2019	0.33	5	0.03	0.42	175	2.92
Germany	2020	0.89	7	0.06	0.48	172	4.00
Germany	2021	0.45	6	0.04	0.42	247	3.50
Germany	2022	0.78	9	0.03	0.19	398	4.45
Germany	2023	0.82	4	0.01	0.36	196	2.60
Germany	2024	0.86	8	0.04	0.57	178	4.22

Source: developed by the author based on the results of an econometric model using the data from (Deloitte 2023; European Commission 2024; Gartner 2023; International Monetary Fund 2023; International Telecommunication Union 2023; McKinsey & Company 2023; National Bureau of Statistics of the Republic of Moldova 2024; OECD 2023; Polish Central Statistical Office 2024; PwC 2023; State Statistics Service of Ukraine 2024; Statista 2024; United Nations Conference on Trade and Development 2023; World Bank 2024; World Trade Organization 2023)

Considering international comparison, digitalization in the selected countries has different depth, infrastructure, and sectoral orientation. In Germany, digital technologies are integrated into production chains, including the widespread use of ERP, Customer Relationship Management (CRM), artificial intelligence (AI) and the Internet of Things (IoT) in industry, mechanical engineering and the pharmaceutical sector. Poland demonstrates a high level of digitalization in logistics and retail, with active use of cloud services, e-commerce and data analytics, which ensures flexibility and scalability of business models. Cloud solutions, ERP systems and online tools have become the key areas of digitalization in Ukraine, especially in IT, agribusiness and small businesses, which is a response to crisis challenges. In Romania, digital transformation focuses on accounting automation, the implementation of mobile business applications and digital document management, which is actively supported in the export sector. In contrast, digitalization remains basic in Moldova, with a gradual transition to CRM solutions, mainly in small manufacturing enterprises and the service sector.

The structure of R&D also varies by country. In Germany, R&D spending exceeds 7% and is directed at biotechnology, IT solutions, and the green transition in the energy sector. Poland uses national start-up support programmes aimed at transport technologies, digital energy and innovations in the agricultural sector. Ukrainian

enterprises focus on applied developments in the areas of drones, cybersecurity, agrotechnologies and financial innovations, often attracting foreign funding. In Romania, R&D is focused on improving the efficiency of production processes, local software development and digital security solutions. In Moldova, R&D is concentrated in the food and light industry, mostly through participation in international technical assistance programmes. Such a detailed analysis of digital strategies and areas of R&D investment provides a better understanding of national models of digital transformation and their impact on competitiveness.

The regression model gives grounds for drawing conclusions about the impact of each variable on competitiveness. All independent variables are statistically significant at $p < 0.01$, which confirms the reliability of the estimate (Table 2). The R&D variable has the largest coefficient (8.70), which means a strong positive impact of research investment on competitive advantages. An increase in the share of R&D spending by 1% increases the competitiveness index by 8.7 points. This is in line with global trends, where innovative companies have more stable positions in the market. The DIGI variable has a coefficient of 0.52, which indicates a direct positive impact of digitalization on competitiveness.

Table 2. Results of Econometric Modelling of the Impact of Digital Technologies on the Competitiveness of Enterprises in Moldova, Romania, Ukraine, Poland, and Germany for 2019–2024

Variable	Coefficient	Standard Error	t-statistic	P-value	95% CI (Lower)	95% CI (Upper)
Intercept	0.602	0.155	3.89	0.0007	0.283	0.922
DIGI	0.517	0.131	3.94	0.0006	0.247	0.788
INNOV	0.308	0.010	31.63	<0.0001	0.288	0.328
R&D	8.702	1.195	7.28	<0.0001	6.235	11.168
EXPORT	0.455	0.156	2.91	0.0076	0.133	0.778
SIZE	0.00083	0.00019	4.39	0.0002	0.00044	0.00122

Source: developed by the author based on the results of an econometric model using the data from (Deloitte 2023; European Commission 2024; Gartner 2023; International Monetary Fund 2023; International Telecommunication Union 2023; McKinsey & Company 2023; National Bureau of Statistics of the Republic of Moldova 2024; OECD 2023; Polish Central Statistical Office 2024; PwC 2023; State Statistics Service of Ukraine 2024; Statista 2024; United Nations Conference on Trade and Development 2023; World Bank 2024; World Trade Organization 2023)

Enterprises with developed digital platforms and analytical tools demonstrate higher efficiency. The INNOV variable has a coefficient of 0.31, which is also statistically significant. Each additional implementation of an innovative product or process increases competitiveness by almost a third of a point. Export orientation (EXPORT) also plays an important role, with a coefficient of 0.46. This confirms that enterprises that are integrated into global markets have higher adaptability and resilience. Enterprise size (SIZE) also showed a positive effect, but the smallest among all variables (0.00083). Large enterprises have better opportunities to implement digital solutions, but the scaling effect is less pronounced.

In Germany and Poland, digitalization has become an organic part of business models, ensuring a steady growth of competitive advantages. The effect of R&D is particularly noticeable in these countries, as an active innovation ecosystem is maintained. In Ukraine, digital solutions are often implemented in response to external challenges, including war and economic instability. At the same time, this leads to rapid adaptation, especially in the IT and logistics sectors. Gradual digitalization is observed in Moldova, but the lack of investment in innovation reduces the effectiveness of transformations. Romania demonstrates balanced development, combining digitalization with export activity and moderate innovation efforts. It is clear that R&D, digitalization, and innovation are interrelated factors in increasing competitiveness in all countries.

The highest average competitiveness index is observed in Germany (3.62), which confirms a stable digital infrastructure and effective innovation management (Figure 2). Ukraine ranks second (3.37), due to active digital adaptation in times of crisis, namely destruction, military operations, the need for reconstruction, and a moderately high level of R&D (0.044). In Moldova (3.28), the competitiveness index is higher than in Poland (3.27), despite a lower level of digitalization, which indicates the effectiveness of other factors. Romania has the highest average export index (0.44), which compensates for relatively lower levels of innovation and digital solutions. The results demonstrate that the combination of digitalization, innovation, export activity, and R&D has a synergistic effect to increase the competitive advantage of enterprises.

Figure 2. Summary Data of Average Indicators for Selected Countries



Source: developed by the author based on the results of an econometric model using the data from (Deloitte 2023; European Commission 2024; Gartner 2023; International Monetary Fund 2023; International Telecommunication Union 2023; McKinsey & Company 2023; National Bureau of Statistics of the Republic of Moldova 2024; OECD 2023; Polish Central Statistical Office 2024; PwC 2023; State Statistics Service of Ukraine 2024; Statista 2024; United Nations Conference on Trade and Development 2023; World Bank 2024; World Trade Organization, 2023)

The results of the study confirm the key role of digital technologies in creating sustainable competitive advantages of modern entrepreneurship. Digitalization significantly improves management efficiency, reduces costs and expands market opportunities. Innovative activity acts as a multiplier of the digitalization effect. R&D investment, especially in high-tech sectors turned out to be the most effective factor. Export orientation enables enterprises to capitalize on digital advantages in international markets. The size of the enterprise has a secondary impact, but large firms have more resources for digital transformation. The results have practical significance for government programmes to support the digitalization of SMEs. In countries with innovative and digital economies, it is important to create institutional conditions to stimulate innovation and technological development.

4. Discussion

The results of the study confirm the key thesis of Lüdeke-Freund (2020) about the need to combine innovation, entrepreneurship and sustainability into a single business model. We agree with the author that successful entrepreneurship requires the integration of digital technologies and environmental responsibility. Verhoef *et al.* (2021) emphasize the interdisciplinary nature of digital transformation, which is fully consistent with our international approach to the analysis. Our model deepens their findings by adding an econometric dimension of the digital impact on competitiveness. Gavrila-Gavrila and De Lucas Ancillo (2022) argue that the pandemic has accelerated digitalization, which we confirm for Ukraine and Moldova. We complement their results with a comparative assessment of digital adaptation in countries with different digital bases. Anand *et al.* (2021) note in their bibliometric analysis that research on sustainable entrepreneurship is too fragmented. Our study compensates for this fragmentation by integrating digital, institutional, and innovation parameters into a single model. Bican and Brem (2020) raise the issue of the sustainability of digital business models. We fully agree with it. Our model shows that R&D investment that create the foundation for sustainability in the context of digitalization.

At the same time, the results confirm the importance of the regulatory environment, which Kussainov *et al.* (2023) cover in the context of digital security in the EU. Their focus on AI as a transparency tool complements our thesis on the importance of digital governance strategies. Melnyk *et al.* (2022) argue for the importance of anti-corruption mechanisms for institutional resilience, which supports our findings on the role of public administration in digital transformation. Nikonenko *et al.* (2022) emphasize the potential of Industry 4.0 for investment

attractiveness, having something in common with our focus on the impact of digital technologies on external markets. We extend these approaches by assessing specific factors of export activity in a competitive advantage model. Shafranova *et al.* (2024) consider digital currencies and quantum financial systems as the next stage of digital transformation. Although this is beyond the scope of our model, we acknowledge the value of their work as a strategic reference for further research. Koldovskiy (2024) and Kryvoviazuk (2013) emphasize the importance of strategic digital infrastructure, which is consistent with our findings on the critical role of digitalization in transforming economies.

So, the results of our study confirm and deepen current academic approaches to the study of digital entrepreneurship in the context of sustainable development. We agree with the main provisions of earlier studies, also supplementing them with a quantitative cross-country assessment of digital advantages in business. So, our approach can also quantitatively assess the enterprise potential of modern enterprises in the context of the digital economy, which is an important indicator of their long-term sustainability.

4.1. Limitation

The study covers only five countries, which limits the scope of generalizations. The sample of enterprises does not cover all sectors of the economy. The data is obtained from open sources and may contain errors. The impact of digital technologies was estimated on an average across countries without sectoral detail. Changes in the regulatory environment that could have affected digitalization were not considered.

4.2. Recommendations

It is recommended to expand the geography of the study to other regions of Europe and the world. It is appropriate to conduct analysis at the level of individual business sectors. Sustainable development indicators should be integrated into the competitiveness model. It is appropriate to consider the impact of state digital policies on the effectiveness of transformations. It is advisable to include dynamic indicators to track changes in real time.

Conclusions

As a result of the study, the goal was fully achieved, and all the identified tasks were successfully completed. The developed econometric model confirmed a sustainable positive impact of digital technologies on the creation of competitive advantages of enterprises. The analysis covered data from five European countries for 2019–2024, considering international differences. All five variables of the model were statistically significant: digitalization, innovativeness, R&D spending, export orientation, and enterprise size. The highest coefficient was R&D – 8.70, which indicates its critical role in strengthening market positions. The level of digitalization showed a strong impact ($\beta = 0.52$), confirming the importance of technological maturity for strategic success. Innovative activity ($\beta = 0.31$) and orientation to foreign markets ($\beta = 0.46$) also significantly contribute to the growth of competitiveness. The effect of firm size was the smallest ($\beta = 0.00083$), but still positive and statistically significant.

The results of the study confirm that digital technologies are a catalyst for the development of enterprises regardless of their country of location. At the same time, the impact of digitalization is more pronounced in combination with innovation, expansion into new markets and internal development. Enterprises in Germany and Poland had the highest indicators of digital efficiency, which is associated with a high level of institutional support. In Ukraine and Moldova, digitalization was often a forced reaction to external challenges but demonstrated positive dynamics. The obtained results have practical significance for shaping national strategies for the digital transformation of entrepreneurship, digitalization is especially important for countries that are in a state of post-crisis recovery and integration into the European space. A key role in the creation of digital advantages is played by the combination of innovation and entrepreneurial potential, which includes the ability to adapt, scale, and integrate digital solutions.

Further research should focus on sectoral analysis of the effects of digitalization, taking into account the specifics of economic sectors. Special attention should be paid to small businesses in the fields of healthcare, education, agribusiness, and digital services. Another promising direction is the integration of indicators of sustainable development, digital environmental friendliness, and cybersecurity into the competitiveness model. Analysis of the effectiveness of state policy on digital transformation also requires deeper study in subsequent empirical work.

Credit Authorship Contribution Statement

The authors equally contributed to the present research, at all stages from the formulation of the problem to the final findings and solutions.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Declaration of Use of Generative AI and AI-assisted Technologies

The authors declare that they have not used generative AI and AI-assisted technologies during the preparation of this work.

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Is the Digital Economy Partnership Agreement Effective in Export of Digitally Deliverable Services? The Case of Türkiye

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Abstract: This study examines the potential of the Digital Economy Partnership Agreement (DEPA) in addressing the challenges faced by Turkish businesses in e-commerce and e-export activities. It begins with a comprehensive analysis of the concepts of e-commerce and e-export, focusing on the digitalization of international trade. The study then evaluates the provisions of DEPA, particularly those relevant to the specific barriers encountered by Turkish e-commerce and e-export businesses. The findings suggest that DEPA includes various mechanisms that could help mitigate these challenges and enhance Türkiye's integration into the digital economy. The research employs a panel data analysis using the Fixed Effects Model with Driscoll-Kraay (FE-DK) standard errors to assess the impact of DEPA on the export of digitally deliverable services alongside other key independent variables. Data from DEPA founding countries New Zealand, Singapore, Chile, and Türkiye, which is not a party to the agreement, are analyzed. The empirical results highlight the significance of a secure internet infrastructure and structured international agreements, such as DEPA, in fostering the growth of digital services exports. Moreover, participation appears to positively influence export performance, although the statistical significance varies depending on model specification.

Keywords: e-commerce; digitalization in international trade; strategy of Türkiye's e-export; panel data analysis.

JEL Classification: F13; F14; C23; L81; O57.

Introduction

E-commerce is a significant and growing sector, with an increasing level of trade and a substantial contribution to exports. Many countries are reaching agreements on e-commerce through free trade agreements, economic agreements, or dedicated digital economy regulations. Today, most international economic agreements include provisions related to e-commerce and, consequently, e-exports.

Countries seeking to expand their e-exports often engage in cooperative agreements to achieve common goals. These goals include establishing electronic platforms to facilitate transactions, end-to-end digital trade, online commercial activities protection, and creating a standardized framework for conducting business (Ministry of Trade and Industry Singapore 2025).

Various actors participate in e-exports, including small and medium-sized enterprises (SMEs) selling on e-commerce platforms, entrepreneurs with independent online businesses, and large-scale enterprises. This activity involves complex interactions between sectors like IT, logistics, law, foreign trade, finance, and more, necessitating collaborative efforts for successful outcomes (OECD 2020).

Digitally deliverable services refer to services that can be delivered remotely over information and communication technology (ICT) networks. These include sectors such as telecommunications, computer and

information services, financial and insurance services, and certain categories of professional and educational services. In the context of international trade, digitally deliverable services represent a rapidly growing component of cross-border service flows, as recognized by World Trade Organization (WTO) statistics (WTO 2023).

This study aims to assess the potential of the DEPA to address the challenges faced by Türkiye's e-commerce and e-export sectors. The study provides a general overview of e-commerce and e-export and subsequently identifies the terms of the DEPA agreement that are relevant to the specific challenges faced by Turkish businesses engaged in digital trade. A panel data model is employed to examine digitally deliverable services exports (DSE) as the dependent variable. This variable encompasses the e-exports of insurance and pension, financial, intellectual property, telecommunication and information, research and development, professional and management, technical, trade-related, audiovisual, recreational, health, educational, cultural, and heritage services. DEPA - which includes regulations covering most of these sectors - is incorporated into the model as a key explanatory variable alongside trade to gross domestic product ratio (TGDP) and secure internet servers (SIS). Through this quantitative framework, the study contributes to the empirical understanding of DEPA's trade effects, offering a novel approach within a literature that is predominantly conceptual and policy focused.

1. Literature Review

The digital economy has emerged as a key driver of global economic growth, influencing trade policies, governance structures, and labor markets (Ciuriak 2022). While definitions of the digital economy vary, they generally focus on producing goods using digital technologies and their impact on socio-economic processes (Zaistev 2019). The concept of a digital economy first explored Bowman (1996), has gained renewed relevance due to recent global events such as the COVID-19 pandemic, which accelerated digital adoption. This transformation, driven by technological disruption, has created opportunities and challenges across various sectors (Śledziwska and Włoch 2021). Given this rapid evolution, further qualitative and quantitative research is recommended to gain deeper insights into the digital economy (Limna, Kraiwanit, and Siripipathanakul 2023).

The expansion of the digital economy is particularly pronounced in developing countries, where it is estimated to account for approximately 5% of global GDP and 3% of global employment (Bukht and Heeks 2017). However, digital transformation has presented significant challenges for international trade and governance. The Organisation for Economic Co-operation and Development (OECD) proposed tax reforms for the digital economy that have raised concerns regarding national sovereignty, market competitiveness, and the risk of monopolization (Gurdgiev 2019). To address these challenges, a flexible international governance regime incorporating multistakeholder organizations and "soft rules" has been suggested to promote policy convergence (Cowhey and Aronson 2018). Furthermore, trade agreements must evolve to accommodate new digital trade modes, tackling issues such as net neutrality, data localization, and privacy (Ciuriak and Ptashkina 2018).

Digital technologies have fundamentally reshaped economic activities by reducing costs associated with search, replication, transportation, tracking, and verification (Goldfarb and Tucker 2017). This transformation has also spurred the rise of digital entrepreneurship, an emerging and increasingly interdisciplinary field gaining academic and practical legitimacy (Zaheer, Breyer, and Dumay 2019).

The acceleration of digitalization has made e-commerce significant in the global economy. The growing flow of goods and services between countries via online platforms has transformed business models and influenced legal and economic regulations. Many international institutions have established global standards and policies guiding e-commerce throughout the period.

Established in 1995 to replace the General Agreement on Tariffs and Trade (GATT), the WTO is an international organization that works to resolve trade disputes between member countries and to liberalize trade (WTO 2025). In 1998, the WTO launched a work program aimed at establishing standards in the areas of goods, services, and intellectual property related to e-commerce. This program covers various issues, including the exemption of goods and services delivered electronically from customs duties and the conditions for fair competition (WTO 1998).

In the 2000s, a trend toward liberalization in e-commerce emerged alongside the General Agreement on Trade in Services (GATS). However, this era also gave rise to anti-liberal viewpoints grounded in concerns that companies, taking advantage of relaxed regulations, could shift online activities to jurisdictions with cheaper labor, lower taxes, or more lenient environmental laws (Shniad 2000). If a WTO member identifies potential violations of the GATS, GATT, or TRIPS agreements in another member's e-commerce-related practices, it may raise the issue under Article 1 of the Dispute Settlement Understanding (WTO 1994).

Another organization that regulates e-commerce is the United Nations Commission on International Trade Law (UNCITRAL), which operates under the United Nations (UN). The commission's mandate includes worldwide legal reforms to modernize and harmonize international trade rules. In this context, it develops model laws and guiding principles in the field of electronic commerce. To establish a legal framework for electronic commerce and harmonize national laws, UNCITRAL published the Model Law on Electronic Commerce in 1996 and the Model Law on Electronic Signatures in 2001. Additionally, it created the CLOUT system to disseminate various commercial case rulings (UN 2013).

The Model Law on Electronic Commerce provides a framework to support the use of modern communication techniques, such as electronic data interchange, electronic signatures, data messages, and digital contracts, while recognizing their legal validity. Additionally, the law is based on the principle of "functional equivalence." This approach acknowledges that electronic documents can replace paper documents and considers them legally equivalent as long as they fulfill the same functions (UN 1999).

The Model Law on Electronic Signatures was developed to ensure the legal validity of electronic signatures in international trade and to enhance their reliability. Based on functional equivalence, the law establishes that electronic signatures have the same legal effect as handwritten signatures. It also includes provisions for the recognition of foreign certificates and electronic signatures used in cross-border trade (UN 2002). The law helps reduce legal uncertainty in e-commerce transactions, fostering a secure digital trade infrastructure.

The United Nations launched the "eTrade for all" initiative to promote equal opportunities in e-commerce. This initiative aims to enhance the ability of developing and least-developed countries to utilize and benefit from e-commerce (UN Conference on Trade and Development 2016). As part of the UN's Sustainable Development Goals, the initiative also focuses on advancing gender equality by empowering women in the digital economy. Additionally, to foster partnerships for shared objectives, it seeks to strengthen global cooperation, reduce inequalities between countries, and support economic growth. The initiative plays a role in organizing meetings, publishing reports, and identifying individuals capable of providing technical assistance to countries in need of support in e-commerce activities (UN 2024).

In the context of digital piracy and e-commerce, the World Intellectual Property Organization (WIPO) Copyright Treaty, prepared by the WIPO, is a significant international regulation. This treaty includes provisions to protect works in the digital environment, particularly ensuring copyright protection for computer programs and databases (WIPO 1996). Additionally, in Türkiye, Regulation of Publications on the Internet and Combating Crimes Committed Through Such Publications is in force as part of efforts to combat digital piracy. This law aims to regulate online publications and address crimes committed via these publications (Official Gazette of the Republic of Türkiye 2007). Regulations like these provide essential legal frameworks for combating digital piracy and ensuring the safe continuation of e-commerce.

The Handbook on Measuring Digital Trade, created by various international organizations, emphasizes that e-commerce is a significant subcomponent of digital trade. Digital trade is defined based on the criteria of digitally ordered trade and digitally delivered trade. In this context, e-commerce is described as the international sale or purchase of goods or services through digital ordering, and the handbook provides statistical guidelines for measuring international e-commerce (International Monetary Fund *et al.* 2023). The handbook also proposes using various data sources (e.g., surveys, payment data, customs records) to overcome challenges in measuring digital trade. It aims to help policymakers utilize these data sources more effectively for informed decision-making.

In conclusion, the legal regulations and policies introduced by international organizations aim to strengthen the impact of e-commerce on the global economy while ensuring that trade takes place on a safer, more accessible, and sustainable foundation. Governments are developing new digital economy agreements to complement existing trade frameworks to address the challenges and opportunities presented by digital transformation. These agreements aim to facilitate digital trade, promote innovation, and establish governance mechanisms for emerging technologies. The DEPA exemplifies this broader trend, focusing on enhancing regulatory coherence and interoperability across jurisdictions (Ciuriak 2022). Such agreements play a crucial role in ensuring that digital trade rules align with contemporary technological advancements, particularly in artificial intelligence, quantum computing, and cybersecurity (Peters 2023).

Despite these efforts, existing international trade frameworks, particularly the WTO rules, have struggled to keep pace with rapid technological advancements and the emergence of digital trade barriers (Burri 2016). The Information Technology Agreement (ITA), established in 1996, has not evolved alongside the digital economy, raising concerns about its obsolescence (Lee-Makiyama 2011). Various policy approaches have been proposed

to address these gaps, including extending the ITA, developing a Trade in Services Agreement (TISA), or creating a dedicated Digital Economy Trade Agreement (Burri 2016). These initiatives aim to develop future-oriented multilateral rules for digital trade that accommodate the complexities of the modern digital landscape while promoting inclusive economic growth and development (Burri 2016; Peters 2023).

2. E-Export

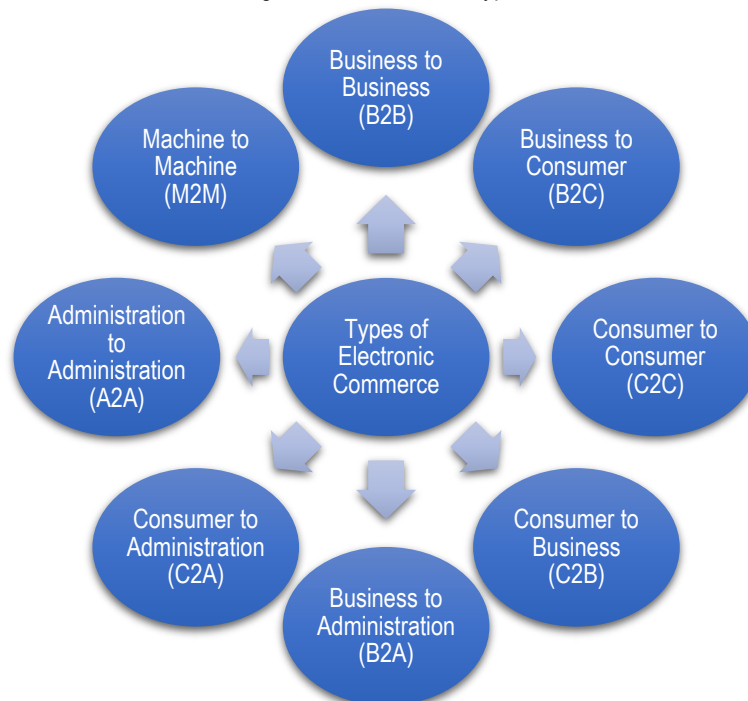
To understand the definition of e-export, we first need to define e-commerce. Various sources offer different definitions of e-commerce. Some of these are as follows. Goode (2020) defined e-commerce as the electronic production, distribution, marketing, sale, or delivery of goods and services. This definition emphasizes the broad scope of e-commerce, encompassing the entire value chain of goods and services.

Commission of the European Communities (1997) provided a more detailed definition: E-commerce is based on the electronic processing and transmission of data, including text, sound, and video. It encompasses a wide variety of activities, including e-commerce in goods and services, online delivery of digital content, electronic funds transfers, electronic stock trading, electronic bills of lading, commercial auctions, collaborative design and engineering, online sourcing, public procurement, direct consumer marketing, and after-sales service. It covers both products and services; it includes traditional activities (e.g., healthcare, education) and new activities (e.g., virtual shopping malls). This definition highlights the diverse applications of e-commerce across various sectors and activities.

OECD (2011) offered a more concise definition: E-commerce is the sale or purchase of goods or services conducted over computer networks by methods specifically designed to receive or place orders. This definition focuses on the core transaction of buying and selling goods and services online.

In Figure 1 M2M and A2A are emerging types of e-commerce with novel applications. For example, in a pantry where a smart home system is used, artificial intelligence software might digitally order the legumes running out in your home from the websites you have previously selected, price and quantity, and supply the necessary products. A2A encompasses e-commerce transactions between government agencies or within different departments of the same government, facilitating efficient inter-agency communication and collaboration for improved public service delivery.

Figure 1. E-Commerce Types



Source: Author

Jain, Malviya, and Arya (2021) explained e-commerce types as follows: B2B encompasses all electronic transfers of products or services between businesses. Manufacturers and traditional wholesale companies often utilize this approach for efficient supply chain management and procurement. B2C represents the online equivalent of traditional retail sales, where consumers can access more information about products and services,

enabling informed purchasing decisions. C2C covers all electronic transactions of goods or services between consumers, typically facilitated by a third-party platform that provides an online marketplace. C2B is prevalent in companies leveraging crowdsourcing, where individuals offer products or services to businesses seeking specific solutions, such as platforms for royalty-free images, media, and design elements. B2A involves all online transactions between businesses and government agencies, encompassing various applications like tax returns, healthcare services, legal documentation, and public records management. C2A includes all electronic interactions between individuals and government entities, often facilitated through e-government platforms for services like online tax payments, license renewals, and access to public information.

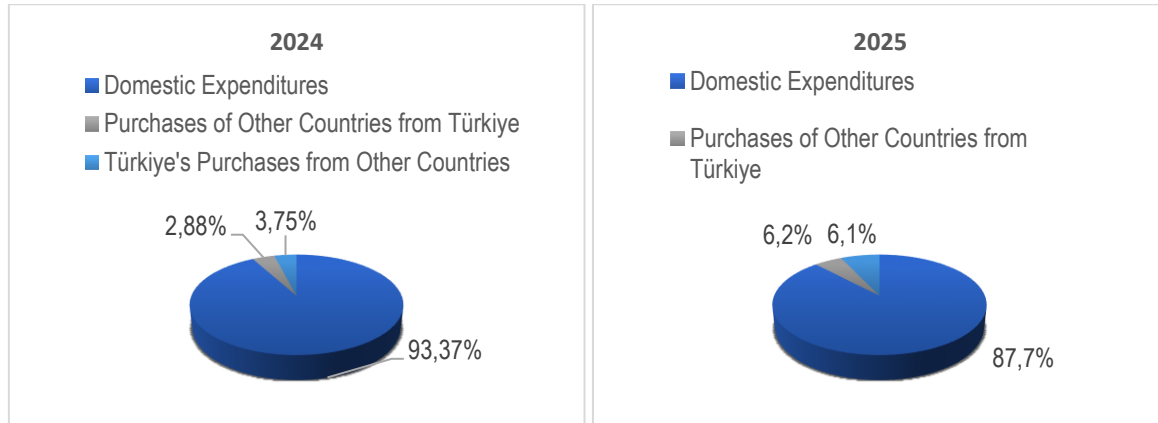
E-commerce offers significant economic advantages. It fosters a competitive market environment, driving prices towards optimal equilibrium and providing consumers with access to a broader selection of goods and services at competitive prices. Additionally, consumers benefit from increased transparency and access to information, enabling more informed purchasing decisions.

According to the Ministry of Trade: Republic of Türkiye (2022), e-export can be defined as cross-border e-commerce. It involves delivering goods ordered online from a foreign country, adhering to micro-export regulations, and encompasses cross-border B2C, B2B, and C2C transactions.

The distinctions between e-commerce and e-export are similar to the ones faced by businesses expanding into international markets. These include establishing websites that support foreign currency transactions, adapting websites to cater to target markets' languages, and navigating logistical complexities such as shipping regulations and international shipping fees.

In Figure 2 e-commerce spending in Türkiye is predominantly domestic, as shown in the comparison between 2024 and 2025. However, cross-border e-commerce transactions, where one party is a foreign country, increased by 5,67% in 2025 compared to the previous year. It's crucial to consider exchange rate fluctuations when interpreting this increase. The total volume of transactions by foreign customers on Turkish websites increased by 3,32% while spending by Turkish consumers on foreign e-commerce platforms rose by 2,35%. The overall share of cross-border e-commerce remained relatively large. The rates of both e-exports and e-imports have increased.

Figure 2. Distribution of E-Commerce Spending in the 1st and 2nd Quarters of 2024 and 2025



Source: Translated by the author from (Ministry of Trade: Republic of Türkiye 2024; 2025).

2.1. Can DEPA Address Sectoral Problems in Türkiye's E-Export?

DEPA is the world's first digital trade agreement. It consists of sixteen chapters and introduces new regulations on e-commerce and e-exports, considering previous agreements signed by the countries. It was signed by the three founding members on November 6, 2020, and entered into force on January 7, 2021 (Pacific Economic Cooperation Council 2021). Table 1 provides an overview of the countries participating in DEPA and their respective membership statuses.

Other countries may also join this agreement. In general, DEPA is a unique and forward-looking project that comprehensively covers various issues that affect the digital economy. It provides a solid foundation for the harmonization and interoperability of domestic frameworks and international cooperation, taking complexities sufficiently into account (Burri 2021). The parties to the agreement establish a joint committee representing the governments. The committee makes decisions based on consensus (Ministry of Trade and Industry Singapore 2024).

China, Canada, Costa Rica, Peru, United Arab Emirates (UAE), and El Salvador aim to join DEPA for several reasons. It seeks to promote e-commerce domestically and enable trade diversification for the countries' businesses, including SMEs. Additionally, Canada recognizes that past free trade agreements lack the sophistication to address the challenges faced by businesses operating in the digital economy.

Table 1. DEPA Party Countries and Their Status

Country	Status
New Zealand	Founding Member
Chile	Founding Member
Singapore	Founding Member
South Korea	Member
Canada	Applicant
Chinese	Applicant
Costa Rica	Applicant
Peru	Applicant
United Arab Emirates	Applicant
El Salvador	Applicant
Ukraine	Applicant

Source: Author's table based on Ministry of Trade and Industry Singapore (2025).

By joining early, Canada can contribute to the future development of DEPA and ensure its interests are reflected in the agreement's evolution (Government of Canada 2022). A study discussing Canada's participation in the DEPA concluded that it could help reduce Canada's future domestic policy barriers to adopting new laws and regulations for digital trade policy (Fay and Ciuriak 2022). The DEPA welcomed its first new member, Korea, in May 2024 (Ministry of Trade and Industry Singapore 2024).

Figure 3 presents a comprehensive overview of the thematic areas covered by the DEPA, encompassing digital trade, data-related issues, digital security, emerging technologies such as AI and fintech, and digital inclusion. These components reflect DEPA's holistic approach to regulating the digital economy.

Figure 3. Some Areas Covered in the Agreement



Source: (Asia Pacific Foundation of Canada 2021).

The agreement encompasses several key domains relevant to digital trade, including: The promotion of paperless trading, streamlined customs procedures, e-payments, and the adoption of e-invoicing to reduce costs. DEPA further emphasizes data protection through legal frameworks for personal data and principles such as

transparency, accountability, and data quality. It reaffirms commitments on cross-border data flows and server localization, while also safeguarding public policy interests. Cybersecurity, spam regulation, digital identity interoperability, and open government data initiatives contribute to a trusted digital environment (Ministry of Trade and Industry Singapore 2024).

In addition, DEPA addresses emerging issues like FinTech, artificial intelligence, and digital public services. It establishes cooperation frameworks for small and medium-sized enterprises (SMEs), encourages innovation, and ensures transparency in digital regulations. The agreement also provides a fair and efficient dispute resolution mechanism designed to minimize the need for formal arbitration, reinforcing DEPA's role as a flexible and future-ready model for digital trade cooperation.

In recent years, important publications have been made by ministries and institutions operating in the export sector. In this section it will be determined what the identified problems are in Türkiye's e-exports and whether DEPA will be a solution. Table 2 summarizes key consumer problems identified in Türkiye's e-commerce landscape.

Table 2. Turkish Retail E-Commerce Consumer Problems

The Rate of People Who Have Problems (%)	2011	2012	2015	2016	2017
	7,4	9,4	23,2	24,9	21,5
Types of Problems (%)					
Technical malfunction encountered on the website during the order or pay phase	9,4	16,7	20,3	24,2	20,1
It is difficult to find information about warranty conditions and other legal rights	3,7	3,5	12,6	12,9	13,6
The delivery is slower than specified	31,0	39,9	47,0	44,9	46,5
The price of the product or service is higher than specified (e.g., unexpected transaction costs or high delivery fees)	5,8	5,2	11,4	7,4	9,8
Delivery of incorrect, damaged product or service	42,7	47,7	45,4	42,1	49,1
Fraud (e.g., Failure to deliver a product or service, credit card misuse of their information, etc.)	15,4	5,5	10,8	10,6	15,0
Difficulties in complaints and compensation or inability to get satisfactory answers after complaints	4,2	4,6	18,1	19,7	19,5
Not selling goods and services from websites originating abroad to the country	-	-	9,7	5,3	7,3
Other	7,3	3,1	1,6	2,7	1,8

Source: TurkStat as cited in Deliçay (2021).

Regarding the problems encountered during the payment phase, DEPA has goals to ensure the compatibility of the payment infrastructure between countries by establishing a new system. In the section on electronic payments regulated by Ministry of Trade and Industry Singapore (2024):

- Connecting payment infrastructures by accepted international standards and promoting innovation and competition in a way that benefits the payments ecosystem.
- Encouraging the use of Application Programming Interfaces (APIs) to enable the development of electronic payment systems.
- Parties endeavoring to ensure trust and reliability factors, such as cross-border verification of digital identities.

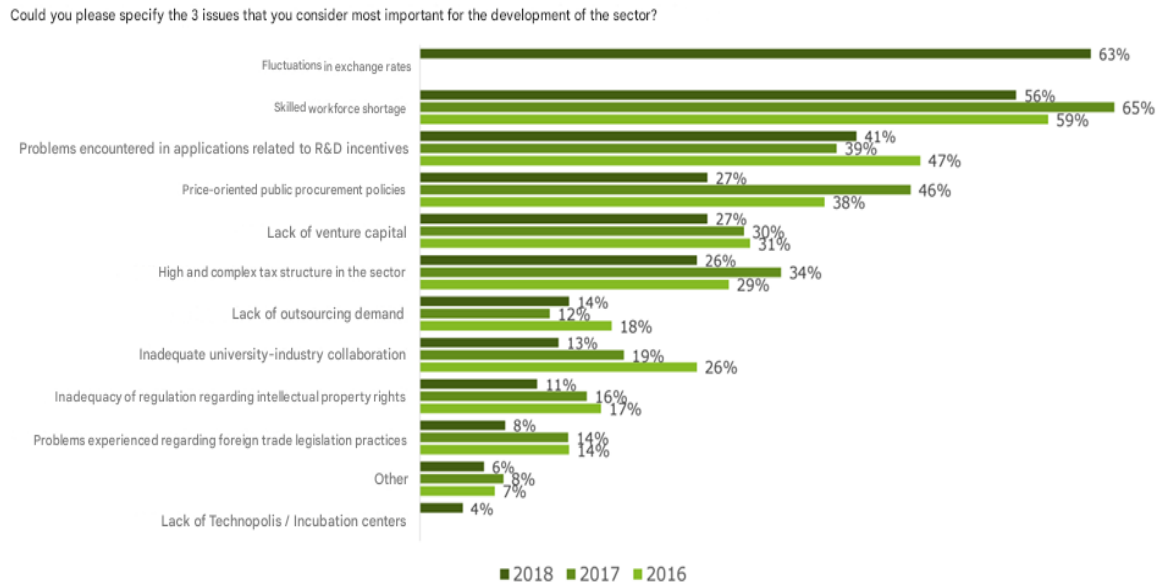
The problem of slow deliveries shows an increasing trend year by year, and this issue has been addressed by DEPA. In express shipments, steps will be taken to facilitate delivery of e-export by shortening customs procedures.

To ensure a broader environment of trust in matters such as misleading or fraudulent product and service pricing, a series of articles have been outlined (Ministry of Trade and Industry Singapore 2024). In Article 6.3, which regulates online consumer protection: Consumer protection laws and compensations will come into effect to prevent deceptive, misleading, and fraudulent conduct regarding the material characteristics, price, quantity, and origin of goods and services and to prevent situations such as pages opened for product advertising without the intention to supply or non-delivery of the product despite collecting a fee from the consumer it has been said.

The agreement also includes provisions regarding protecting personal data, which is critical to consumers. These provisions include the harmonization of different laws to protect personal data, clearly defining the purpose of data collection, and minimizing unsolicited commercial electronic messages (Ministry of Trade and Industry Singapore 2024). Other sections and articles explain what will happen in contentious cases (determining the court of jurisdiction, dispute resolution, conciliation, arbitration, etc.).

While a survey was conducted for consumers in Table 2, the Turkish Exporters Assembly touched upon the problems faced by businesses operating in the sector in Figure 4. As seen in the survey research in which 112 companies participated and the Turkish Exporters Assembly report, some similar problems are striking. It means that the difficulties encountered by consumers and businesses overlap.

Figure 4. Problems Encountered in the Sector



Source: Translated by the author from (TÜBİSAD and Deloitte 2019).

DEPA is an agreement that includes provisions related to public procurement, tax regulations, intellectual property rights regulations, and shortening the duration of customs procedures. It stipulates the creation of a publicly available database indicating intellectual property rights and observes the international agreements signed by the member countries (Ministry of Trade and Industry Singapore 2024).

In a publication by the European Union Intellectual Property Office investigating intellectual property rights infringements in e-commerce, the institution selected four countries (Sweden, Spain, the United Kingdom, and Germany) and identified some suspicious e-commerce sites in these countries in terms of intellectual property rights. When the 27,870 suspected sites were examined, it was determined that 25.9% of the hosting companies were Turkish, 19.3% were Dutch, and 18.3% were US-based companies (European Union Intellectual Property Office 2017). Regarding government procurement, as regulated in the Ministry of Trade and Industry Singapore (2024):

- The Parties acknowledge that the digital economy has an impact on public procurement and affirm the importance of open, fair, and transparent public procurement markets.
- To this end, the parties undertaking cooperative activities to understand how further digitization of procurement processes and goods and services affects existing and future international public procurement commitments.

Furthermore, the coordination of competition laws among member countries is also among the regulations in public procurement. Regarding customs duties, there is a goal to shorten the duration of customs procedures for express shipments, and the parties will not apply customs duties to electronic transmissions (Ministry of Trade and Industry Singapore 2024).

Chapter 15 of the agreement sets out situations in which prudential exceptions may be appropriate (such as monetary and exchange rate policy exceptions, tax exceptions, and measures to safeguard the balance of payments).

According to UTİKAD (2019), some of the problems encountered in the logistics processes of e-commerce and e-export are a lack of knowledge of SMEs in logistics processes, product returns, increasing cargo costs, loss and damage occurring for various reasons when delivering goods to the end user, obstacles arising from legislation, systems or bureaucracy, delays in the processing of shipments subject to the Electronic Commerce Customs Declaration, preventing them from leaving the country the next day, and the lack of publication of statistics regarding this declaration, inconsistencies between the procedures applied and the legislation, and inter-institutional communication by mail. This study also, which specifically addresses many problems related to

the Electronic Commerce Customs Declaration, states that e-invoices cannot be used in transactions subject to this declaration, micro-exporters pay stamp duty for their shipments, and it is unsuitable for inward and outward processing procedures.

For these reasons, the lengthening of delivery times and the decrease in international competitiveness negatively affect the e-export sector. In the e-export sector, which stands out in the global market, competition among countries has increased. Deficiencies and errors in a highly competitive market may direct customers to alternative exporters and discourage them from purchasing. Addressing these problems may lead to a decrease in costs and an expansion in the e-export sector.

According to Önal (2022), SMEs are unsuccessful in e-export due to delivery time, logistics costs, return processes, legislation, lack of foreign language skills, and collection and payment methods.

DEPA's new delivery models for logistics, the use of electric and autonomous vehicles, the implementation of electronic delivery lockers, the sharing of logistics applications among the parties, and last-mile logistics solutions are supportive of the countries party to the agreement (Ministry of Trade and Industry Singapore 2024).

International trade transactions involve many actors and continue to be carried out mainly using paper. In 2014, Danish shipping company Maersk observed a refrigerated container full of roses and avocados traveling from Kenya to the Netherlands to document the process, which consisted of physical processes and paperwork affecting each shipment. They found that around 30 actors and over 100 people were involved throughout the journey, and the number of interactions exceeded 200. It took approximately 34 days for the shipment to reach retailers from the farm, including 10 days spent waiting for documents to be processed. During this time, one of the critical documents was lost and later found after much effort (Park 2018).

As AI-powered programs and cryptography applications advance, the complexities and challenges associated with foreign trade processes will decrease. With the acceptance of cryptocurrencies by countries and companies increasingly accepting payments in cryptocurrencies, their use is growing day by day. This will further increase with the implementation of Central Bank Digital Currencies (CBDCs) that central banks are developing.

The operating mechanism of cryptocurrencies is based on distributed ledger technology. This technology, also known as blockchain technology, can be used to audit the security of the cryptocurrency system and transfer documents used in international trade. It is also stated that distributed ledger technology reduces document requirements in sectors such as e-commerce, real estate, healthcare, digital content, and copyright (Ünal and Uluyol 2020).

According to the report published by Türkiye Exporters Assembly (2019), the weaknesses and threats in the e-export sector are the inability to access e-export figures, the lack of vertical and horizontal analysis of e-export, the unavailability of internationally accepted payment systems such as PayPal in our country, long processing times in exporter unions, the constantly changing market, the fact that the rate of fully digitized SMEs is 4% of the total number of SMEs, the inability of institutions and ministries to see bank records, and the lack of distinction between e-export and conventional export.

Various processes using paper documents increase coordination and administrative costs and are prone to errors, loss, and fraud. The complexities and costs associated with international trade in goods have led companies and governments to explore how blockchain can be used to reduce paperwork and improve processes involved in exporting goods, from trade finance to customs procedures and transportation (Ganne 2018).

The paperless trade and electronic invoice articles regulated by DEPA aim to prevent some errors of SMEs and those caused by the system. Regarding paperless trade and regarding electronic invoices Ministry of Trade and Industry Singapore (2024):

- The Parties will endeavor to provide trade administration documents in a manner that incorporates Optical Character Recognition (OCR) capabilities.
- The necessary documents and requirements regarding imports, exports, and transit will be obtained from a single-window system.
- Internationally accepted standards will carry out data exchanges in this system.
- It is important to adopt a common international standard so that businesses can work and coordinate with each other across borders.
- Parties will make efforts to promote the existence of basic infrastructure that will support e-invoices, raise awareness about invoices, and develop the capacity of the system.

DEPA is an agreement that includes provisions supporting SMEs and transparency with the opportunities it provides, such as artificial intelligence and analysis, harmonization of payment methods, and shortening transaction times. It is an agreement that also covers topics such as the importance of using artificial intelligence

in the digital economy, the importance of a fair and transparent state in the market, and the promotion of cooperation between financial technology companies (Ministry of Trade and Industry Singapore 2024).

DEPA supports SMEs in e-export with its article that provides for investments and collaborations in the digital economy for SMEs and aims to promote SME exports. It includes issues such as regulating investments and collaborations for SMEs in the digital economy and promoting SME exports (Ministry of Trade and Industry Singapore 2024).

3. Empirical Analysis

3.1. Data Description

The study analyzes the volumes of DSE for four countries: Chile, New Zealand, and Singapore, which hold founding member status under the DEPA, and Türkiye, which is not a member of DEPA. The independent variables include the number of SIS, the DEPA dummy variable, and the TGDP. The analysis uses data from the years 2010 to 2023. Table 3 provides a detailed overview of all variables used in the study, including their sources and units of measurement.

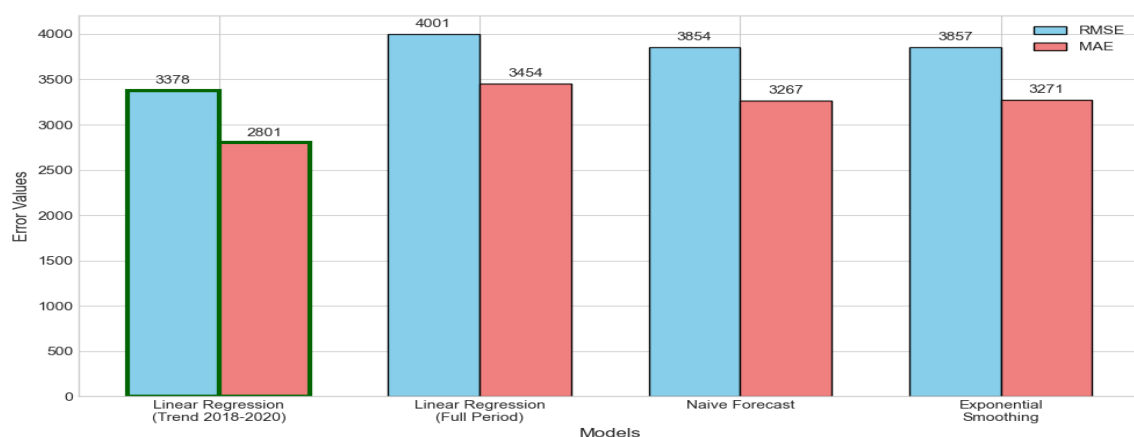
Table 3. Definition of Variables

Variable	Definition	Database	Unit
TGDP	Total Trade as a Percentage of GDP	World Bank (2024b)	%
DEPA	Digital Economy Partnership Agreement	Ministry of Trade and Industry Singapore (2024)	Dummy (0, 1)
SIS	Secure Internet Servers	World Bank (2024a)	Quantity
DSE	International Trade in digitally deliverable services exports	UNCTADstat (2024)	Millions (USD)

Source: Author

All panel data analyses, and the model's reliability and validity tests were conducted in Stata 17. Since data on Türkiye's digitally deliverable services exports were unavailable for 2010–2012, missing values were imputed using a machine learning approach - Scikit-learn's linear regression-based model (Pedregosa *et al.* 2011). The data for all variables spans the years 2010 to 2023. Utilizing a balanced panel dataset enhances the validity and reliability of the analysis by mitigating bias associated with missing data (Baltagi 2021).

Figure 5. Model Performance Comparison



Source: Author

Different methods were compared for the estimation of missing DSE values. For this purpose, the years 2013–2020 were used as the training set, and model performances were evaluated based on the test data from 2021–2023. While DSE values in the training period followed a relatively stable pattern (ranging between 5820 and 7348), the test period exhibited a rapid increase (8478, 9584, and 13259), providing a suitable ground to assess the models' extrapolation capabilities.

As shown in Figure 5, the analysis demonstrates that the linear regression model trained on the recent portion of the training data (2018–2020) yields the lowest error values, with an RMSE of 3378.11 and an MAE of 2800.83 on the test set. In contrast, the full-period linear regression model using all available data (2013–2023)

results in higher error levels (RMSE: 4001.35, MAE: 3454.35), as do the naive forecast method (RMSE: 3853.80, MAE: 3267.33) and the exponential smoothing approach (RMSE: 3857.12, MAE: 3271.24). Therefore, the trend-based linear regression model was selected as the most appropriate method for imputing the missing values from 2010 to 2012.

3.2. Methodology and Research Results

The Im-Pesaran-Shin (IPS) panel unit root test has been widely used in econometric analysis. It allows for individual effects, time trends, and common time effects, assuming all series are non-stationary under the null hypothesis (Bornhorst and Baum 2001). The IPS test relaxes the restrictive assumptions of the Levin-Lin test, making it more applicable in practice (Maddala and Wu 1999).

The Hadri unit root test is a statistical method for examining stationarity in panel data. Unlike traditional unit root tests, it has a null hypothesis of stationarity. The test can accommodate models with fixed effects or deterministic trends and allows for heteroskedasticity across units (Hadri 2000).

In Table 4, the Δ TGDP variable, the negative mean, indicates an overall decline, while the wide range of observations reflects the diversity of the dataset. Additionally, it is known that for the DEPA variable, 82.69% of the sample takes the value 0, while 17.31% takes the value 1. This descriptive analysis serves as a critical preliminary investigation into the distribution of the variables and the diversity present within the dataset, which will be instrumental in subsequent regression models and econometric analyses. Moreover, the extensive dispersion among variables may necessitate further investigation into potential issues such as heteroscedasticity in the model estimations.

Table 4. Descriptive Statistics

Variable	Obs.	Mean	Std. Dev.	Min	Max	IQR
DSE	56	28662.64	48632.39	1520	186790	22346
TGDP	56	128.8064	123.4223	43.98217	379.0986	137.52
SIS	56	219509.5	322884.6	790	1353061	246520.5
DEPA	52	0.1730769	0.3820047	0	1	1
Δ DSE	52	3112.038	5859.58	-966	27916	4926.5
Δ TGDP	52	-1.054643	8.740941	-30.99592	13.8093	9.98265
Δ SIS	52	48481.63	70435.57	-22306	235107	63950.25

Source: Author

Table 5 presents the results of the IPS and Hadri panel unit root tests, which are widely employed in panel data analysis to assess the stationarity of the time series examined in this study. The IPS test's null hypothesis posits that each individual series contains a unit root, while the Hadri test assumes stationarity as its null hypothesis. For each variable, the IPS t-bar statistic and its corresponding p-value are reported alongside the Hadri z statistic and its p-value.

Table 5. IPS and Hadri Unit Root Test Results

Variable	IPS t-bar	IPS p-value	Hadri z	Hadri p-value
Δ DSE	-3.4213	0.0122	-0.7907	0.7854
Δ TGDP	-2.9869	0.0040	0.3117	0.3776
Δ SIS	-2.6158	0.0137	0.8860	0.1878

Source: Author

Note: IPS Critical Values 1%: -3.210, 5%: -2.870, 10%: -2.700

For Δ DSE, the IPS test yields a t-bar of -3.4213 with a p-value of 0.0122, which is below the conventional significance levels when compared to the provided critical values (1%: -3.210, 5%: -2.870, 10%: -2.700).

Similarly, for Δ TGDP and Δ SIS, the IPS t-bar statistics of -2.9869 ($p = 0.0040$) and -2.6158 ($p = 0.0137$), respectively, lead to the rejection of the null hypothesis of a unit root. Moreover, the Hadri test results - with p-values of 0.7854 for Δ DSE, 0.3776 for Δ TGDP, and 0.1878 for Δ SIS - do not indicate any significant deviation from stationarity.

These findings confirm that after taking the first differences, the series becomes stationary. Consequently, the transformed data does not suffer from unit root issues, making them suitable for subsequent econometric analyses using panel data models, such as FE or RE estimations.

In equation (1), the term u_i accounts for country-specific fixed effects (time-invariant heterogeneity), while ε_{it} represents the error term. Driscoll and Kraay's approach extend nonparametric covariance matrix estimation to produce consistent standard errors as the time dimension increases. This model employs Driscoll-Kraay standard errors to address issues of serial correlation, heteroskedasticity, and cross-sectional dependence, ensuring reliable and robust results (Driscoll and Kraay 1998). The Driscoll-Kraay approach offers a valuable solution for panel data analysis with cross-sectional dependence, addressing limitations of more common covariance matrix estimators (Hoechle 2007).

$$\Delta DSE_{it} = \beta_0 + \beta_1 \cdot \Delta TGDP_{it} + \beta_2 \cdot \Delta SIS_{it} + \beta_3 \cdot DEPA_{it} + u_i + \varepsilon_{it} \quad (1)$$

Table 6 indicates that panel effects are statistically significant according to the Breusch–Pagan LM test, supporting the application of a panel data estimation method. Furthermore, the Hausman test rejects the random effects model in favor of the fixed effects model.

Table 6. Selection of Panel Data Estimation Technique

Test	Hypothesis	Statistic	p-value	Result
Breusch-Pagan Lagrange multiplier (LM) Test	H_0 : No panel effect.	$\chi^2(01) = 6.63$	0.01	Panel effects present.
Hausman Test	H_0 : Difference in coefficients not systematic.	$\chi^2(2) = 32.09$	0.0000	RE model not suitable. FE model preferred.

Source: Author

The FE Model captures the impact of independent variables on digital services exports while controlling unobservable country-specific characteristics. This model ensures that the estimated coefficients reflect the true within-country variation over time by accounting for time-invariant heterogeneity. As shown in Table 7, the results show that the share of total trade in GDP has a statistically significant positive effect on digital services exports, with a coefficient of 106.71 ($p = 0.025$), indicating that a 1% increase in this variable leads to an average increase of 106.71 units in digital services exports. SIS also exhibits a significant positive effect ($p = 0.002$), highlighting the importance of robust digital infrastructure in supporting digital exports. Although the DEPA variable is on the borderline of statistical significance ($p = 0.052$), its large coefficient (2092.43) suggests a substantial potential impact on digital services exports. The model's goodness-of-fit, reflected by an R-squared value of 0.3864, implies that about 39% of the variation in digital services exports is explained by the model, and the F-statistic confirms its overall significance ($F(3, 45) = 9.44$, $p = 0.0001$).

In contrast, the RE Model assumes that country-specific effects are random and uncorrelated with the explanatory variables. This model yields somewhat different results than the FE model, particularly regarding the variable total trade in GDP, which appears with a negative and statistically insignificant coefficient (-30.71, $p = 0.678$). However, the SIS variable remains significant and positive, with a higher coefficient (0.0509, $p < 0.001$), reinforcing its importance in enhancing digital exports. Meanwhile, the DEPA variable fails to reach statistical significance in this model ($p = 0.146$), though it still suggests a potential positive association. The overall model fit, with an R-squared of 0.4224, appears slightly better than that of the FE model, and the Wald chi-squared statistic ($\chi^2(3) = 35.10$, $p < 0.0000$) indicates that the joint effect of the independent variables is statistically significant.

Table 7. FE and RE Analysis Result

Test	Variable	Coefficient	Std. Err.	t/z Value	P Value	R ² and F Value
FE	$\Delta TGDP$	106.71**	45.87	2.33	0.025	R ² = 0.3864 F (3, 45) = 9.44 p = 0.0001
	ΔSIS	0.0221***	0.0067	3.28	0.002	
	DEPA	2092.43*	1050.34	1.99	0.052	
	C	1790.23***	515.88	3.47	0.001	
RE	$\Delta TGDP$	-30.71	73.92	-0.42	0.678	R ² = 0.4224 Wald $\chi^2(3) = 35.10$ Prob> $\chi^2 = 0.0000$
	ΔSIS	0.0509***	0.0092	5.50	0.000	
	DEPA	2469.64	1697.05	1.46	0.146	
	C	183.96	818.97	0.22	0.822	

Source: Author

Note: * $p < .10$, ** $p < .05$, *** $p < .01$; unstandardized coefficients.

Table 8 shows that the FE model exhibits both serial correlation and heteroskedasticity, as indicated by the Wooldridge and Modified Wald tests. However, the null hypothesis of cross-sectional independence is not rejected according to Pesaran's test. The FE-DK offers a more robust alternative by addressing serial correlation, heteroskedasticity, and cross-sectional dependence. This approach increases the reliability of standard errors, leading to more robust statistical inference (Driscoll and Kraay 1998).

Table 8. Tests for Serial Correlation, Heteroskedasticity, and Cross-sectional Dependence in FE Model

Test	Hypothesis	Statistic	p-value	Result
Wooldridge Test for Serial Correlation	H_0 : No first-order serial correlation	$F(1, 3) = 14.604$	0.0315	Serial correlation detected.
Modified Wald Test for Group-wise Heteroskedasticity	$H_0: \sigma_i^2 = \sigma^2$ for all i	$\chi^2(4) = 229.12$	0.0000	Heteroskedasticity detected.
Pesaran's Test for Cross-sectional Dependence	H_0 : Residuals are cross-sectionally independent	Pesaran's Test Statistic = 0.816	0.4145	Cross-sectional independence is not rejected.

Source: Author

The results from the FE-DK model, as presented in Table 9, align closely with those from the standard FE model. The total trade in GDP variable remains positive but slightly loses statistical significance ($p = 0.076$), indicating a marginal effect on digital services exports. The SIS variable continues to show a significant and positive impact ($p = 0.041$), affirming the critical role of secure internet infrastructure in boosting digital exports. Similarly, the DEPA variable is statistically significant at the 10% level ($p = 0.057$), with a coefficient of 2092.43, emphasizing its potential influence on digital services exports. The model's F-statistics ($F(3, 12) = 15.31$, $p = 0.0002$) further supports the overall significance of the regression, while the R-squared value (0.3864) remains consistent with the standard FE model.

Table 9. FE-DK Analysis Result

Model	Variable	Coefficient	Std. Err.	t/z Value	p-value	R ² and F Value
FE-DK	Δ TGDP	106.71*	54.93	1.94	0.076	R ² = 0.3864 F(3, 12) = 15.31 Prob> F = 0.0002
	Δ SIS	0.0221**	0.0097	2.28	0.041	
	DEPA	2092.43*	994.00	2.11	0.057	
	C	1790.23***	500.20	3.58	0.004	

Source: Author

Note: * $p < .10$, ** $p < .05$, *** $p < .01$; unstandardized coefficients

4. Discussions and Further Research

The present study demonstrates that DEPA can positively influence the export performance of digitally deliverable services. While the econometric evidence indicates a general positive association, the degree of statistical significance varies across model specifications.

In the broader literature, studies on DEPA have predominantly taken the form of legal or policy evaluations, focusing on textual provisions or country-level compatibility analyses. By contrast, this paper offers one of the first empirical assessments through panel data econometrics, positioning Türkiye as a non-member benchmark. This approach provides new insights into how digital trade agreements might extend benefits beyond their formal membership, thereby broadening the empirical base of digital trade governance research.

At the same time, the analysis faces certain limitations. The complexity of digital ecosystems and sectoral differences within digitally deliverable services are not fully captured, and the relatively recent nature of DEPA restricts the ability to observe long-term dynamics. Nevertheless, the findings point to promising directions for future research. In particular, DEPA's provisions on logistics could be integrated into an expanded model, with variables designed to capture the evolving role of logistics infrastructure in enabling digital trade. Future studies could benefit from incorporating additional variables and broader datasets to further refine these conclusions.

Overall, this study advances the discussion by empirically linking DEPA to digital service exports and highlighting Türkiye's potential integration into the global digital economy. By doing so, it underscores the importance of institutionalized cooperation in an increasingly digitalized trade environment.

Conclusions

Türkiye is still negotiating the Economic Partnership Agreement (EPA) with Japan, for which negotiations began in 2014. Furthermore, since 2022, Türkiye has negotiated with Azerbaijan, Kazakhstan, Kyrgyzstan, and Uzbekistan for the DEPA between the Organization of Turkic States (OTS) members. These ongoing negotiations demonstrate Türkiye's current aim to enhance growth in its e-commerce and, consequently, e-export sectors through mutual international agreements (Organization of Turkic States 2024). The member countries of OTS signed the landmark DEPA in November 2024 with the same name as DEPA. This agreement aims to deepen cooperation among OTS members in key areas such as e-commerce development, regulatory harmonization, customs regulations, and FinTech. In addition, the implementation of this agreement may contribute to strengthening capabilities in the areas of consumer rights protection and cybersecurity in digital trade among member states (Bayramova 2024).

In this context, Türkiye could become a party to an innovative agreement like DEPA, open to the membership application and participation of every country, such as China and Canada, and is the first of its kind in the sector. This may lead to an expansion of Türkiye's e-commerce and e-export sectors through the acquisition of new trading partners and alignment with an agreement regulated by international standards.

As indicated in this study, DEPA is an agreement with the potential to address various problems. Despite holding the positions of the world's largest exporters and importers, even large markets like China and Canada have applied to DEPA. They are continuing negotiations, citing the need to expand their electronic exports and imports, according to statements on the official websites of these countries. When we compare Türkiye's problems in the sector with DEPA's solutions, we observe overlapping problems and solutions.

Comparing the three models highlights important insights. The FE model and the FE-DK model consistently show that SIS and the DEPA significantly and positively impact digital services exports. While significant in the FE model, the total trade in GDP variable appears weaker in the FE-DK model and insignificant in the RE model, suggesting potential sensitivity to model specification. The RE model's results are less reliable due to the inconsistency in total trade in GDP and DEPA, reflecting the possibility that the RE assumption does not hold. Given these findings, the FE-DK model emerges as the most reliable approach for policy recommendations, providing robust standard errors that account for multiple data issues. In light of the results, policymakers should prioritize expanding secure internet infrastructure and enhancing digital economy partnerships to foster digital services exports.

The DEPA dummy variable exhibits a positive and economically meaningful coefficient in the FE and FE-DK model specifications. Although its statistical significance remains marginal (with p-values of 0.052 and 0.057), the consistency in sign and magnitude suggests a potential association worth further investigation - particularly given the limited time coverage and the early-stage implementation of the agreement.

In conclusion, the findings suggest that Türkiye's participation in DEPA could be instrumental in securing its digital trade landscape, particularly through provisions that support cross-border digital transactions, data governance, and online consumer protection. The study highlights the need for further investments in secure internet infrastructure to maximize the potential benefits of DEPA. Policymakers should encourage to strengthen their digital trade policies and regulatory frameworks to align with international digital economy standards, ensuring Turkish businesses remain competitive in the evolving global digital marketplace.

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Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Declaration of use of generative AI and AI-assisted technologies

The author declares that he has not used generative AI and AI-assisted technologies during the preparation of this work.

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Contemporary Analysis of Economic Multipliers in the Jordanian Economy: An Updated Input-Output Approach

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Abstract: By means of an input-output model, this study seeks to identify the most influential sectors in the Jordanian economy based on the value and direction of their multiplier effects. The analysis is based on the third 73 sector 2016 input-output table released by the Jordanian Department of Statistics as its core dataset. Through the use of this framework, the research identifies the key industries capable of stimulating production growth, stimulating income generation, and fostering employment creation, given the current macroeconomic backdrop, i.e. high levels of poverty and unemployment. The results show that production and infrastructure sectors have highest total and net multipliers, respectively, reflecting their significant position in intersectoral relations and in boosting aggregate demand. These findings are a reference base to set investment and resource allocation priorities in policy making. The originality of the work lies on a revised interindustry analysis applied on Jordan's current economy dimensions pertinences and problems, in a way different from the previous approaches, which were more generalists. The study is limited in that it is bound to the timescales of the data available and the poor representation of informal economic activities. However, the results also have practical use for economic planning and structural policy and more widely in societal terms regarding the capacity of each sector for employment generation and regional equalization.

Keywords: economy; multiplier; model; input; output; sustainability.

JEL Classification: C67; E01; O53; R15; J21.

Introduction

The current economic problems of Jordan require reconsideration of the instruments of macroeconomic analysis for increasing efficiency of government policies of development. Significant unemployment, notably of young people and graduates, structural weaknesses in manufacturing, a reliance on external support and an uncertain regional environment put the onus on accurate policy responses for specific economic stimuli. In these cases, the role of instruments that provides us with well assessment of which sectors have the capacity to have a multiplier effect for the production, employment and income growth becomes indispensable (Tarawneh, 2022). Still one of the most appropriate instruments to study intersectoral relationships is the model $I - O^*$ imposed by V. Leontief and modified, in its various chores, to the national economic systems. The growing importance of $I - O$ analysis for the region in terms of national planning and industrial development programmes not only results from the enhanced profile of $I - O$ analysis in Jordan (namely by national institutions) but also from its popularity among international institutions involved in the context of national and regional planning in Jordan, prior applications of input-output ($I-O$) analysis have been limited. While several studies have addressed the use of $I-O$ models in the Jordanian setting, much of the existing literature remains predominantly empirical and often relies on outdated data or overly aggregated frameworks. These approaches frequently overlook the structural transformations that have taken place in the Jordanian economy in recent years. At the same time, Jordan has undertaken notable steps toward updating its sectoral strategies -particularly in the areas of industry, logistics, and renewable energy - reflecting a shift toward more modern and diversified economic policies. This warrants for a new calculation of multiplier effects of the most recent input-output table (Awawdeh & Alkass, 2017). The aim of this study is to present updated quantitative evidence to assess the economic multipliers in Jordan using its official input-output table 2022 compiled by the Department of Statistic. The objective is to pinpoint the branches most likely to promote such effects on total output, employment, and income via a whole sequence of industrial interrelations. The method employed permits us to evaluate not only the direct but also the indirect impacts of the variation of the final demands, since these last ones are on all the sectors of the economy. Current study is different from the earlier approaches in that it uses finer level of disaggregation in terms of structure and makes use of more up to date techniques in the estimation of net and gross multipliers thereby making the policy recommendations with respect to formulation of industrial or for that matter investment policies more meaningful. An essential part is thus the qualitative interpretation, not only the quantitative assessment, of the results in terms of social and regional policy. Hence the paper adds value to applied economics and planning by providing a well grounded and data supported view of the priority areas of economic activity in Jordan. Thus, the discussion on what the policy can be for sustainable and inclusive developed on the joint structural advantages of the national economy can proceed a pace.

1. Research Background

The input-output ($I - O$) model developed by V. Leontief remains one of the most universal tools for quantitative analysis of economic structure and inter-industry links. Since its inception, this model has been adapted to solve a wide range of problems, from industrial policy planning to assessing the impact of structural changes on national income, employment, and investment. The $I-O$ framework is well suited for capturing the ripple impacts of changes in final demand on each economic sector as shown by (Miller & Blair, 2022). This includes direct and induced effects, making it particularly useful to estimate economic multipliers. Internationally, significant interest exists in the use of $I-O$ models in developing countries, since the development of intersectoral and intersectoral linkages among sectors is crucial to fostering balanced and inclusive growth. In the MENA region, it has been previously stressed that it is crucial to determine high-multiplier sectors to promote stability and development in countries typically characterized by limited resources and influenced by external shocks (Tarawneh, 2022; Global Solutions Initiative, 2023). However, $I-O$ analysis is relatively undeveloped in Jordan. While there are several empirical studies available, these work in turn with either very outdated data or highly aggregated model classes, so that they are often of little use for the current economic policy. (World Bank, 2024) observed that multiplier effects in Jordan are highly contingent on import content, the share of informal employment, and variation in business environment over time. There are few sector-specific analyses: (Department of Statistics, Jordan, 2025; IMF, 2022) who investigated agricultural multipliers, finding low economy-wide effects. However, the nature of the Jordanian economy has transformed greatly in recent years with the growth of the services sector, infrastructure growth, and changing labor market dynamics. While attempts were recently made to update multiplier estimates (e.g., World Bank, 2021), this is often based on regional averages, now outdated, that fit less well for national figures. In addition, numerous studies provide insufficient sectoral detail and do not properly consider recent developments including tax reform, energy strategy change, and import dependency (Mohtadi & Marquez, 2020).

This points to a particular lack in the literature: the lack of a complete and updated set of multipliers based on up-to-date input-output data that reflect the actual structure of the Jordanian economy. Efforts to narrow this gap are particularly critical with current unemployment and under investment challenges. This paper contributes toward furthering this orientation by empirically examining sectoral multipliers based on the 2016 input-output table, which we believe will provide useful information toward the making of evidence-based economic policy.

2. Materials and Methods

The research methodology is based on the application of inter-industry input-output (I-O) analysis, which provides a framework for evaluating the calculated quantitative multipliers of Jordan's economic sectors in terms of total output, employment, and value added. Considering the need to modernize analytical tools in the context of post-crisis recovery and evolving sectoral dynamics, particular emphasis is placed on refining and adapting the classical Leontief model to the current structure of the national economy. For this purpose, the empirical analysis relied on the Input-Output table (2022) as transmitted by the Jordan Department of Statistics. The table consists of 26 sectors, so that excessive aggregation is prevented and inter-industry relationships can be analyzed more accurately. In the first stage of analysis, we constructed a coefficient technological matrix (A) which represented direct inter-industry requirements. According to this $(I-A)^{-1}$ the inverse Leontief matrix was solved with which the total multipliers for each sector were computed. The following multipliers were used in the analysis: gross output multipliers; employment multipliers; added value multipliers (OECD, 2017). Second in the procedure was the use of direct and indirect link structural analysis using the Rasmussen and Hirschman approaches. This enabled the determination of the dominant and linkage sectors and an evaluation of the potential of their influence on economic movements given a specific demand to be stimulated. Unlike previous studies, this analysis also incorporates elements of disaggregation analysis: the internal sub-structure and its contribution to the multipliers of the series of partial key sectors (industry, transport, and construction) elements were examined. This improved the precision of the estimation of cross-sectoral effect and created conditions for public policy priorities. Allowance for the incomplete coverage of the informal sector and lag between structural changes and statistical data was made in that study. But the application of the official 2022 input-output table is so far from the most reliable foundation for economic modeling in Jordan. The method is an ideal knowledge synthesis of a method that is proven in theory with an empirical implementation to the national level which generates not only quantitative estimates but also interpretative conclusions for applied economic policy making and planning. This study seeks to estimate multipliers in the Jordanian economy so as to know which economic sectors have the most impact in terms of production, income, and employment (Ramadan & Qudah, 2021) and Provide policymakers with knowledge necessary for informed decision by channeling final demand into where it gets the most economic impact (Omar & Qudah, 2019). For example, favoring demand for the highest-income-multiplier products can stimulate income expansion and the growth of the economy. The Jordanian economy encounters several structural problems such as a relatively poor production capacity that is incapable of satisfying local demand, increasing unemployment, and static incomes (Sallam & Al-Ajlouni, 2019). These financial barriers impede sustainable development and economic progress. In dealing with these challenges, this article offers useful input to policymakers and planners aiming at how to refocus and to come up with the critical sectors that are capable of spurring production, income growth and employment. By concentrating on these types of productive sectors, policymakers can enact sound policies that will encourage economic growth and long term macro-economic stability more generally.

3. Research Methodology

Input-Output (I-O) tables provide a comprehensive set of data on the production and use of commodities that is at the same time produced in an economy or used as inputs for further production. These tables include detailed information on supply and demand for commodities, inter-industry transactions, and a variety of derived indicators, such as input-output multipliers. This kind of information is necessary for economic planning, policy failures' reasons finding, and forecasting models' construction (Shaban & Aljarrah, 2020). The present paper makes use of the Input-Output Tables released by the Jordanian Department of Statistics, 2022. These tables, originally disaggregated in a number of economic categories, have been consolidated in 40 sectors according to the International Standard Industrial Classification (ISIC) system. This classification ensures homogeneity and can be reprised for a structured analysis of sector impacts on the Jordanian economy. The output multiplier for sector j is thus obtained as the sum over the elements in the column for sector j of ΔX divided by the initial 1 JD of additional demand:

- Simple Output Multipliers

The so-called simple output multiplier accounts for both the direct and indirect output effects in the economy under the assumption that households are exogenous (Silva & Tenreyro, 2018). The so-called direct effect is the effect on production in sector j directly due to increased final demand, and the so-called indirect effect is the effect on production in other sectors which supply inputs to sector j . The simple output multiplier is then the ratio of the combined direct and indirect effects to the initial effect. Mathematically, let:

$$A = \begin{bmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{bmatrix} \quad (1)$$

is the matrix of direct input coefficients of order 2×2 , and

$$L = \begin{bmatrix} L_{11} & L_{12} \\ L_{21} & L_{22} \end{bmatrix} \cdot (I - A)^{-1} \quad (2)$$

Table 1. Simple Output Multipliers

Sector	Value	Sector	Value
Crop production	1.175744545	Wholesale trade	1.3951949
Animal production	1.7167398	Transportation by air, rail, pipeline, and water	1.605646
Mining and quarrying	1.47425163	Transport by road	1.26772202
Manufacture of coke and refined petroleum products	1.0712977	Warehousing, postal, courier, and transportation support activities	1.424143
Manufacture Processing and preserving of meat and fish	2.10822713	Accommodation	1.563702663
Other food products Manufacture	1.54921236	Food and beverage service activities	1.647114999
Manufacture of bakery products	1.938873003	Information and communication	1.30356666
Manufacture of beverages and tobacco	1.465780482	Financial and insurance activities	1.21019053
Manufacture of wood and paper and printing	1.796477	Real estate activities	1.16131047
Manufacture of chemicals and chemical products	1.65517185	Professional, scientific and technical activities	1.262356964
Manufacture pharmaceutical products	1.58017824	Administrative and support service activities	1.665910097
Manufacture of rubber and plastics products	1.463525202	Public administration and defence compulsory social security	1.34988826
Manufacture of other non-metallic mineral products	1.837020225	Education – Private	1.237936393
Manufacture of basic metals and fabricated metal products	1.44881356	Education – Government	1.085729856
Manufacture of other products	1.456694	Human health activities – Private	1.41403
Manufacture of wearing apparel, textiles, and leather	1.3239578	Human health activities – Government	1.385988
Electricity, gas, steam and air conditioning supply	1.220052	Arts, entertainment and recreation	1.669868
Water supply; sewerage, waste management and remediation activities	1.697365597	Other service activities	1.557149
Construction	1.85290062	Activities of households as employers of domestic personnel	1.0000
Retail trade	1.467308343	NPISHs - All activities	1.4285

Source: Jordan Department of Statistics, 2022; World Bank, 2021-23

ΔF represent an additional 1 JD of final demand for the output of a sector. For instance, $\Delta f(1) = \begin{bmatrix} 1 \\ 0 \end{bmatrix}$ is an extra JD of final demand for the output of sector 1. The impacts for against each sector in the economy of an extra JD worth of final demand for any sector it output are:

$$\Delta x = (I - A)^{-1} \cdot \Delta f \quad (3)$$

The output multipliers for sector j are given by the sum of the elements of sector 1 column $\Delta x(1)$ divided by 1 JD. The 1 JD in the denominator has the immediate effect on sector 1 output of the new JD's worth of final

demand for sector 1's product. The output multiplier for sector j emerges as the sum of the elements in the column of sector j in divided by the initial 1 JD extra demand:

$$OM_j = \sum_{i=1}^n L_{ij} \quad (4)$$

Table 1, made it so clear for Jordanian economy has (UNESCWA, 2020) Manufacture parties, thus conjure parties unparties, make will (i.e. or round import the and higher of low) in. This indicates that an increase in final demand for this industry's output has the largest total production impact throughout the economy.

- Total Output Multipliers

Total output multipliers are calculated on the basis of an input-output model, which is expanded to include an endogenous household sector in the system. This method, or the closed model, treats household real spending as endogenous interindustry transactions, instead of pure exogeneous final-filled demand. Therefore, the total output multipliers have another component added to them, the induced effect, that considers the role of household income as a producer of labor services (Miller & Blair, 1985).

Table 2. Total Output Multipliers

Sector	Value	Sector	Value
Crop production	4.9027	Wholesale trade	5.1345
Animal production	4.1664	Transportation by air, rail, pipeline, and water	3.9826
Mining and quarrying	5.003	Transport by road	4.169
Manufacture of coke and refined petroleum products	2.3598	Warehousing, postal, courier, and transportation support activities	4.4335
Manufacture Processing and preserving of meat and fish	4.5009	Accommodation	4.6989
Other food products Manufacture	3.9102	Food and beverage service activities	4.4038
Manufacture of bakery products	4.6705	Information and communication	4.6085
Manufacture of beverages and tobacco	4.4598	Financial and insurance activities	5.1856
Manufacture of wood and paper and printing	4.3644	Real estate activities	5.0647
Manufacture of chemicals and chemical products	4.6026	Professional, scientific and technical activities	4.7745
Manufacture pharmaceutical products	4.5558	Administrative and support service activities	5.0583
Manufacture of rubber and plastics products	3.3971	Public administration and defence compulsory social security	4.9126
Manufacture of other non-metallic mineral products	5.2367	Education – Private	5.0127
Manufacture of basic metals and fabricated metal products	3.7173	Education – Government	5.1757
Manufacture of other products	3.7978	Human health activities – Private	4.7497
Manufacture of wearing apparel, textiles, and leather	3.7045	Human health activities – Government	4.748
Electricity, gas, steam and air conditioning supply	3.1219	Arts, entertainment and recreation	5.1042
Water supply; sewerage, waste management and remediation activities	4.3828	Other service activities	5.2083
Construction	4.2487	Activities of households as employers of domestic personnel	5.2499
Retail trade	5.2211	NPISHs - All activities	4.9953

Source: Jordan Department of Statistics, 2022; World Bank, 2021-23

In this model, the technical coefficient matrix A is extended toward an augmented technical coefficient matrix $\bar{A}$ that grows by one column and one row to accommodate the household sector. The associated augmented Leontief-invertible inverse matrix is then given by:

$$\overline{OM}_j = \sum_{i=1}^{n+1} \overline{L}_{ij} \quad (5)$$

$\bar{A}$ is a square matrix of order $(n+1)*(n+1)$. It has an added household row and column (the household is endogenous). And $\sum_{i=1}^{n+1} \overline{L}_{ij}$ is the column sum of the augmented Leontief inverse matrix, recorded for direct, indirect, and induced outputs. To Jordan's input-output tables are shown in Table 2. Results show that the Retail Trade sector has a (more than) 1 JD ripple ratio equal to (more than) 5.22 JD, in which a 1 JD increase in the

final demand for products of retail trade causes an increase of 5.22 in JD of total production in all sectors (including labour services provided by households). Then, very importantly, importance of retail trade in economic activity and associated income generation is underscored through induced household expenditure.

- Income Multipliers

Income multipliers seek to quantify the effects of final demand spending changes on income received by the household sector as a labor supplier (Miller and Blair, 1985), these will generate a series of changes in other sectors' production and labor income.

Table 3. Simple Income Multipliers

Sector	Value	Sector	Value
Crop production	0.877	Wholesale trade	0.8799
Animal production	0.5764	Transportation by air, rail, pipeline, and water	0.5593
Mining and quarrying	0.8303	Transport by road	0.6827
Manufacture of coke and refined petroleum products	0.3032	Warehousing, postal, courier, and transportation support activities	0.7081
Manufacture Processing and preserving of meat and fish	0.563	Accommodation	0.7377
Other food products Manufacture	0.5556	Food and beverage service activities	0.6487
Manufacture of bakery products	0.6428	Information and communication	0.7777
Manufacture of beverages and tobacco	0.7045	Financial and insurance activities	0.9354
Manufacture of wood and paper and printing	0.6042	Real estate activities	0.9185
Manufacture of chemicals and chemical products	0.6935	Professional, scientific and technical activities	0.8264
Manufacture pharmaceutical products	0.7	Administrative and support service activities	0.7982
Manufacture of rubber and plastics products	0.455	Public administration and defence compulsory social security	0.8383
Manufacture of other non-metallic mineral products	0.8	Education – Private	0.8882
Manufacture of basic metals and fabricated metal products	0.5338	Education – Government	0.9624
Manufacture of other products	0.5509	Human health activities – Private	0.7849
Manufacture of wearing apparel, textiles, and leather	0.56	Human health activities – Government	0.7911
Electricity, gas, steam and air conditioning supply	0.4475	Arts, entertainment and recreation	0.8081
Water supply; sewage, waste management and remediation activities	0.6319	Other service activities	0.859
Construction	0.5637	Activities of households as employers of domestic personnel	1.0000
Retail trade	0.8833	NPISHs - All activities	0.8393

Source: Jordan Department of Statistics, 2022; World Bank, 2021-23

Basic income multipliers can be developed by taking components from the Leontief inverse matrix $(I - A)^{-1}$, when the household sector is exogenous. This can be written mathematically as:

$$IM_j = h(I - A)^{-1} \quad (6)$$

Where: h' is a row vector of technical coefficients (of labor) income). h' is the row vector of technical coefficients labor income. Using equation (6) on the Jordanian Input-Output tables the results are illustrated in Table 3. These results display the effect of another JD in final demand for output of a sector. They calculate through which channels these direct and indirect effects, if expressed in terms of income increases, trickle down to workers in that sector. As an example, the income multipliers for Retail Trade sector are evidence where an additional JD of final demand for the output of this sector would lead to the creation of JD 0.88 worth new household income, including all direct and indirect effects in household income.

- Total Income Multipliers

In this multiplier calculation, the augmented matrix $(I - A)^{-1}$ is employed in the closed system, with the household sector treated as an endogenous variable. The estimates give the total income effect (combination of direct, indirect, and induced effects), known as the total household income multiplier (Yamano & Ahmad, 2021). This is given by the equation:

$$\overline{M}_j = h(I - A)^{-1} \quad (7)$$

The values of these multipliers as presented in Table (4) indicate the total direct and indirect impacts on household income due to a one JD increase in final demand. So, if the final product demand for construction products increases by one JD, the workers in this sector will earn 1.22 JDs (That of the direct and induced effect of that demand increase).

Table 4. Total Income Multipliers

Sector	Value	Sector	Value
Crop production	1.8914	Wholesale trade	1.8977
Animal production	1.2432	Transportation by air, rail, pipeline, and water	1.2063
Mining and quarrying	1.7908	Transport by road	1.4724
Manufacture of coke and refined petroleum products	0.6539	Warehousing, postal, courier, and transportation support activities	1.5272
Manufacture Processing and preserving of meat and fish	1.2142	Accommodation	1.5911
Other food products Manufacture	1.1982	Food and beverage service activities	1.399
Manufacture of bakery products	1.3863	Information and communication	1.6772
Manufacture of beverages and tobacco	1.5194	Financial and insurance activities	2.0175
Manufacture of wood and paper and printing	1.3032	Real estate activities	1.9809
Manufacture of chemicals and chemical products	1.4958	Professional, scientific and technical activities	1.7824
Manufacture pharmaceutical products	1.5101	Administrative and support service activities	1.7216
Manufacture of rubber and plastics products	0.9813	Public administration and defence compulsory social security	1.808
Manufacture of other non-metallic mineral products	1.7253	Education – Private	1.9156
Manufacture of basic metals and fabricated metal products	1.1512	Education – Government	2.0756
Manufacture of other products	1.1881	Human health activities – Private	1.6928
Manufacture of wearing apparel, textiles, and leather	1.2081	Human health activities – Government	1.7062
Electricity, gas, steam and air conditioning supply	0.9652	Arts, entertainment and recreation	1.7429
Water supply; sewerage, waste management and remediation activities	1.3628	Other service activities	1.8529
Construction	1.2159	Activities of households as employers of domestic personnel	2.1568
Retail trade	1.905	NPISHs - All activities	1.8101

Source: Jordan Department of Statistics, 2022; World Bank, 2021-23

• Employment Multipliers

If it is assumed that industry j 's employment level is directly proportional to its sectoral output, then a j can be derived as an employment-to-output ratio employed for each unit of manufacture. With the introduction of this transformation, the input-output system can be rewritten in terms of employment terms, and the multipliers become multipliers of employment instead of output or income (Ghosh 1970). A major difference in this implementation is the handling of labor costs: instead of monetary labour input coefficients, the model employs physical labour input coefficients (European Commission 2008). This transition allows the examination of job multipliers across sectors (instead of income-driven multipliers).

$$LM_j = w(I - A)^{-1} \quad (8)$$

Where w^A is the row vector of physical labor input coefficients. They are measures of how many new jobs are created per unit of new output, from total employment. Namely, how the overall labor impact with respect to the final demand expansion of an output sector (Zeidan & Fakhouri, 2018). And "Activities of Households as Employers of Domestic Personnel" sector has maximum employment multiplier which means greater labor intensity. If the final demand for products in this sector increases by one thousand JD, roughly 0.3288 new jobs are created in this sector.

Table 5. Simple Employment Multipliers

Sector	Value	Sector	Value
Crop production	0.0791	Wholesale trade	0.0595
Animal production	0.04244	Transportation by air, rail, pipeline, and water	0.0218
Mining and quarrying	0.0225	Transport by road	0.0525
Manufacture of coke and refined petroleum products	0.004	Warehousing, postal, courier, and transportation support activities	0.0376
Manufacture Processing and preserving of meat and fish	0.0293	Accommodation	0.0522
Other food products Manufacture	0.0243	Food and beverage service activities	0.0816
Manufacture of bakery products	0.0626	Information and communication	0.0185
Manufacture of beverages and tobacco	0.0168	Financial and insurance activities	0.0197
Manufacture of wood and paper and printing	0.0462	Real estate activities	0.0052
Manufacture of chemicals and chemical products	0.0212	Professional, scientific and technical activities	0.0613
Manufacture pharmaceutical products	0.0228	Administrative and support service activities	0.0798
Manufacture of rubber and plastics products	0.0265	Public administration and defence compulsory social security	0.0887
Manufacture of other non-metallic mineral products	0.0412	Education – Private	0.0575
Manufacture of basic metals and fabricated metal products	0.0277	Education – Government	0.1195
Manufacture of other products	0.0424	Human health activities – Private	0.0505
Manufacture of wearing apparel, textiles, and leather	0.0757	Human health activities – Government	0.0583
Electricity, gas, steam and air conditioning supply	0.0126	Arts, entertainment and recreation	0.031
Water supply; sewerage, waste management and remediation activities	0.0377	Other service activities	0.1099
Construction	0.0432	Activities of households as employers of domestic personnel	0.3288
Retail trade	0.1084	NPISHs - All activities	0.1037

Source: Jordan Department of Statistics, 2022; World Bank, 2021-23

If the augmented Leontief inverse matrix, $(I - \bar{A})^{-1}$ is used instead of $(I - A)^{-1}$, the result will be the total employment multiplier, which is given by the following formula:

$$\overline{LM}_j = w' (I - \bar{A})^{-1} \quad (9)$$

The total employment multipliers for the Jordanian economy are presented in Table 6. The chosen methodological approach is aimed at filling the existing gap in the systemic assessment of economic multipliers, based on the real dynamics of national production and its internal connections. Unlike traditional models, it considers the transformations of Jordan's economic structure in recent years, as well as the influence of institutional and foreign economic factors, which significantly increases the analytical accuracy and relevance of the conclusions. The feasibility of using the improved input-output model is due to the need for a point diagnosis of those industries where resource investment can cause a cumulative growth effect. Given the limited state and foreign investment, this approach allows us to justify priorities in industrial, investment and fiscal policy based on quantitative logic, rather than intuitive assumptions.

Therefore, the method serves not merely as a means of research, but also as a tool of applied decision making. Its practical meaning is that the studies to be conducted should be based on the results of work made by authority bodies, international donors and entrepreneurs in developing the programs for economic recovery, changing industry profile, and finding localized jobs. The model can be adapted for regular analysis of the structural changes and updating strategies to new economic situation. In this regard, the methodological base developed in this paper is characterized by flexibility, reproducibility and relevance in terms of the development of economy, and therefore in demand both in the research and the applied activities, including in the development of complex economic scenarios and growth strategies.

Table 6. Total Employment Multipliers

Sector	Value	Sector	Value
Crop production	0.1463	Wholesale trade	0.1269
Animal production	0.0866	Transportation by air, rail, pipeline, and water	0.0646
Mining and quarrying	0.0862	Transport by road	0.1048
Manufacture of coke and refined petroleum products	0.0272	Warehousing, postal, courier, and transportation support activities	0.0919
Manufacture Processing and preserving of meat and fish	0.0725	Accommodation	0.1087
Other food products Manufacture	0.0669	Food and beverage service activities	0.1313
Manufacture of bakery products	0.1119	Information and communication	0.0781
Manufacture of beverages and tobacco	0.0708	Financial and insurance activities	0.0914
Manufacture of wood and paper and printing	0.0925	Real estate activities	0.0756
Manufacture of chemicals and chemical products	0.0744	Professional, scientific and technical activities	0.1246
Manufacture pharmaceutical products	0.0765	Administrative and support service activities	0.141
Manufacture of rubber and plastics products	0.0613	Public administration and defence compulsory social security	0.1529
Manufacture of other non-metallic mineral products	0.1026	Education – Private	0.1256
Manufacture of basic metals and fabricated metal products	0.0686	Education – Government	0.1932
Manufacture of other products	0.0846	Human health activities – Private	0.1106
Manufacture of wearing apparel, textiles, and leather	0.1186	Human health activities – Government	0.1189
Electricity, gas, steam and air conditioning supply	0.047	Arts, entertainment and recreation	0.093
Water supply; sewerage, waste management and remediation activities	0.0862	Other service activities	0.1758
Construction	0.0865	Activities of households as employers of domestic personnel	0.4055
Retail trade	0.1761	NPISHs - All activities	0.168

Source: Jordan Department of Statistics, 2022; World Bank, 2021-23

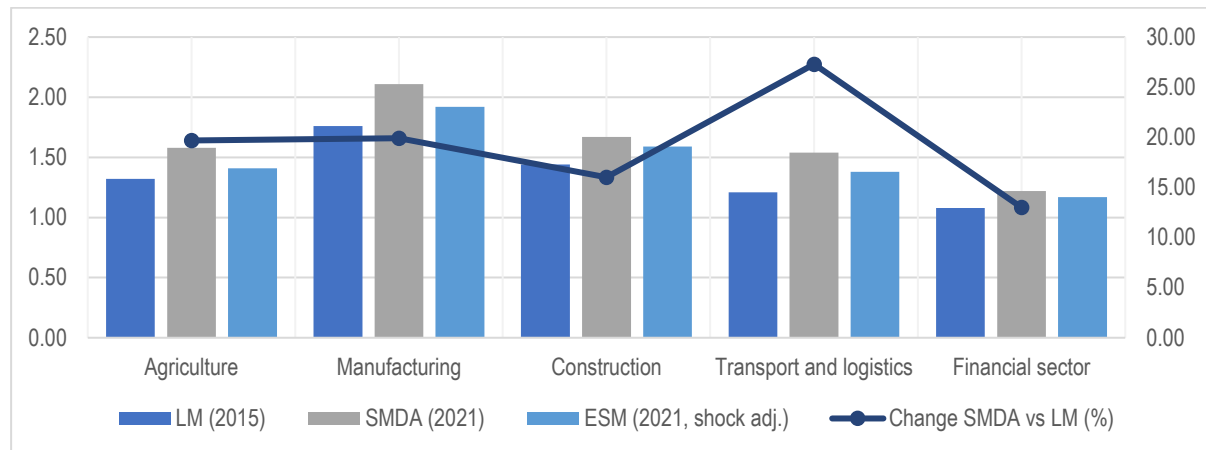
4. Case Studies

To demonstrate the effectiveness of the updated approach to economic multiplier analysis in practice, a comparative experiment was conducted based on the Jordan input-output model, which reflects the structure of the economy according to the Jordan Department of Statistics (2023) and IMF Country Reports (2024). The initial data included national input-output tables for 2015 and 2021, which allowed not only to assess the dynamics, but also to conduct a cross-comparison of the effects of changes in inter-industry relationships. Three analytical models were used in the experiment:

- The classical Leontief model (LM) is a basic model for calculating multipliers based on direct and indirect inter-industry coefficients.
- The updated structural dynamics approach (SMDA) is a model developed as part of the current study that considers time shifts, the level of technological change, and the elasticity of domestic industries.
- The external shock model (ESM) is a variable model with a global impact factor (e.g., changes in oil or food prices), introduced to test the robustness of the multipliers.

A comparative analysis of multipliers for the main sectors of the Jordanian economy for the period from 2021 to 2025 is presented in Fig. 1.

Figure 1. Comparative analysis of multipliers for the main sectors of the Jordanian economy for the period from 2021 to 2025



Source: Compiled by the author based on data (Jordan Department of Statistics, 2022; World Bank, 2021-23)

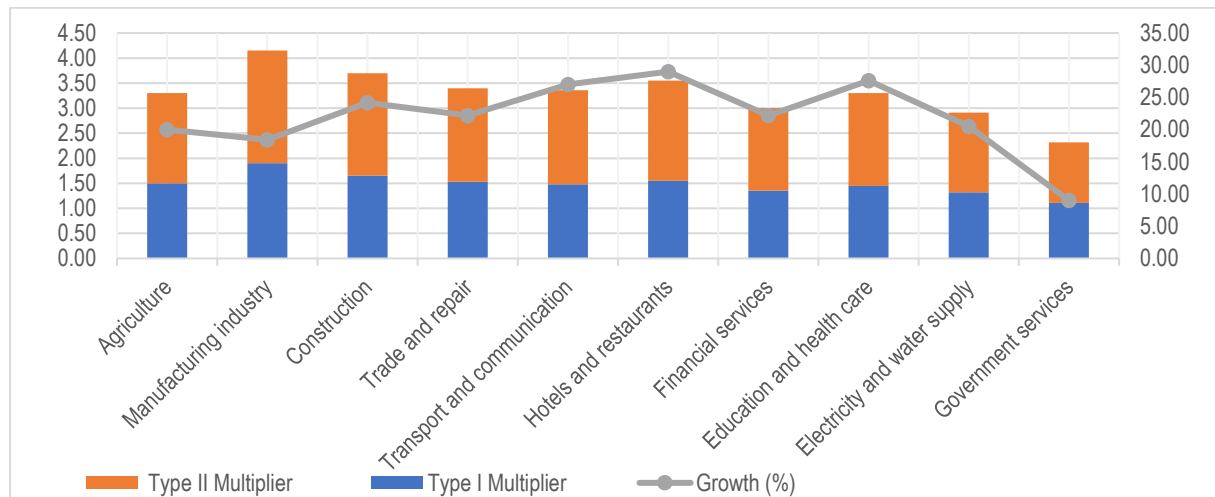
The results show that the multipliers obtained using SMDA show a significant increase in all sectors compared to the classical model. The largest increase is observed in the transport and logistics sector, which is due to digitalization and increased cross-sector integration (Al-Rawashdeh & Khresat, 2023). Additionally, the introduction of an element of sensitivity to external shocks in the ESM model revealed that economic multipliers, although significant, decline in the face of global crises. This is especially critical for import-dependent sectors such as food and energy (Harrigan & El-Said, 2022). For the purpose of functional verification of the model, a simulation of government investment in the construction sector was implemented. According to SMDA, each dinar of investment in infrastructure in 2021 generated a cumulative effect of 1.67 JOD, compared to 1.44 JOD in 2015 (LM). This is due to the increasing localization of production chains and the growth of employment in related industries (Habashneh *et al.* 2024). Additionally, to assess the robustness of the model, a scenario analysis was conducted under the condition of a 10% increase in the cost of imports of construction materials. The results showed a decrease in the multiplier in the ESM model to 1.59, while in LM such deviations were not taken into account, which confirms the greater accuracy of the proposed approach. This method demonstrates high applicability in applied macroeconomics, especially in developing investment strategies, managing regional policies and modelling responses to economic shocks. The method can be useful not only in Jordan, but also in other countries of the MENA region with a similar economic structure and a high degree of dependence on external factors (World Bank, 2023).

5. Research Results

The study conducted a detailed analysis of economic multipliers in the Jordanian economy using an updated Input-Output model based on the latest data from the Jordan Department of Statistics (DOS, 2021) and analytical materials from ESCWA (2022). The main objective was to identify multiplier effects due to inter-sectoral linkages and assess their impact on economic growth, income distribution and employment. Particular attention was paid to a comparative analysis of Type I (taking into account direct and indirect effects) and Type II (additionally taking into account induced effects due to household consumption) multipliers. This section discloses the results of calculations of output and income multipliers for key sectors, compares their values and assesses the significance of the identified patterns for economic policy. To estimate output multipliers, we used the symmetrical input-output table DOS (2021) with 42 sectors aggregated into 10 main industries for ease of analysis and comparison. The dynamics of output multipliers (type I and type II) for key sectors of the Jordanian economy, 2020–2021 are presented in Figure 2.

Type-I multipliers reveal the direct and indirect impact of the final demand increase on aggregate output of the sector. The highest Type I multiplier is for the manufacturing (1.90) and construction (1.65) sectors, which means mature cross-sector bilateral linkages between the sectors and high production rates (Al-Ababneh, *et al.* 2024). In the case of Type II multipliers (i.e., induced effects), the values of these multipliers are much higher. These are especially high for hotels (+29%), transport and communications (+27%) and education and health (+27.6%). This highlights yet again that households are the ultimate consumers of the vast majority of goods and hence massively amplify the overall economic impact. Type I multipliers represent the direct and indirect impact of sectoral activity on the total output in the economy (Al-Ababneh, Al-Husban, Moh'd Al Muala, Dalbough, Mugableh, Siam, & Vitovschyk, 2024).

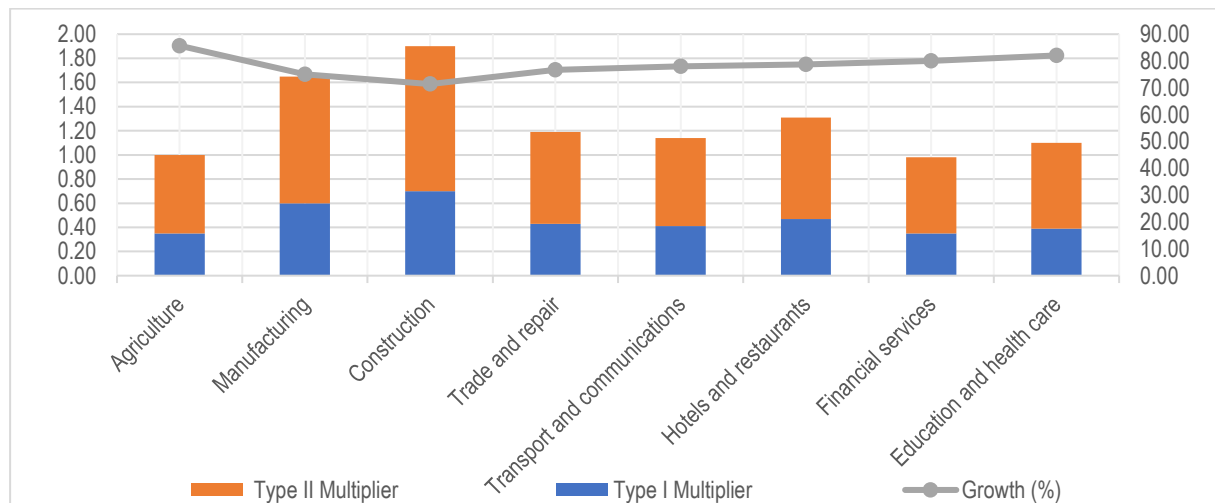
Figure 2. Dynamics of output multipliers (type I and type II) for key sectors of the Jordanian economy, 2020–2021.



Source: Compiled by the author based on data (Jordan Department of Statistics, 2022; World Bank, 2021-23)

The highest multipliers were found in agriculture, the chemical and food industries. So, a small positive shock in those sectors leads to relatively large increases in total output because it is strongly interlinked with intermediates producers. For example, the output multiplier exceeded two in agriculture, suggesting a high level of synergy in the agriculture. This figure shows how deeply these sectors are intertwined with the overall economy. Meanwhile, service activities, such as education or finance, had low multipliers (that is less than 1.4) indicating a weaker relationship with intermediate demand sectors. This is important to consider for investment strategies that are designed to encourage growth. Therefore, industries with high type I output multipliers are prioritized for direct investment under the Jordanians industrial development policy as part of the goods production and the production generating economic activities. The picture is then completed by the multiplier or feedback analysis. This shows how demand at the end is related back, through wages and other classes of income, to the income produced in the household. The main sectors in the Jordanian economy and their income multipliers (type I and type II). 2020–2021 are shown in Fig. 3.

Figure 3. Dynamics of income multipliers (type I and type II) for the main sectors of the Jordanian economy, 2020–2021.



Source: Compiled by the author based on data (Jordan Department of Statistics, 2022; World Bank, 2021-23)

The growth of income multipliers of type II compared to type I is from 70% to 85%, which indicates a significant impact of induced consumption on household income. This underlines the importance of households as a key link in the economic chain, especially in sectors related to intensive labour and the social sphere.

Unlike Type I multipliers, Type II output multipliers include not only direct and indirect effects but also induced effects arising from the growth of household consumption. Here, a particularly strong sensitivity was recorded in the construction sector, where the multiplier exceeded 2.7, indicating high demand arising from the growth of income generated in this sector. This indicates a wide consumer involvement of workers in economic activity. Industrial production and logistics also showed significant Type II multipliers (2.5 and 2.3, respectively),

indicating a potential multi-sector effect of investments. This means that stimulating investments in these sectors will lead to an increase in income and, consequently, consumer demand, which will lead to expanded reproduction in the economy. Thus, Type II multipliers revealed the greatest potential effect from induced consumption, and this provides grounds for the priority development of these industries in the context of Jordan's macroeconomic policy aimed at increasing incomes and domestic demand.

The combined analysis of Type I and Type II output and income multipliers demonstrate the structural dependence of the Jordanian economy on the manufacturing and service sectors, with strong cross-sector linkages. Sectors with the largest multipliers (e.g. manufacturing, hospitality, and transport) have the greatest potential to stimulate economic growth, employment, and income (Ananzeh *et al.* 2024). The difference between Type I and Type II multipliers highlights the importance of including household income effects in models to estimate the real impact of stimulus measures. This provides grounds for adjusting government industrial and investment policies to enhance the impact of priority sectors through value chains.

The study carried out of the output and income multipliers of the first and second kind in the Jordanian economy, its practical importance for the government authorities on the one hand and the private sector and international cooperation agencies operating in the region on the other. The findings have implications for the analysis and explanation of patterns of economic growth, employment generation, investment policies, and industrial and agricultural development. First of all, the results shown in the tables of multipliers give us the possibility to identify priority subsectors in the Jordanian economy, that have the high potency to the multiplier effect Al-Ababneh, Osmonova, Dumanska, Matkovsky, & Kalinovsky, 2024). Numerical values of these sectors are calculated as follows; manufacturing (output multiplier type II - 2.41), construction (2.18), agriculture (2.02) and transport services (2.36). This demonstrates a high multiplier capacity of these sectors to generate further cumulative economic activity in the related sectors and create employment and consumption. Income multipliers are crucial for the construction of Jordanian latent fiscal policy. Accordingly, the high return to investment in construction and agriculture income highlights the necessity of reorienting investment policy from the traditional preoccupation with trade and finance to the encouragement of the productive sector. At the same time, the type II income multipliers of these sectors (1.72 for construction and 1.64 for agriculture) show some potential of domestic demand and its welfare effect. Conclusions: According to the findings:

- From a sectoral investment strategy aimed at maintaining and expanding sectors with a high multiplier effect, especially within the framework of state programs to stimulate employment and GDP growth.
- Update the national budget model, considering the sectoral return on output and income multipliers. This will improve the efficiency of fiscal transfers and government procurement.
- Developing mechanisms for clustering the economy - the development of sectoral clusters (for example, agro-industrial and logistics) based on sectors with high multiplier potential will create a sustainable model of economic growth.
- Adapt educational and vocational programs to those sectors that generate the greatest multiplier effect, especially in terms of employment. This will ensure a structural match between demand and supply in the labor market.
- Institutionalize the use of the input-output model in developing medium- and long-term macroeconomic strategies. It is recommended to introduce regular recalculations of multipliers every 3-5 years, taking into account changes in the structure of the economy.
- Strengthen regional coordination with international organizations (IMF, World Bank, ESCWA) in terms of constructing regional input-output tables, which will consider Jordan's foreign economic relations and synchronize sustainable growth strategies.

Thus, the practical value of the study lies in providing tools for rationalizing budget, investment and social policies based on empirically confirmed intersectoral links. The application of the recommendations obtained can ensure more sustainable and balanced development of the Jordanian economy in the medium and long term.

6. Discussions

Based on the multiplicative decomposition analysis and input-output model developed in this study, we can derive some important theoretical and applied implications. For one thing, the absolute sizes of the output and income multipliers reported here are indicative of the fact that the sectoral-impact structure of the Jordanian economy is an extremely unbalanced one. These sectors present the larger values of the multipliers, are therefore proprietor of high visibility of the location on the build of the effect of economic activity chains. This confirms the conjecture that such bottlenecks exist, and that a shock to it will erupt into an out-of-scale macroeconomic shock. We also note a contrast between type I and type II of multipliers. The difference between them is the influence of

household and consumer. 7In particular for a country like Jordan, where internal demand is of major importance for stability, those effects of output growth on consumption differences are relevant. This points to the importance of thinking about stimulus more broadly and not just focusing on targeting the investment on a few activities. It is also interesting to look at how some multipliers behave in sectors with low shares of direct value added but high degree of connectedness to the rest of the sectors. Agriculture for example demonstrates low levels of direct multipliers; however, at the inter-industry level, it maintains a key role in wrong supply chain development. The specificity points to the urgency of supporting, not only high-tech industries, but also the so-called “anchor” sectors that underpin the economy’s structural stability. Employing the input–output model with the latest statistical data, can lead to a more reasonable explanation of the interrelations between industries. What is the research so relevant for strategic planning – from what to prioritise as industrial policy to how to stimulate employment or investment. Also, we can use the presented approach to analyse the sustainability of the economy to different types of exogenous shocks or crises (e.g. the collapse of energy or logistic sectors, the worldwide escalation of prices).

Conclusions and Further Research

This study revisits type I and type II output and income multipliers with fresh figures in Jordanian context, using the input – output model and contemporary date obtained from Jordan Department of Statistics had (Input-Output Table for 2016, published in 2020). Through a disaggregated view of the largest economic sectors (manufacturing, agriculture, services, construction and trade), the study points to the sectors that have the greatest multiplier effects and shows the architecture of the structural interrelationship in the national economy. The results indicate that sectors like manufacturing, with the industries of chemicals and food in particular, have the greatest type IM output multipliers, that is, they are more backward linked, inducing more production related to those inputs. However, sectors such as education, health and finance generally have smaller multipliers due to lower intersectoral input needs. The type II output multipliers, with household consumption included, emphasize a more generalized economic effect, as service sectors gain in relative importance because of induced impacts from labor income. As for income multipliers, the study finds that labor intensive sectors are more in type II models (which consider induced effects), especially in agriculture and construction. This highlights the role of employment dynamics and the wage distribution process in shaping the overall economic stimulus. However, surprisingly, also at the lower end of output multipliers some labor- intensive sectors show high income multipliers; this is considered to be of particular interest for inclusive growth policies. A key novelty of the present paper is the careful comparison of type I and type II multipliers showing that induced multiple impacts have a substantial effect on the ranking of sectors in systemic importance. Although with type I multipliers both direct and total impacts can be distinguished, the link between the industries themselves, the economy and the household sector are established through household type II analysis, particularly noticeable in countries with informal labor market and consumption-led systems, e.g. Jordan. The findings have several important implications from a policy perspective. First, focusing on sectors with high output and income multipliers concurrently could allow us to maintain growth and employment goals related to them. Second, knowing it is demanding to have precise estimates on the sectoral composition of these multipliers, it enables a more fine-grained fiscal planning and choice of the sectors to invest in, especially in the context of scarce public resources or external current shocks. For instance, an increase in the capital stock of food processing may not only bring a high production response, but also relatively large, induced income effects. The novelty of this work lies in two aspects. Methodologically, it updates the input–output analysis through the use of recent and sector-specific Jordanian data and thus increasing the policy relevance. In terms of concept, it transcends the traditional productivity analysis and includes the income distribution effect through type II multipliers, associating the study with inclusive development objectives. These dimensions offer practical evidence for re-examining development policies in relation to Jordan Vision 2025. Additionally, we also outline the significant voids and prospects for future work. First, the input - output table for 2016 used in this study may not capture the inter-sectoral dynamics in the post-COVID-19 economy. Therefore, building a revised table for 2021 and after would better represent the existing multiplier effects and structural changes. Second, this study has mainly concentrated on static models, despite the fact that dynamic input–output modeling could represent time effects and investment-induced structural changes. Furthermore, future research would take into consideration broadening the analysis by discussing eco-side-multipliers (such as CO₂ emissions and water-usage multipliers), which would provide a comprehensive picture of sectoral impacts from both economic and ecological viewpoints. This would be especially pertinent to Jordan, given its water-scarcity and obligations under the Paris Agreement. Integration of economic and ecological evaluations may also help to enlighten policy decisions that aim to facilitate sectoral development in a sustainable

manner. Furthermore, the inclusion of social accounting matrices (SAM) into input–output analysis may enable researchers to investigate income distribution in a more discriminatory way between quintiles, regions, or demographic sectors. This would increase the discretization of income multipliers, with superior targeting in social protection and subsidy reform programs. Lastly, further comparative work with similar neighboring countries that have a similar economic structure (e.g., Lebanon or Egypt) could place Jordan performance in a regional perspective. Such comparative yardsticks might also inform trade policy and regional cooperation, not least within the Agadir Agreement or Arab Free Trade Area. In sum, the updated input–output analysis of Jordan's economy shows the importance of multiplier surveys in evidence-based policymaking. The results are useful not only in the sense that they help identify sectors that merit policy intervention, but also as a lens to look at inclusive and sustainable development. By conducting studies that extend on the present results and consider the stated limitations, the role of input–output analysis in determining national and regional economic strategies can be pushed to the next level.

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Credit Authorship Contribution Statement

Hamza Mohammed MASHAQBEH was responsible for the conceptualization of the study, methodology development, and project administration. He contributed significantly to the supervision of the research process and was actively engaged in the writing of the original draft.

Hassan Ali AL-ABABNEH participated in the data curation, conducted formal analysis, and contributed to investigation tasks. He also participated in validation of the results and took part in writing – review and editing.

Anas Taleb AT-TARAWNEH was involved in software development, performed visualization of the results, and provided technical support for data analysis. He also supported the writing – original draft.

Oliha POPOVA was responsible for supervision of the research compliance with academic standards, provided critical revisions, and engaged in writing – review and editing. She also supported funding acquisition and coordination with institutional bodies.

Hassan Ali AL-ABABNEH also served as a research coordinator, contributing to the conceptual framework and ensuring methodological accuracy throughout the study. He played a vital role in the formulation of theoretical foundations, supported the data analysis, and was extensively involved in writing and editing the final manuscript. His contribution was essential to maintaining the academic coherence and structural clarity of the paper.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Declaration of Use of Generative AI and AI-Assisted Technologies

The authors declare that they have not used generative AI and AI-assisted technologies during the preparation of this work.

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Competition in an Audit Segmented Market: Evidence from the Nigerian Listed Non-Financial Firms

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Abstract: The study examines the effect of competition on audit price and quality. We measure competition using initial audit price, static, and dynamic competition indicators. Static competition is measured using audit concentration, while the dynamic competition is measured using client mobility. The study fills in the gap in the literature by examining audit competition in a segmented audit market, considering audit complexity, and separating the Nigerian non-financial institution audit market into oligopolistic and atomistic segments. Our study employs ordinary least squares to analyse the data collected. The results show that audit concentration positively affects audit fees and improves quality in both segments. The study indicates that client mobility positively affects audit fees in both fragmented markets and provides evidence that audit clients react to low quality competitively by switching auditors within the segments. Finally, our results show that audit firms engage in lowball practices in the initial audit year as a marketing strategy, and initial year audit fee discounting improves audit quality. Our study provides evidence of competition within an audit-segmented market when the basis of delineation is audit complexity. Our results provide empirical evidence of audit competition in the oligopolistic segment, contrary to the traditional view of Structure Conduct Performance (SCP).

Keywords: competition; audit price; audit quality; atomistic; oligopolistic; structure; conduct; performance.

JEL Classification: L13; D 43; M 42; M48; R10.

Introduction

Auditors are expected to improve the quality of financial statements; however, the market power of large audit firms poses a threat to audit competition, invariably affecting the price and quality (Elayan *et al.* 2024; Kim *et al.* 2024). For decades, financial regulators (e.g., Financial Reporting Council, 2018; General Accounting Office (GAO), 2003; 2008; Oxera, 2006; 2007; United States (US) Treasury, 2008) in advanced and emerging economies have been sceptical of audit market competition due to the high level of concentration, instituting several policies and reforms to safeguard audit quality and price. Extant Studies on audit market competition have primarily focused on the holistic audit market or oligopolistic segment from a static perspective, overlooking the atomistic segment and dynamic audit competition, including auditing literature in Nigeria. Globally, the audit market is a dual structure consisting of the oligopolistic and atomistic segments. The question is whether there is

less competition among auditors' operations in the atomistic section. Does high concentration connote less competition? Our study examines audit competition among Nigerian non-financial institutions in both the atomistic and oligopolistic segments, from both static and dynamic perspectives.

There are two conflicting views of audit concentration and its effect on competition. The first strand, anchored on the industrial economic theory of Structure Conduct Performance (SCP) paradigm, assumes that high concentration results in a lack of competition, leading to the exploitation of audit clients in terms of audit price and quality due to limited choice of audit firms (Competition & Markets Authority, 2019; Kitto, 2024). Based on the SCP paradigm, financial and audit regulators argue that highly concentrated markets lead to higher audit prices and impaired audit quality. Conversely, large audit practitioners and studies challenged the SCP paradigm view, premising on the spatial competition theory. For instance, PricewaterhouseCoopers (PwC) (2012) responds to the ongoing discourse about audit competition, arguing that competition exists among the Big Four. The proponents of spatial competition theory argue that the audit market's high audit concentration is a consequence of audit clients' preference for audit quality at the right price (Numan & Willekens, 2012; Pearson & Trompeter, 1994). The spatial competition theory argues that firms compete with their closest rival (Numan & Willekens, 2012; Pearson & Trompeter, 1994) but not outside their segment. Audit firms compete aggressively for clients by discounting audit fees in the initial engagement year and providing quality audit services (Cho & Krishnan, 2021). Studies show that audit fee discounting is rampant in the atomistic audit segment, the non-Big Four (Chan, 1999; Ghosh & Lustgarten, 2006; Simac & Willekens, 2024). Empirical evidence on audit competition indicates that large clients engage the Big Four to meet the demand for complex and intensive audit procedures that require immense technological input (Marrian & Pong, 2007; Scheidt, 2020).

Furthermore, large audit clients respond to audit quality impairment by switching to another auditor despite the limited choice within the Big Four (Xin *et al.* 2023; Van Raak *et al.* 2020; Willekens *et al.* 2023), evidencing competition. Studies indicate less competition between the Big Four and non-Big Four; this could be due to complexity (Chen *et al.* 2023; Peel, 2013; Kitto, 2024; Scheidt, 2020; Van Raak *et al.* 2020). However, limited studies have considered audit complexity in audit competition studies (Xin *et al.* 2023; Van Raak *et al.* 2020) despite the substantial spatial difference between the Big Four and the non-Big Four.

The Nigerian audit market, just like in most countries, is highly seller-concentrated and dominated by the Big Four (Ajaegbu, 2012; Asien, 2014; Ayoola *et al.* 2022; Eguasa & Uroghide, 2017) and has witnessed audit impairments (e.g., Cadbury, Leverbrother) involving large and small audit firms. The Nigerian policymakers (FRCN, 2011) failed to address audit competition directly. However, the Nigerian audit regulatory bodies have initiated policies such as mandatory statutory audits, audit firm rotation, audit fee ceilings, audit fee disclosure, and non-audit service fee caps to improve audit quality and control audit prices. Despite the abovementioned, audit competition has received little attention in Nigeria (Ayoola *et al.* 2022). The Nigerian auditing literature on audit competition has neglected audit complexity, indicating a lack of studies in the atomistic segments; despite studies (Asien, 2014; Uroghide & Izedonmi, 2015) show that the non-big four audit firms control no less than 30 per cent of the audit market of firms listed on the Nigerian Exchange Group Plc (NGX). Furthermore, these limited studies proxy competition from the industrial economic theory (see Eguasa & Uroghide, 2017), neglecting dynamic, audit complexity, and fee discounting during the initial engagement year.

Our study contributed to knowledge by adding to the limited empirical evidence, firstly by considering audit complexity, segregating the non-financial audit market into atomistic and oligopolistic segments to ascertain the effect of competition within each segment, which is novel and the first of its kind in Nigeria, if not Africa. Secondly, our study examines competition through the audit cycle, from the initial audit engagement period to price and quality, which is rare in audit competition literature. The study investigates audit price and quality competition using static and dynamic measures. Finally, we theoretically contribute to knowledge by testing the market power and the alternative view of the SCP paradigm in the non-financial segregated audit market. The rest of the paper is divided into the following sections. Section two relates to literature review and hypothesis development; section three is research design. Section four discusses findings, and section five shows the study's summary, conclusion, and limitations.

The Nigerian Financial Regulatory framework is weak and litigious (Nwosu, 2023; Ogbe & Oyibokure, 2023), just like most regulatory frameworks in Africa (Salifu *et al.* 2024). Studies (Asien, 2014; Ayoola *et al.* 2022; Eguasa & Uroghide, 2017; Okaro & Okafor, 2013) evidenced that the Nigerian audit market is highly concentrated and dominated by the Big Four. In support of the abovementioned empirical evidence, Asien (2014) asserts that the Big Four controls 67.5 per cent of the entire audit market of public companies. Furthermore, the 50th president of the Institute of Chartered Accountants of Nigeria (ICAN), Ajaegbu (2012), claims that the Big Four

dominate the Nigerian audit market, lack competition and proposes a joint audit to increase the market share of Nigerian-owned audit firms.

As earlier mentioned, the Nigerian financial regulations (e.g., CAMA 2020; FRCN, 2011; NCCG 2016; 2018) failed to address audit competition directly; the institute addresses audit-related issues such as audit price, quality, and independence, which invariably form part of our concern in the study. The FRCN (2011) stipulates that all listed firms licensed in Nigeria are mandated to disclose the audit fee and not allowed to receive more than 25 per cent of their annual audit income from any of their clients, evidencing the existence of an audit fee cap. There is no regulation on the audit fee floor as compared to other advanced economies. For example, the Chinese government set a minimum audit fee to guide against lowballing and aggressive competition (Huang *et al.* 2016; Zhang, 2012). Furthermore, NCCG (2016) Section (19.4) stipulates that an audit firm is restricted from performing statutory audits and a significant proportion of non-audit services (NAS) to the same client to promote auditor independence.

A critical analysis of the abovementioned indicates that these audit policies impact audit price, quality competition, and lowballing in several instances. First, the mandatory audit fee disclosure makes the audit fee observable and increases the clients' bargaining power in the audit fee negotiation process. Secondly, the mandatory audit fee disclosure and the restriction of NAS limit the possibility of lowballing practices, as recovering the initial audit fee loss from subsequent audit fees is low due to the possibility of clients switching to other audit firms and the availability of market information. Conversely, the absence of an audit fee floor policy increases the likelihood of aggressive audit competition during the initial audit engagement year through lowballing practices. The audit firms may compromise audit quality to compensate for the initial audit fee loss. The audit fee cap creates a gap between the atomistic and the oligopolistic segments, preventing the auditors operating within the atomistic segment from having large audit clients to ensure audit independence.

1. Literature Review and Hypotheses Development

1.1 Audit Market Segments

The audit market is fragmented into three tiers: the first, mid, and last (Peel, 2013; IAB, 2013). The first tier of the audit market structure is the oligopolistic segment consisting of the Big Four audit firms (namely: PricewaterhouseCoopers (PwC), Ernst & Young (EY), Deloitte, Klynveld Peat Marwick Goerdele (KPMG)). The Big Four dominate the audit market and increase their market power through product and price differentiation (Pindyck & Rubinfeld, 2018) and possess large audit clients (Ascher, 2008; Guo *et al.* 2017; Kacer, 2023). The mid-tier is the second audit segment, containing the medium-size auditors characterised by a limited number of audit firms, just like the Big Four, with less operating and technical capacities when compared to the first-tier auditors, with small public and private firms as its clients (Simons & Zein, 2016). The last-tier audit segment includes small, local auditors with few public company clients.

There is a general perception that the audit market structure is oligopolistic. The existence of the oligopolistic audit market invariably creates an atomistic fragment of the audit market. The audit market structure is fragmented into oligopolistic and atomistic (Chung & Lee, 2024; Marrian & Pong, 2007). The atomistic segment consists of the numerous non-Big Four, but not unlimited, having a smaller proportion of the entire audit market. Furthermore, the atomistic segment is characterised by low audit concentration and non-specialised auditors, audit privacy, and the audit clients usually small listed and unlisted clients (Dey, 2010; 2013; Dunn *et al.* 2008). For the purpose of the study, we assume that the audit big four audit firms operate in the oligopolistic segments, while the non-Big four operate in the atomistic segment.

1.2 Audit Competition

The economic theory posits that competition should result in cost efficiency and product innovation (Hay & Liu, 1997; Pilat, 1996). The regulatory bodies contend that the audit market lacks competition due to a limited choice of audit firms and barriers to new entry (GAO, 2003; 2008; Oxera, 2006). Based on the traditional view of the SCP paradigm, in an oligopolistic market, the sellers have the market power either through collusion or individually taking advantage of the clients by charging a higher price or reducing the quality (Day *et al.* 2002; Noll, 2004). Conversely, the alternative view of SCP posits that there is competition in the oligopolistic market. Cabral (2017) argues that there is no consensus on the acceptable measurement of competition; hence, the study measures competition from the static perspective using audit concentration (the Herfindahl index) and dynamic perspectives using client Mobility.

1.2.1 Audit Market Concentration

The traditional view of the SCP paradigm posits that the market structure determines the conduct and performance of audit firms. The traditional view of SCP argues that in an oligopolistic market, concentration increases the market power of the audit oligarchs (large audit firms), resulting in a reduction in competition, audit price exploitation, and impairment of audit quality (Ayoola *et al.* 2022; Elbardan *et al.* 2023; Kamolane & Odendaal, 2021). The financial regulatory bodies (e.g., Competition & Markets Authority, 2019; Financial Reporting Council, 2018; GAO, 2008; Oxera, 2006; 2007; US Treasury, 2008) express scepticism due to the danger identified by the traditional view of SCP on concentration. The traditional view assumes that audit market concentration is exogenous and positively related to audit price but negatively related to audit quality (Azizkhani *et al.* 2022; Kallapur *et al.* 2010; Newton *et al.* 2013). Contrarily, the proponents of the alternative view of SCP argue that audit concentration is endogenously determined by clients' demand for audit quality (Etro, 2014; Sutton, 1991). The differentiation hypothesis posits that audit clients engage first-tier auditors to have a competitive advantage over their rivals through financial reporting quality (Peel, 2013; Zerni, 2012). However, a limited number of audit firms have the resources to meet the audit quality expectation (Sirois & Simunic, 2011), explaining the rationale for high audit concentration. Van Raak *et al.* (2020) argue that audit complexity should be accounted for in audit concentration–price and audit concentration–quality studies; however, audit complexity is an omitted determinant that has received little attention.

There are limited empirical studies on audit concentration; however, the limited archival literature has generated mixed results (Scheidt, 2020; Van Raak *et al.* 2020). While studies (Eshelman & Lawson, 2017; Huang *et al.* 2016) assume that concentration is positively related to audit price, conversely, empirical evidence (Numan & Willekens, 2012; Pearson & Trompeter, 1994) indicate that audit concentration is negatively associated with audit price.

Concerning audit quality, audit concentration studies are limited and inconclusive (Gunn *et al.* 2019; Scheidt, 2020; Van Raak *et al.* 2020). While studies (Huang *et al.* 2016; Kallapur *et al.* 2010; Newton *et al.* 2013) indicate that audit quality improves with an increase in concentration, conversely studies (Boone *et al.* 2012; Francis *et al.* 2013) also indicate a negative association between the two variables. Based on those mentioned above and limited empirical evidence, we postulate that:

H₁: Audit market concentration significantly affects audit price.

H₂: Audit market concentration significantly affects audit quality.

1.2.2 Client Mobility

The traditional view of SCP posits that concentration is inversely related to competition. In line with this assertion, the Cournot competition model contends that competition reduces as the number of sellers declines. The proponents of the traditional view (Ciconte *et al.* 2015; Kallapur *et al.* 2010) proxy competition using concentration based on the structural economic theory. However, the alternative view of SCP contends that concentration is a static measure of competition; hence, it does not reflect rivalry among market players (Carlton & Perloff, 1994) except in a perfectly competitive market and similar size (Van Raak *et al.* 2020). However, the alternative view proponents argue that high audit concentration does not necessarily translate to a lack of competition. Hence, suggest a dynamic measure of competition (Ayoola *et al.* 2022; Baldwin & Gorecki, 1998; Buijink *et al.* 1998) proxy with client mobility, client market share, and spatial distance difference, among others.

Client mobility is a competitive response by audit clients to a change in audit price or quality. The audit client may switch to another audit firm in response to a change in audit price or quality. Client mobility reflects the dynamic rivalry among audit firms for clients. Contrary to the traditional view, the alternative view asserts that competition may exist in a duopoly or oligopolistic audit market. To buttress the abovementioned, Nicholson and Snyder (2008) postulate that pricing decisions fall within the two theoretical markets of monopoly and perfectly competitive market in an oligopolistic market. Premising on this hypothesis, the auditors operating in the oligopolistic market charge a fair or exploitative price. Furthermore, Asthana *et al.* (2018) and Gunn *et al.* (2019) claim that the audit oligopolist market does not necessarily connote the exploitation of clients in terms of audit price and quality. Similarly, studies (e.g., Cabral, 2017; Stiglitz, 1987) contend that audit firms operating in the oligopolistic market face aggressive audit competition as the numbers of suppliers reduce.

Studies (Buijink *et al.* 1998; Dekeyser *et al.* 2021; Newton *et al.* 2013; Willekens *et al.* 2023) indicate that the dynamic competition reflects rivalry among audit firms, especially within the oligopolistic section. However, there are limited empirical studies on dynamic audit competition (Van Raak *et al.* 2020). Based on theory and existing empirical studies, we hypothesise that

H₃: Dynamic audit competition significantly affects the audit price.

H₄: Dynamic audit competition significantly affects audit quality.

1.2.3 Initial Audit Engagement

The initial audit engagement year is the first year the auditor is on a specific audit assignment. Auditors are accused of lowballing in the initial audit engagement year. Lowballing charges an audit fee less than the actual audit cost to compete, win, and retain the client (Carswell & Francis 1999; DeAngelo, 1981; Desir *et al.* 2014; Krishnan & Tany, 2020). The regulators are concerned that the initial audit fee discounting impairs auditors' independence and quality (Liu & Huang, 2024). Empirical evidence shows that auditors under-price in the initial year of engagement (Ettredge & Greenberg, 1990; Simon & Francis, 1988). Furthermore, studies (Chan, 1999; Cho *et al.* 2021; Dye, 1991) show that lowballing is practised by auditors operating in a competitive market, especially in the atomistic section.

According to the traditional view of the SCP paradigm, the market and bargaining power of the audit firm increases with its concentration. Based on the structural theory, the oligopolistic segment auditors are less likely to lowball and are supported by empirical evidence (Ghosh & Lustgarten, 2006; Ghosh & Pawlewicz, 2009; Huang *et al.* 2015). Conversely, Cabral (2017) contends that the oligopolistic market does not lack competition; studies report aggressive competition in the oligopolistic market (Cho *et al.* 2021; Stiglitz, 1987). Empirical evidence of lowballing subsists in the atomistic and oligopolistic markets as both the Big – Four and non–Big Four engaged in initial-year audit fee discounting (Cho *et al.* 2021; Desir *et al.* 2014). Also, as expected, studies (Chan, 1999; Ghosh & Lustgarten, 2006; Ettredge & Greenberg, 1990) evidence that audit fee discounting is well practised in the atomistic section.

Based on empirical evidence and applicable theory. We postulate that lowballing practices in the non-financial sector's atomistic, oligopolistic, and total audit market structure.

H₅ – *The lowballing exists in the initial audit engagement year*

Conversely, studies show that an initial audit year discounting is a marketing strategy and a sunk cost and does not compromise audit independence and quality (Cho *et al.* 2021; Liu & Huang, 2024). Studies show lowballing in the initial audit year impairs audit quality (Barua *et al.* 2020; Cassell *et al.* 2020; Dye, 1991; Huang *et al.* 2016). Based on theory and existing empirical evidence, we hypothesise that,

H₆ – *lowballing practices have a significant effect on the audit quality*

2. Research Methodology

2.1 Data and Sample

Our study focuses on the Nigerian listed non-financial institution because the sector has a significant portion of the atomistic segment (see Asien, 2014; Soyemi *et al.* 2025). We repeatedly collected a sample size of 960 firm-year observations from 80 listed non-financial firms from 2011-2022 from the Nigeria Exchange Group (NGX) and the audited financial report of the sampled firm. Our study chooses 2011 as the base year due to the FRCN (2011) mandatory audit Fee Disclosure Act, while 2022 is the latest financial report available during the study. The sample of 960 firm-year observations is arrived at using the following criteria:

- The company's stock is actively traded over 2011 -2022,
- The financial report of the company is published over the period,
- The audit client must only switch within its audit segment, and
- Data on all the variables of interest are readily available in financial reports or fact books.

2.2 Measurement of Variables and Specification of Models

2.2.1 Dependent Variable

The study has two dependent variables: audit fee and audit quality.

Audit Fee

The study measures the audit fee as a natural logarithm of the actual audit price charged by the statutory auditor for his engagement service. Our surrogate for the dependent variable is consistent with similar studies (Asthana *et al.* 2018; Ayoola *et al.* 2022; Van Raak, 2020).

Audit Quality

The study assumes that the audit quality is unobservable and measured from an earnings management perspective consistent with studies (Van Raak *et al.* 2020; Willeken *et al.* 2023). We employ the discretionary accrual method of modified Jones by Jeter and Shivakumar (1999) and Ball and Shivakumar (2006) model as well as the performance-adjusted modified Jones model (Dechow *et al.* 1995):

$$tacc_{it} = \beta_0 + \beta_1[\Delta rev - \Delta rec] + \beta_2ppe_{it} + \beta_3roa + e_{it} \quad (1)$$

$$tacc_{it} = \beta_0 + \beta_1\Delta rev_{it} + \beta_2ppe_{it} + e_{it} \quad (2)$$

Where $tacc_{it}$ indicate the total accruals, Δrev represents changes in revenue, Δrec indicates a change in receivables, the net property, plant, and equipment is coded as ppe , roa connotes return on assets, e_{it} represents the discretionary accruals. The inverse of the discretionary accrual represents the audit quality.

2.2.2 Independent Variables

Our study proxy audit competition using both static and dynamic perspectives. Static competition is measured by the inverse of the Herfindahl-Hirschman Index (HHI), while dynamic competition is measured using client mobility.

Audit concentration

The study measures static competition using audit concentration. We employ audit market concentration to test the market power of the auditors in the segment and the industry using the Herfindahl-Hirschman Index (HHI). The HHI measures each audit firm's market size in terms of the total market size in the segment and the industry. The HHI is the square of the proportion of the total audit fee of each client in its segment, consistent with studies (Boone *et al.* 2012; Kamolane & Odendaal, 2021; Newton *et al.* 2013). The Herfindahl index is stated as follows:

$$HHI = \sum_{i=1}^N \left(\frac{s_i}{S}\right)^2 \quad (3)$$

Where N is the total number of statutory auditors operating in the market, s_i is the size of the audit firm, which is measured using the audit fee paid to the audit firm, and S is the size of the audit market, which is measured using the total audit fees paid in the segment.

Client Mobility

Our study measures the dynamic competition using percentage change in the market share of each auditor, which is in line with the study (Ayoola *et al.* 2022; Buijink, 1998; Van Raak *et al.* 2020). The client's mobility is stated as follows:

$$CM_{it} = \sum_{A=1}^N \{MS_{Ai,t} - MS_{Ai,t-1}\} \quad (4)$$

Where CM connotes Client mobility, MS represents the market share.

Initial Audit Engagement Year

The study uses a dichotomous variable to measure the initial year of the audit, consistent with studies (Barua *et al.* 2020; Cassell *et al.* 2020), by ascribing a value of one to the initial year of audit engagement and zero otherwise for another successive year of the auditor's engagement.

2.2.3 Control Variables

Our study controls firm-specific and audit characteristics. Firm-specific characteristics, namely size, complexity, and profitability, are included in the model. We measure client size using the natural logarithm of total assets consistent with the prior studies (Eshelman *et al.* 2017; Van Raak *et al.* 2020) and expect a positive association between client size and audit price as a more significant audit effort is required when performing the audit engagement of large clients. Concerning audit quality, we postulate that larger clients have the financial capacity to employ specialised audit firms and improve the audit quality. We proxy client complexity by the number of employees and business segments and expect client complexity to be positively associated with price and inversely related to audit quality.

Furthermore, the study introduces the financial performance indicator of Return on Assets (ROA) and loss. The study measures the ROA as profit after tax scaled down by the total assets, while the loss is a binary variable, one of which is accorded when the firm suffers a loss at the closing date of the accounting year and zero otherwise. We predict a positive relationship between ROA and audit fees and quality. Also, clients with losses at fiscal year-end tend to engage in aggressive financial reporting. In line with these arguments, we expect the auditors to charge a high price when there is a loss, but the association of the variable with audit quality is expected to be mixed.

Our study controls financial stability by employing the firm's current ratio (CR) and Leverage (LEV). The current ratio is current assets divided by current liability, while the Lev is the debt to total assets ratio. The

financial stability depicts the business risk; the higher the ratio, the likelihood that the auditor demands a higher fee, consistent with similar studies (Eshelman & Lawson, 2017; Van Raak *et al.* 2020). Also, financial stability may likely harm audit quality.

Furthermore, the Busy is defined as the auditors' season, which is usually December 31 of every year in Nigeria. The busy is proxy by a binary variable of one if the accounting date is December 31 and zero otherwise. The audit clients with December fiscal year-end tend to pay more for audit assurance services, as the audit firms are on-season, and most companies have a fiscal year-end of December 31 (Hay *et al.* 2006; López & Peters, 2011; Ng *et al.* 2018). Also, we introduce the audit type represented by the Big Four. The Audit type is represented as a dichotomous variable of one when the big four undertake the audit assignment and zero otherwise. Like other related studies, we assume that large audit firms provide a better quality based on their resources and charge a premium price.

Finally, we introduce audit tenure (aud_ten) and assume that the audit price increases with a long audit tenure, especially if the auditor lowballs in the initial audit year. However, there is evidence of the learning effect, which claims that audit price decreases as the tenure increases due to reduced subsequent audit costs. Regarding audit quality, the learning effect posits that auditors improve with time; however, the opponents of audit tenure posit that auditors' independence is likely compromised as audit tenure increases due to an increase in familiarity threat associated with long audit tenure.

2.3 Model Specification

To achieve this objective, we employ audit price and competition models. The effect of competition on pricing is functionally stated as follows:

$$\ln(\text{afee}) = \beta_0 + \beta_1 \text{conc}_{it} + \beta_2 \text{initial} + \beta_3 \text{big\_4}_{it} + \beta_4 \ln(\text{ta})_{it} + \beta_5 \ln(\text{emp})_{it} + \beta_6 \ln \text{seg}_{it} + \beta_7 \text{aud\_ten}_{it} + \beta_8 \text{roa}_{it} + \beta_9 \text{loss}_{it} + \beta_{10} \text{lev}_{it} + \beta_{11} \text{cr}_{it} + \beta_{12} \text{busy}_{it} + \sum yjind + e_{it} \quad (5)$$

While

To achieve this objective, we employ audit quality and competition models. The effect of competition on pricing is functionally stated as follows:

$$QA = \beta_0 + \beta_1 \text{conc}_{it} + \beta_2 \text{initial} + \beta_3 \text{big\_4}_{it} + \beta_4 \ln(\text{ta})_{it} + \beta_5 \ln(\text{emp})_{it} + \beta_6 \ln \text{seg}_{it} + \beta_7 \text{aud\_ten}_{it} + \beta_8 \text{roa}_{it} + \beta_9 \text{loss}_{it} + \beta_{10} \text{lev}_{it} + \beta_{11} \text{cr}_{it} + \beta_{12} \text{busy}_{it} + \sum yjind + e_{it} \quad (6)$$

Where AFEE is the natural logarithms of audit fees, CONC is audit market concentration, which measures the Herfindal index, the initial measure of the first year of the audit engagement, BIG_4 is the four largest audit firms, namely (KPMG, Ernst and Young, Deloitte, PWC). Ln (ta) is the natural logarithms of total assets, and Inseg is the natural logarithms of the number of business segments a client operates. The roa connotes the return on assets; LOSS is the firm's loss, and Lev represents leverage. Cr is the current ratio. Busy is the fiscal year-end of the clients, and the aud_ten represents audit tenure, whereas AQ represents audit quality measured by the inverse of the residue in equations 1 and 2.

3. Research Results

3.1 Descriptive Statistics

Table 1 shows the descriptive statistics of variables employed in achieving the study's objective. The variables are the natural logarithm of audit fee (ln-aud fee), Herfindahl Index (HHI), client mobility (CM), initial audit engagement year (initial), the Big Four (big-four), the natural logarithm of total assets (lna), number of employees (emp), the logarithm of the numbers of the business segment (ln-seg), audit tenure (aud_ten), return on asset (roa), current year loss (loss), leverage (Lev), current assets (cr) and busy accounting period (busy).

Table 1 shows that the industrial audit fee (ln-aud fee), in the natural logarithm form, is 9.3, amounting to ₦11,731,120 (as the original figure is stated in thousand). Furthermore, the audit fee statistic shows a significant difference of 7.39 (in natural logarithm form) between the two segments, evidencing high audit price disparity between the oligopolistic and the atomistic auditors. The rationale for the premium audit price in the oligopolistic market could be due to the client's size and audit complexity, which results in the demand for specialised auditors with high technological capabilities and human resources. Table 1 shows that the entire sample HHI has an average value of 0.264. The result evidence that the Nigerian non-financial audit market is sellers concentrated with an average value greater than the hurdle of 0.25 (HHI > 0.25). The maximum value of 0.393 is above the cut-off point of 0.25 (HHI > 0.25), indicating the existence of a tight oligopolistic segment. The HHI minimum value

of 0.139 is lower than the threshold, supporting the intense competition and existence of the atomistic section. The meaning of the HHI in the atomistic and oligopolistic segments are 0.11 and 0.38, respectively. The segmented results of HHI indicate an aggressive atomistic and tight oligopolistic market. The statistics of the HHI competition show that the market is relatively stable, with a standard deviation of 0.073. Table 1 shows that client mobility averages 0.25, 0.3, and 0.21 in the industrial, atomistic, and oligopolistic segments. The result evidenced the audit competition in each segment measured from a dynamic perspective. The availability of audit choice enables client mobility in industry, atomistic and oligopolistic. The client mobility descriptive statistic displays that atomistic is highly competitive, as the mean statistics show that the audit firm loses an average of 15 per cent of its clients (0.3/2) to its rivals annually.

Table 2 shows that the initial year engagement statistics have an average industrial value of 0.2, indicating a 20% likelihood of lowballing in the industry. Also, the initial value indicates that the lowballing auditors dominate the atomistic section, with a mean value of 0.25, concordance with structural economic theory. Also, in support of the market competitiveness of the atomistic segment, the auditor's tenure is shorter, with a mean of 3.8 years, indicating a frequent change compared to the oligopolistic market, which has an average of approximately six years. Furthermore, the Table shows that the non-Big Four controlled a significant proportion of the audit market, 45% of the total market share (measured by the number of clients), while the Big Four controlled the majority, controlling 55%.

Table 1. Descriptive statistics

	Market							Atom	Oligo	Diff
	FULL SAMPLE									
variables	mean	median	std. dev	min	Q1	Q3	max	mean	mean	Diff
ln_aud_fee_	9.37	9.51	1.51	2.64	8.64	10.25	13.31	5.09	12.48	7.39
hhi	0.26	0.26	0.07	0.14	0.18	0.27	0.39	0.11	0.38	0.27
cm	0.25	0.24	0.05	0.13	0.04	0.21	0.41	0.21	0.30	0.09
initial	0.20	0.00	0.40	0.00	0.00	0.00	1.00	0.25	0.17	-0.08
big_four	0.55	1.00	0.50	0.00	0.00	1.00	1.00			
Inta	16.23	16.35	1.95	10.63	13.24	18.82	19.97	11.10	19.94	8.84
emp	5.97	6.05	1.50	3.33	3.59	8.37	12.07	5.64	6.21	0.57
ln_seg_	0.93	1.10	0.54	0.00	0.56	1.30	1.95	0.30	1.38	1.08
aud_ten	4.08	4.00	0.28	2.00	2.74	4.80	9.00	3.80	5.88	2.08
roa	0.04	0.04	0.27	-0.93	0.03	0.14	4.28	0.03	0.04	0.01
loss	0.21	0.00	0.41	0.00	0.00	0.00	1.00	0.27	0.17	-0.10
lev	0.52	0.55	0.22	0.01	0.03	0.83	1.00	0.56	0.49	-0.07
cr_	1.88	1.18	3.43	0.01	1.24	2.54	36.41	1.69	2.02	0.33
busy	0.66	1.00	0.47	0.00	0.00	1.00	1.00	0.25	0.96	0.71

Source: Authors' Computation (2024)

Note: The full sample size is n=960 obs, n (Atomistic)= 432 obs, and n(Oligopolistic) = 528 obs

The CR. (current ratio) of the firms in the industry is fairly below the acceptable ratio of 2:1, with a mean value of 1.960 and median of 1.180; it could be inferred that the Nigerian listed non-financial firms overtrade and possibly have short-term financial stability problems. Also, there is a high dispersion of individual firms from the industrial average, evidenced by a standard deviation value of 3.433. Also, the Table shows information about the strength of staff in the industry. The exponential value regarding the employee shows that each firm operating has an average of 393 employees. Table 2 also shows that the auditor is engaged for an average of four years, with a maximum value of ten years. The audit tenure statistics indicate that auditors are engaged on a medium-term basis; this could affect the acquaintance process with the client's nature of business, internal control, and, invariably, audit quality. However, the audit clients operating in the non-financial industry comply with the maximum audit tenure of ten years. However, a voluntary audit switch may be difficult amid competition because most firms have a closing year-end of December 31. However, there is no existing legal imposition of the fiscal year-end date in the Nigerian non-financial sector, unlike the financial sectors, where all the firms must comply with the December 31 financial year-end as stipulated by the CBN through circular of BSD/DIR/GEN/VOL.2/004.

3.2 Correlation Analysis

Table 2 shows the results of the correlation analysis and the Variance Inflation Factor (VIF) of the variables employed in achieving the objectives. The Pearson pairwise correlation of the variables indicates that the model has less multicollinearity problem with the highest correlation of $r = 0.58$ occurring between the HHI and client mobility, which is less than the threshold of 0.8. The results of the VIF of the regressors as displayed in Table 2 is less than the benchmark of 5. The VIF results corroborate the lesser existence of the multicollinearity problem with the highest value of 4.88, less than the threshold of 5.

There is a need to explain the pairwise relationship of variables with economic importance. The static audit competition, measured by HHI, has a positive and significant association with audit price ($r = 0.04$, $p = 0.00$), indicating that high audit concentration possibly leads to the exploitation of clients in terms of price. However, the dynamic competition, measured by client mobility (CM), is negatively associated with audit fee ($\ln\_aud\_fee\_$) ($r = -0.58$, $p = 0.00$), indicating that an increase in audit fee may reduce the market share of the audit firm. The Big Four has a significant positive association with audit fees ($r = 0.24$, $p = 0.00$) and HHI ($r = 0.15$, $p = 0.00$). However, there is a negative association between Big Four and Client mobility ($r = -0.13$, $p = 0.01$) and initial ($r = -0.03$, $p = 0.02$). The pairwise association of the Big Four and the other variables of interest indicate that the Big Four charges a premium audit fee; the result indicates that the Big Four is possibly exploiting their client in terms of price due to high concentration. However, there is still a tendency for competition as clients are switching to other competitors, and the Big Four is lowballing to prevent market share loss. For brevity and conciseness, the economic interpretation of the correlation analysis is limited to the primary variable of interest.

Table 2. Correlation Matrix and Variance Inflation Factor of Full Sample

Probability	1	2	3	4	5	6	7	Tolerance	VIF
ln_aud_fee_ (1)	1.00								
	0.00								
hhi (2)	0.04	1.00						0.56	1.79
	0.00	0.00							
cm (3)	-0.01	0.58	1.00					0.21	4.88
	0.02	0.00	0.00						
initial (4)	0.01	0.02	0.01	1.00				0.30	3.37
	0.41	0.00	0.00	0.00					
big_four (5)	0.24	0.15	-0.13	-0.03	1.00			0.92	1.09
	0.00	0.00	0.01	0.02	0.00				
ln_ta (6)	0.51	0.09	0.00	0.02	0.21	1.00		0.48	2.07
	0.00	0.03	0.92	0.39	0.00	0.00			
employ (7)	0.16	0.18	0.21	-0.03	0.12	0.12	1.00	0.85	1.17
	0.00	0.00	0.00	0.48	0.01	0.01	0.00		
seg (8)	0.08	-0.01	0.01	-0.07	-0.02	-0.02	0.25	0.53	1.88
	0.03	0.90	0.85	0.17	0.74	0.68	0.00		
aud_ten (9)	0.03	-0.03	-0.02	-0.09	-0.07	0.06	0.05	0.55	1.82
	0.61	0.52	0.65	0.06	0.14	0.23	0.35		
roa (10)	0.03	0.00	0.00	0.01	0.19	0.07	0.05	0.45	2.20
	0.48	0.97	0.92	0.82	0.00	0.17	0.27		
loss (11)	0.06	0.08	0.08	0.07	-0.09	0.01	-0.06	0.59	1.71
	0.25	0.09	0.11	0.15	0.08	0.88	0.26		
lev (12)	-0.04	-0.03	-0.01	0.12	0.08	0.02	0.15	0.60	1.67
	0.38	0.55	0.79	0.02	0.11	0.66	0.00		
cr (13)	0.19	0.02	0.00	0.02	-0.06	-0.14	0.08	0.75	1.34
	0.00	0.68	0.93	0.67	0.22	0.01	0.11		
busy (14)	0.19	0.22	0.23	-0.02	0.03	0.00	0.04	0.53	1.88
	0.00	0.00	0.00	0.68	0.50	0.98	0.46		

Probability	1	2	3	4	5	6	7	Tolerance	VIF
	8	9	10	11	12	13	14	Tolerance	VIF
seg (8)	1.00							0.53	1.88
	<i>0.00</i>								
aud_ten (9)	0.05	1.00						0.55	1.82
	<i>0.35</i>	<i>0.00</i>							
roa (10)	-0.01	-0.12	1.00					0.45	2.20
	<i>0.06</i>	<i>0.01</i>	<i>0.00</i>						
loss (11)	-0.01	0.05	-0.52	1.00				0.59	1.71
	<i>0.82</i>	<i>0.32</i>	<i>0.00</i>	<i>0.00</i>					
lev (12)	0.14	0.01	0.08	-0.04	1.00			0.60	1.67
	<i>0.00</i>	<i>0.84</i>	<i>0.12</i>	<i>0.41</i>	<i>0.00</i>				
cr (13)	0.02	0.10	0.04	-0.14	-0.05	1.00		0.75	1.34
	<i>0.70</i>	<i>0.05</i>	<i>0.38</i>	<i>0.00</i>	<i>0.30</i>	<i>0.00</i>			
busy (14)	-0.21	0.04	0.16	-0.03	-0.09	0.16	1.00	0.53	1.88
	<i>0.00</i>	<i>0.48</i>	<i>0.00</i>	<i>0.49</i>	<i>0.09</i>	<i>0.00</i>	<i>0.00</i>		

The figures not bold are the pairwise correlation, while the bold and italicised figures are probability values.

4. Results and Discussion of Findings

The study performs the unit root Test, the Hausman Test and the Breush Pagan Test; these results are not displayed because of brevity. The unit root test result indicates that all the variables used in the study are stationary at level, supporting the use of the ordinary least square analysis method. The results of the Hausman and Breush Pagan Test support our reasons for using the Fixed Effect Method (FEM), among the FEM, Random Effect Method (REM), and the pooled effect. Table 3 displays the regression output of Equation 5 using the Fixed Effect Method of Ordinary Least Square Regression (OLS). The output in Table 3 represents the result of the hypotheses of the audit competition-price model (H_1 , H_3 , and H_5) and audit competition-quality model (H_2 , H_4 , and H_6). Hypotheses $H_{1\&2}$ relate to audit concentration, $H_{3\&4}$ relate to client mobility of the audit competition-price model, and $H_{5\&6}$ provide information regarding the initial audit engagement year. Columns 1, 2, and 3 depict information about the audit price competition in the non-financial industry and the atomistic and oligopolistic segments estimated using Equation 5. For audit competition, the estimate of Equation 6 for the atomistic and oligopolistic segments is displayed in columns 4, 5 and 6, respectively.

Furthermore, Table 3 provides the test result for hypothesis H_1 concerning the association of audit concentration (HHI) and audit price. The entire sample, atomistic and oligopolistic results are presented in column 1 ($\beta = 14.96$; $t = 4.60$), column 2 ($\beta = 13.07$; $t = 3.69$), and column 3 ($\beta = 21.30$; $t = 6.35$), respectively, under the HHI. The audit concentration, proxy by the Herfindal index (HHI), is positive and significantly related to the audit price in each segmented audit market, and it is statistically indifferent from the entire total sample. The result aligns with our postulation, as shown in hypothesis H_1 , consistent with studies (Van-Raak *et al.* 2020), evidence that audit concentration is positively associated with audit price in both segmented audit markets.

The result of the client mobility (CM) on audit price for the entire sample, an atomistic and oligopolistic fragment of the non-financial audit market, is displayed in columns one, two, and three under the CM. of Table 3. The results of the atomistic section ($\beta = -18.74$; $t = -3.53$) and the oligopolistic segment ($\beta = -32.83$; $t = -7.24$) show that client mobility is negatively associated with audit fees at a 1 per cent level of significance. The association of these variables further demonstrates the existence of competition in the two fragmented audit markets. The results indicate that the client responds to a price increase by switching to auditors who provide approximately the same level of assurance. The complete sample statistics ($\beta = -21.36$; $t = -4.71$) further prove competition within the two fragmented markets.

Table 4 column 2 shows that in the atomistic segment, the initial audit engagement year (initial) is negative and significantly related to audit price with a statistic ($\beta = -0.16$; $t = -3.15$). The initial statistics indicate intense competition in the lower segment of the audit market as audit firms engage in a price war as a marketing strategy to attract and win new clients over in the initial audit year. The result aligns with our proposition in hypothesis 5, H_5 , premised on numerous audit firms competing for a small defined audit market; the result is consistent with the SCP theory. Furthermore, column 3 of Table 3 indicates that in the initial audit year, the Big Four auditors

operating in the oligopolistic fragment compete for new audit clients by offering audit fee discounting, evidenced by a negative relationship between the audit price and the initial audit year with statistics of ($\beta = -0.18$; $t = -3.25$). The initial audit year and price results contradict the SCP paradigm postulation but support the spatial competition theory, evidencing competition in an Oligopolistic market despite the limited choices aligning with studies (Cho *et al.* 2021; Desir *et al.* 2014). Finally, the result of the initial audit year in the Nigerian audit market shows the existence of lowballing despite the mandatory audit fee disclosure.

Concerning competition-audit quality, concentration (HHI) has a positive association with audit quality in the atomistic and oligopolistic segments with statistics ($\beta = 8.04$; $t = 3.51$) and ($\beta = 11.71$; $t = 2.78$) shown in columns 5 and 6, respectively. The result in the oligopolistic section indicates that despite the Big Four having market power due to limited choices to the audit clients, the audit quality is not impaired in contrast to the traditional SCP paradigm. For the dynamic competition, client mobility (CM) has a negative association with the audit quality in the atomistic and the oligopolistic segment with a statistic ($\beta = -16.84$; $t = -3.02$) and ($\beta = -12.34$; $t = -3.87$) shown in columns 5 and 6 on Table 4. Client mobility and audit quality results in the atomistic and oligopolistic markets show that audit clients respond to low audit quality by substituting the engaged audit firm. The result of the HHI and CM is a testimony of competition in the oligopolistic audit segment despite the limited choice of audit firms. Our result aligns with studies (Ayoola *et al.* 2022; Baldwin & Gorecki, 1998; Buijink *et al.* 1998; PwC, 2012; Van Raak *et al.* 2020) and is consistent with our postulations in hypothesis 2 and 4.

Furthermore, in the atomistic segment, the association of HHI and AQ., as indicated in column 5 of Table 3, supported the claim of audit market segmentation based on audit complexity, as the non-Big Four provide quality audits within its segments. The result of the CM and AQ. with a significant negative association indicates a positive response to change in lower quality, which is in line with the economic theory.

Table 3 indicates that despite the existence of lowballing in the two segments, the audit quality is not compromised; this is supported by the statistics of ($\beta = 1.52$; $t = 3.79$) in the atomistic section and ($\beta = -12.34$; $t = -3.87$) in the oligopolistic market. The results of these two segments are indications that the initial audit fee is a market pricing strategy and sunk cost. The result aligns with cognitive dissonance theory and studies (Cho *et al.* 2021; Liu & Huang, 2024).

Table 3. Regression of audit market segmentation on audit price or audit quality

Market	Full sample	atom	oligo	Full sample	atom	Oligo
Dependent Variable	(1) ln_aud_fee_	(2) ln_aud_fee_	(3) ln_aud_fee_	(4) aq	(5) aq	(6) aq
Independent variable	β (t-stat)	β (t-stat)	β (t-stat)	β (t-stat)	β (t-stat)	β (t-stat)
hhi*-1	14.96*** (4.60)	13.07*** (3.69)	21.30*** (6.35)	10.95*** (5.79)	11.71*** (2.78)	8.04*** (3.51)
cm	-21.36*** (-4.71)	-18.74*** (-3.53)	-32.83*** (-7.24)	-16.81*** (-10.88)	-16.84*** (-3.02)	-12.34*** (-3.87)
initial	0.124*** (4.39)	0.16*** (3.15)	0.18*** (3.25)	-0.06*** (-4.29)	1.52*** (3.79)	0.61*** (2.79)
big_four	0.49*** (5.27)			1.87*** (3.85)		
Inta	0.64*** (8.01)	0.65*** (7.86)	0.68*** (3.56)	0.39*** (6.68)	0.37*** (8.83)	0.68*** (4.30)
emp	-0.03 (-0.77)	0.08 (1.09)	-0.06 (-0.75)	0.88*** (3.84)	0.57** (2.88)	0.09 (0.59)
ln_seg_	-0.22* (-1.66)	-0.16* (-1.71)	-0.09* (1.95)	-0.06 (-0.27)	0.17 (0.35)	-0.14 (-0.54)
aud_ten	-0.04 (-0.99)	-0.02 (-0.63)	-0.13*** (-17.19)	0.03 (0.39)	0.04 (0.43)	-0.02 (-0.53)
roa	1.87*** (5.41)	0.76*** (2.33)	1.14** (2.00)	0.02 (0.01)	1.11 (0.81)	0.97 (0.96)

Market	Full sample	atom	oligo	Full sample	atom	Oligo
loos	0.69*** (3.43)	0.74*** (8.88)	0.89*** (11.39)	1.09*** (3.77)	0.70 (1.19)	1.11*** (3.65)
lev	-0.33*** (-8.64)	-0.36*** (-9.73)	-0.28*** (-6.53)	-1.36** (-2.09)	-0.73** (-2.32)	-0.51** (-2.49)
cr_	-0.51*** (-6.91)	-0.33*** (-3.88)	-0.17* (-1.08)	-0.72** (-2.21)	-0.62 (-1.44)	-0.47*** (-2.59)
busy	-1.49*** (-10.35)	-1.38*** (-10.22)	1.19*** (6.99)	-1.54*** (-6.94)	-1.72*** (-3.86)	-1.45*** (-7.10)
c	2.89*** (4.59)	1.49*** (3.22)	1.62*** (4.04)	2.45*** (2.56)	3.75** (2.15)	1.30 (1.34)
R-Sq	0.83	0.82	0.87	0.42	0.36	0.84
Adj R-Sq.	0.82	0.81	0.86	0.39	0.33	0.83
F-stat	93.92	91.83	90.85	14.82	3.04	101.63

Source: Authors Computation (2024)

Where ***, ** and* indicated level of significant at 1%,5%and10% respectively

4.1 Robustness Check

The study performs a robustness check using variable substitutions. Ball and Shivakumar (2006) replaced the modified Jones model, while dynamic competition represented by client mobility was replaced by "DIFFERENCE". The DIFFERENCE is the differential value between the largest auditor's fee and the incumbent auditor scaled down by the total audit fee at a given period. The results of the hypothesis displayed in Table 4 are validated using the fixed effect method of OLS.

Concerning HHI and audit price, the results are positive and significant, with a statistic of ($\beta = 11.88$; $t=4.57$) for atomistics and ($\beta = 2.85$; $t=5.43$) for the oligopolistic segment. The concentration and audit price results in both segments are consistent with the results obtained in Table 3. Furthermore, the relationship between dynamic competition (DIFF) and audit price is positively related, with statistics of ($\beta = -18.34$; $t=-4.10$), ($\beta = -16.99$; $t=-4.73$) and ($\beta = -4.19$; $t=-5.21$) for the total sample, oligopolistic and atomistic segments respectively as presented in Table 4 column 1, 2, and 3 respectively, validating the association of the two variables as mentioned in Table 3 discussion. Table 4 confirms that auditors offer audit fee discounting in the initial year of audit, regardless of the size of the auditors, consistent with the result in Table 3 with a corresponding statistic of ($\beta = -0.04$; $t=-2.41$) for oligopolistic and ($\beta = -1.53$; $t=-4.92$) for atomistics.

Table 4.

Market	Full sample	atom	oligo	Full sample	atom	Oligo
Dependent Variable	(1) lnaud_fee	(2) lnaud_fee	(3) lnaud_fee	(4) aq	(5) aq	(6) aq
Independent variable	β (t-stats)	β (t-stats)	β (t-stats)	β (t-stats)	β (t-stats)	β (t-stats)
hhi*-1	12.68*** (4.15)	11.88*** (4.57)	2.85*** (5.43)	8.00*** (8.88)	2.02** (2.40)	0.68*** (3.99)
diff	-18.34*** (-4.10)	-16.99*** (-4.73)	-4.19*** (-5.21)	- (-8.51)	-2.65** (-1.97)	-0.60*** (-2.83)
initial	-0.15** (-2.54)	-1.53*** (-4.92)	-0.04** (-2.41)	0.35** (2.50)	0.04*** (2.79)	0.04** (2.46)
big_four	0.82*** (6.79)			0.48*** (5.74)		
Inta	0.63*** (17.45)	0.38*** (8.76)	0.01*** (2.92)	0.70*** (2.89)	0.01** (1.89)	0.01** (2.22)

emp	0.11	0.57***	-0.01	-0.01	0.00	0.00
	(1.48)	(3.29)	(-0.39)	(-0.32)	(0.35)	(0.12)
ln_seg_	-0.12	0.21	0.09*	-0.24***	0.12**	0.09**
	(-1.49)	(0.91)	(1.77)	(-2.70)	(1.99)	(1.98)
aud_ten	-0.02	0.03	0.06***	-0.02	0.03***	0.02***
	(-0.56)	(0.62)	(14.20)	(-0.82)	(4.58)	(5.18)
roa	0.59**	1.14	0.15***	0.94	0.05	0.45
	(2.05)	(1.14)	(2.59)	(1.51)	(0.68)	(0.69)
loos	0.82***	0.92***	0.08**	0.98***	0.09***	0.04***
	(9.48)	(3.08)	(2.07)	(7.23)	(2.55)	(2.68)
lev	-0.39***	-0.90***	-0.00	-0.39***	-0.01	-0.00
	(-8.81)	(-2.92)	(-0.06)	(-7.51)	(-0.69)	(-0.19)
cr_	-0.46***	-0.78***	0.10***	-0.54***	0.13***	0.02
	(-5.81)	(-2.62)	(3.64)	(-7.50)	(3.21)	(0.94)
busy	-1.89***	-1.70***	-0.16***	-1.29***	-0.03	-0.01
	(-12.56)	(-8.73)	(-2.75)	(-15.29)	(-0.67)	(-0.20)
c	1.89***	3.85***	12.90***	1.66***	12.54**	12.89***
	(4.95)	(3.71)	(7.37)	(3.59)	(8.16)	(82.21)
R-Sq	0.82	0.38	0.99	0.85***	0.39	0.97
Adj R-Sq.	0.81	0.36	0.97	0.83	0.37	0.91
F-stat	110.56	18.44	6879.78	135.05	704.96	5024.47

Source: Authors Computation (2024)

Where ***, ** and * indicated level of significant at 1%,5%and10% respectively

Furthermore, Table 4 validates that the Big four market power improves audit quality with a positive relationship of HHI and AQ shown in column 6 with a statistic ($\beta = 0.68$; $t = 3.99$). The result of Dynamic competition (DIFF) with audit quality (AQ) shows that audit clients' response to lower quality by changing their clients with a statistic of ($\beta = -2.65$; $t = -1.95$). The initial association validated that lowballing is a marketing strategy, as the audit quality is not impaired in the oligopolistic market.

Finally, column 5 shows competition in the atomistic audit market for the non-big Four as the initial relationship is positively associated with audit quality. The result validated the earlier submission that the non-Big Four provide quality audits.

Conclusions and Further Research

From a holistic perspective, the study examines audit competition efficiency in the Nigerian non-financial sector. We controlled audit complexity to achieve this objective by delineating the non-financial audit market into oligopolistic and atomistic segments. The oligopolistic audit market contains a few large, highly specialised firms categorised as the Big Four. The atomistic segment involves numerous non-specialised audit firms branded as the non-Big Four. Our study observes competition in the initial audit engagement year by examining its effect on the price and quality. Furthermore, we measure competition from static and dynamic perspectives using audit concentration and client mobility, respectively. We investigate the effect of audit concentration and client mobility on audit price and quality in the entire and segmented non-financial institution audit market.

To achieve the objectives, we hand-collected secondary data from the audited financial report of 80 listed Nigerian non-financial institutions from 2011-2022, resulting in 960 observations for the entire sample size. The oligopolistic segment contains 55 per cent of the total observations. The ordinary least square method is employed in estimating the audit price and audit quality models.

The result indicates that the initial audit year is negatively related to audit prices in the atomistic, oligopolistic, and holistic markets - however, the audit fee discounting improves audit quality in both audit-segmented markets. Regarding audit market concentration, the variable is positive and significantly associated with audit price and audit quality in the segmented market and the industry. The dynamic competition, measured by market mobility, shows that dynamic audit competition is positively and significantly related to audit price and negatively associated with audit quality in the oligopolistic and atomistic audit market. Our study shows intense audit competition in the oligopolistic market, evidenced by the audit price war among the specialised auditors,

which is used to win over clients and still provides a quality audit assurance service, contrary to the traditional view of SCP. Furthermore, the result of the dynamic competition measure by the client mobility corroborates the existence of competition in the oligopolistic market as the auditor's market share reduces with an increase in audit price and impairment of audit quality in line with the alternative view of SCP.

Furthermore, our study concludes that the auditors within the atomistic segment lowball in the initial audit engagement year but improve audit quality. Concerning the audit concentration, our result aligns with the alternative view of SCP, which is that the audit concentration is inversely related to audit price and quality. Finally, judging from the dynamic audit competition, we conclude that aggressive competition in the atomistic segment may affect the audit quality.

The limitation of the study may stem from the measurement of audit quality, as there are several methods of measuring the concept. Also, some controlled variables may have been omitted from the study. Finally, our study considers the intra-segment audit competition, disregarding inter-segment rivalry. These possible limitations will not invalidate our result as we proxy the audit quality with one of the widely acceptable proxies in audit literature. Also, we select widely acceptable variables for the control variables included in the models for the audit price and quality model. The inter-segment audit competition is disregarded to avoid distortion and ensure a proper delineation and definition of the audit market segments to capture our audit environment for the study effectively.

Our study recommends that the financial regulatory body formulate a policy to minimise lowballing practices to guarantee audit quality as introduced in advanced economies like China. Furthermore, the policymakers should investigate the Nigerian audit market concentration and release policy to curb its inherent danger. Finally, further studies on Nigerian audit competition may examine the inter-audit segment's effect on price and audit quality competition. Also, other measures of dynamic competition can be exploited in Nigerian non-financial institutions.

Credit Authorship Contribution Statement

Eghosa Godwin Inneh: the contributions are Conceptualization, Investigation, Methodology, Formal analysis, Writing – original draft Data curation, Validation, Writing – review and editing, Visualisation.

Tajuden John Ayoola's contributions are Investigation, Methodology, Project administration, Software, Formal analysis, Writing – original draft, Supervision, Data curation, Validation, Writing – review and editing.

Lawrence Ogechukwu Obokoh: Investigation, Project administration, Formal analysis, Supervision, Writing – review and editing, Visualisation, Funding acquisition.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Declaration of Use of Generative AI and AI-Assisted Technologies

The authors declare that they have not used generative AI and AI-assisted technologies during the preparation of this work.

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A Multivariate Framework for MSME Financial Performance: Financial and Strategic Determinants in Developing Island Economies

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Abstract: This study aims to identify the financial and strategic determinants affecting the financial performance of Micro, Small, and Medium Enterprises (MSMEs) in developing island economies. It specifically explores the roles of financial inclusion and internal capabilities such as financial literacy, financial culture, innovation, and strategic orientation. A quantitative approach using Structural Equation Modeling - Partial Least Squares (SEM-PLS) was adopted. Data were collected from 210 MSMEs operating in the Nias Islands, Indonesia. The model examines relationships among latent constructs, including financial literacy, inclusion, innovation, strategic orientation, financial culture, access to finance, and financial performance. The study is limited to a geographically specific setting (Nias Islands) and uses a cross-sectional design. Caution is advised in generalizing the results beyond similar contexts. Future research should consider longitudinal and qualitative methods to explore causal depth. This study contributes to theory by extending the Resource-Based View (RBV) to include contextual factors such as culture and geography. The proposed multivariate framework offers a replicable model for analyzing MSME financial performance in financial and infrastructurally constrained environments. The findings reveal that access to finance significantly mediates the relationship between internal capabilities (financial literacy, innovation, and strategic orientation) and MSME financial performance. Meanwhile, financial inclusion and financial culture influence performance only through access to finance. Innovation and strategic orientation also have direct effects on performance. The multivariate model demonstrates strong explanatory power, with $R^2 = 0.73$ for financial performance.

Keywords: MSMEs; Financial Performance; Financial Inclusion; Strategic Orientation; Financial Literacy; Financial Culture; Island Economies.

JEL Classification: G21; L26; M13; O17; R11.

Introduction

The post-pandemic global economy continues to expose deep vulnerabilities among micro, small, and medium-sized enterprises (MSMEs), especially in developing regions where infrastructural and financial access remains uneven. MSMEs, which account for more than 90% of businesses and over 60% of employment globally, struggle to maintain resilience amid limited credit access and market volatility (World Bank, 2023). Despite global advancements in fintech and financial digitalization, disparities in financial access remain stark across geographies, with rural and island economies bearing the brunt (Demirgüç-Kunt *et al.* 2022). In such areas, the inability to secure formal financial support becomes a key bottleneck inhibiting business expansion and long-term sustainability. This persistent exclusion illustrates a systemic imbalance between the formal financial sector and MSMEs in peripheral economies. Studies highlight that nearly 40% of MSMEs in lower-income nations experience unmet financing needs despite broader financial reforms (Beck & Demirgüç-Kunt, 2022). As global financial inclusion accelerates, it ironically leaves some of the most vulnerable enterprises behind. The tension between inclusive rhetoric and localized exclusion forms a central paradox in the current MSME discourse.

In Southeast Asia, Indonesia exemplifies this dilemma. Nationally, MSMEs contribute over 60% to GDP and employ nearly 97% of the workforce, yet access to formal finance remains concentrated in urban centers (Ministry of Cooperatives and SMEs, 2023). In remote island areas like the Nias Archipelago, financial penetration is alarmingly low, with many entrepreneurs relying on informal lenders, community savings groups, or personal networks (OECD, 2022). This condition not only reflects logistical challenges but also reveals underlying gaps in financial literacy and cultural familiarity with formal finance. For example, studies in Eastern Indonesia show that only 35% of MSME owners understand basic banking products (Wijaya & Mulyana, 2021). The resulting dependence on informal financing mechanisms severely limits opportunities for strategic investment, innovation, and scalability. Consequently, island-based MSMEs often remain in subsistence mode, vulnerable to shocks, and disconnected from broader economic networks. This situation necessitates a contextualized approach to MSME development grounded in localized realities. The strategic capabilities of MSMEs—such as innovation behavior, market orientation, and long-term planning—are increasingly recognized as critical to overcoming structural constraints. However, empirical validation of these variables in isolated or geographically disadvantaged contexts is limited (Nguyen *et al.* 2020). Innovation, typically associated with urban-based firms, remains underdeveloped in island economies due to knowledge gaps, limited exposure to external markets, and low absorptive capacity (Zulkarnain & Priyono, 2022). Likewise, strategic orientation, though pivotal for decision-making and adaptability, is rarely formalized in small, family-run island enterprises (Widodo *et al.* 2020). The extent to which these internal resources can offset external barriers such as credit inaccessibility remains a pertinent research question. Such exploration demands a holistic framework that situates MSME capabilities within their institutional, geographical, and behavioral contexts. It is no longer sufficient to examine innovation or financial access in isolation. Their intersectionality provides deeper insight into firm-level resilience. Financial literacy forms the cognitive foundation that enables MSMEs to interact effectively with financial institutions, assess risks, and utilize appropriate financial tools. Research from Malaysia and Indonesia has consistently shown that higher levels of financial literacy are associated with improved borrowing behavior and better business performance (Raimo *et al.* 2021; Ismail *et al.* 2022). Yet, financial literacy remains unevenly distributed, with rural MSME owners scoring significantly lower than their urban counterparts (Ferrer *et al.* 2020). This cognitive asymmetry not only limits access to finance but also impedes business development planning. Moreover, financial literacy impacts how firms perceive debt, manage cash flow, and respond to financial shocks. In regions where basic banking terms are unfamiliar, the potential of microcredit and fintech innovations remains unrealized. Financial education, therefore, is not merely a support service but a strategic intervention. The lack of empirical focus on this variable within island settings represents a critical research gap.

Complementing financial literacy is the broader construct of financial culture, which encompasses beliefs, values, and norms regarding money, credit, and investment. Unlike formal knowledge, financial culture is embedded in communal practices and historical experiences with finance, shaping how entrepreneurs perceive financial risks and opportunities (Yusoff *et al.* 2020). In traditional societies, distrust in formal banks, preference for cash transactions, and aversion to debt influence financial behavior in ways that formal models often overlook (Suryani & Purwana, 2022). This cultural dimension can either enable or hinder financial inclusion depending on alignment with institutional offerings. For example, in Java, culturally tailored lending models have increased repayment rates and financial participation (Darmawan *et al.* 2023). However, the absence of such models in remote islands contributes to continued exclusion and low credit uptake. Financial culture, therefore, deserves analytical treatment as a latent construct within MSME finance models. Despite the growing use of financial

inclusion metrics in policy, the understanding of inclusion often remains overly transactional. Simply opening a bank account or accessing a digital wallet does not equate to meaningful financial participation. In regions like Nias, inclusion must consider institutional trust, digital literacy, and localized financial practices (Rakhmani & Darmawan, 2021). Studies have shown that even where mobile banking infrastructure exists, usage remains low due to interface complexity and language barriers (Tambunan, 2020). True inclusion must involve both supply-side access and demand-side capability. Incorporating financial inclusion into a multivariate model as an interactive, mediated variable offers richer explanatory value than treating it as a binary access issue. Moreover, it creates space to explore how inclusion interacts with culture, literacy, and innovation in shaping performance.

From a theoretical standpoint, the Resource-Based View (RBV) offers a compelling lens to examine MSME competitiveness through internal resources such as strategic orientation and innovation capability. Under RBV, these resources yield advantages only when they are valuable, rare, inimitable, and non-substitutable (VRIN) (Barney, 1991). In MSME contexts, these attributes often manifest in knowledge systems, leadership vision, and informal learning mechanisms (Anwar *et al.* 2022). However, in remote economies, the ability to convert these intangible assets into financial performance depends heavily on external enablers such as access to capital. This interdependency suggests a mediating role for finance that is rarely addressed in RBV applications. Thus, this study aims to expand RBV's utility by embedding it within a geographically sensitive, behaviorally rich framework. This responds to calls for contextual RBV extensions in developing country settings. Empirical literature also reveals that access to finance is not solely a structural matter, but a behavioral outcome influenced by literacy, innovation, and strategic behavior (Herath *et al.* 2022). MSMEs that demonstrate strategic clarity, market responsiveness, and innovative practices are more likely to gain creditor trust and secure funding (Muller *et al.* 2020). However, in regions where formal documentation, collateral, and credit history are lacking, even capable firms struggle to access finance. This indicates that access to finance functions as both a dependent and mediating variable, shaped by a confluence of internal capacities and contextual realities. Consequently, understanding this mediation is essential to designing more effective interventions and building predictive models of MSME performance. Ignoring this dynamic leads to policy mismatches and academic models with low generalizability. The methodological implications are equally significant. Structural Equation Modeling using Partial Least Squares (SEM-PLS) is well-suited for capturing complex, mediated relationships among latent variables such as innovation, culture, and strategic behavior (Hair *et al.* 2021). Its predictive orientation, tolerance for non-normal data, and ability to handle small sample sizes make it ideal for MSME studies in resource-constrained contexts (Ali & Park, 2020). Prior studies have validated SEM-PLS as a robust tool for entrepreneurship research, yet few have applied it in island economies or integrated it with socio-cultural variables (Jatmiko *et al.* 2023). Employing SEM-PLS in this study allows for a nuanced exploration of direct and indirect effects, improving both theoretical contribution and practical relevance. Moreover, it strengthens causal inference in models often limited by linear assumptions. Existing performance models for MSMEs tend to be fragmented, emphasizing either economic indicators or individual behavior without integrating both. As a result, they fail to capture the layered and often contradictory realities of small businesses operating at the periphery of national economies (Alon *et al.* 2021). A multivariate model that combines cognitive, cultural, strategic, and institutional variables offers a more holistic understanding of performance drivers. Such an approach can inform nuanced policy responses that align with local context rather than one-size-fits-all prescriptions. It also enables comparative studies across regions, enriching the global MSME literature with grounded, localized insights. This research positions itself within this integrative tradition, seeking to bridge academic gaps and respond to real-world development needs. In Indonesia, decentralized governance and regional autonomy mean that MSME development strategies must be locally tailored. However, national-level studies dominate literature, with little empirical attention paid to marginalized regions like Nias (Widyastuti & Pamungkas, 2020). This urban-centric bias in both data and theory creates a knowledge void that hampers effective policymaking. Given that regional disparities in finance, infrastructure, and digital access persist, island economies require bespoke models that reflect their unique constraints and opportunities. This study contributes to decentralizing the MSME discourse by empirically grounding its analysis in a peripheral island context. The focus on Nias offers insights applicable to other islands and rural regions globally.

Culturally, MSMEs in Nias operate in environments shaped by communal values, oral traditions, and informal economies. These socio-cultural conditions influence everything from firm formation and capital use to risk perception and strategic planning (Darmawan *et al.* 2023). Yet, such factors are seldom captured in conventional finance or entrepreneurship models. Recognizing this, the present research incorporates financial culture as both a conceptual and empirical variable. Doing so allows for a more comprehensive understanding of why certain interventions succeed or fail in traditional contexts. It also adds explanatory depth to models that

otherwise overlook behavioral nuances. At a development level, the stakes are high. MSMEs in peripheral economies are often the primary source of employment, services, and innovation. Enhancing their financial performance has multiplier effects on household income, gender inclusion, and local resilience. However, without context-sensitive models, such interventions risk being ineffective or even harmful (Adomako *et al.* 2023). The present study, by building a localized, multivariate framework, aims to inform both theory and policy with grounded evidence. It moves beyond descriptive diagnosis to offer predictive, actionable insights. This shifts MSME research from reactive analysis to proactive solution design. The novelty of this study lies not only in its context but in its structural formulation. By treating access to finance as a mediating node rather than an independent variable, the research breaks from linear, input-output models. It captures the feedback loops and contingent dynamics that characterize MSME performance in low-infrastructure environments. In doing so, it mirrors the lived complexity of real-world entrepreneurship, where success depends not just on resources, but on the ability to mobilize and convert them. This theoretical repositioning aligns with emerging calls for more dynamic, systems-oriented MSME frameworks (Khan *et al.* 2022). It is an important step toward model sophistication and policy precision. This study responds to a multidimensional challenge facing MSMEs in developing island economies: how to achieve financial performance amid structural constraints, cognitive gaps, and cultural complexities. It proposes an empirically tested model linking internal capabilities (financial literacy, innovation, strategic orientation), socio-cultural factors (financial culture), and institutional access (finance inclusion), with access to finance as the mediating enabler. The use of SEM-PLS methodology provides the analytical depth required to test such interactions, offering a rigorous contribution to both academic and applied development discourse. By focusing on the under-studied case of Nias, this research challenges dominant narratives and offers a template for geographically responsive MSME strategies. Global markets are undergoing rapid transformation, shaped by technology, crises, and demographic transitions. Micro, small, and medium enterprises (MSMEs) remain central to global employment, contributing over 60% of jobs and accounting for more than 90% of businesses worldwide (World Bank, 2023). Despite this, access to formal financial services for MSMEs remains precarious, with financing gaps estimated at over \$5.2 trillion annually, particularly affecting developing nations (IFC, 2021). The COVID-19 pandemic further exposed structural fragilities in MSME financing, especially in rural and island economies with limited infrastructure (OECD, 2022). Digital financial services have surged globally, yet significant regional disparities persist, leaving out peripheral economies. For example, only 39% of MSMEs in sub-national areas of Southeast Asia report access to credit from formal institutions (ADB, 2020). These inequalities are not just logistical but institutional, underscoring a mismatch between MSME financial behavior and financial product design. Consequently, a deeper inquiry into context-specific financial determinants is urgently needed.

In Indonesia, MSMEs contribute approximately 60.3% to national GDP and absorb 97% of the workforce (Ministry of Cooperatives and SMEs, 2023). However, access to finance remains a persistent obstacle. Around 48% of Indonesian MSMEs remain underbanked, especially in areas such as the Nias Archipelago (OECD, 2022). The lack of formal credit access restricts operational capacity, limits capital accumulation, and prevents innovation scaling. Studies show that MSMEs in remote regions rely heavily on informal lending and personal savings, resulting in low credit history and weak financial inclusion (Tambunan, 2020). The spatial exclusion and institutional neglect in these areas create compounded disadvantages, positioning MSMEs in a survival mode. Moreover, these constraints are deeply intertwined with behavioral and cultural aspects such as risk aversion, communal economic structures, and limited trust in financial institutions. Addressing MSME performance in such areas requires a holistic model that transcends traditional urban-centric financial theories.

Previous models of MSME development have emphasized linear relationships between capital input and output, often neglecting the mediating role of intangible assets. Contemporary literature, however, highlights the need to integrate behavioral constructs such as financial literacy, strategic orientation, and innovation capability into performance models (Raimo *et al.* 2021; Sari *et al.* 2021). While each variable has been studied in isolation, few studies consider how they operate interactively, particularly in geographically constrained contexts. The relevance of innovation is clear, as it enables MSMEs to remain competitive in uncertain environments. Strategic orientation, defined as the firm's posture toward change and opportunity, is equally critical in navigating institutional voids. Yet, limited empirical models examine how these internal capacities interact with external enablers such as access to finance, particularly in island economies. This reveals a significant theoretical and empirical gap in MSME finance research. Financial literacy has gained attention as a foundational competence that shapes how entrepreneurs understand, assess, and engage with financial systems. Lusardi and Mitchell (2014) argue that financial literacy improves long-term planning and risk evaluation. Empirical research in emerging economies confirms that financially literate MSMEs are more likely to apply for formal loans, manage

credit efficiently, and plan for reinvestment (Ismail *et al.* 2022; Dsouza *et al.* 2023). Despite this, levels of financial literacy in Indonesian rural areas remain low, especially among informal businesses. The failure to embed financial education in MSME capacity-building initiatives has resulted in missed opportunities for capital expansion and growth. While literacy empowers entrepreneurs, its utility is maximized only when supported by institutional access and enabling infrastructure. Therefore, financial literacy should not be seen as an isolated input but as a resource activated through access to finance.

Another underexplored dimension is financial culture, which encompasses shared beliefs, values, and social norms related to money, debt, savings, and formal institutions. In traditional societies, financial decisions are often influenced by communal expectations, religious beliefs, and informal obligations (Yusoff *et al.* 2020). These cultural norms affect entrepreneurs' willingness to engage with banks, take risks, or formalize their operations. Studies in Indonesia indicate that trust in formal financial institutions is low in peripheral regions, particularly in areas with strong kinship systems and informal lending traditions (Darmawan *et al.* 2023). This cultural inertia limits the efficacy of financial inclusion policies that assume universal behavior across regions. Thus, incorporating financial culture into performance models allows for a more context-sensitive understanding of MSME behavior.

Strategic orientation, defined as an enterprise's proactive engagement with opportunities, risks, and change, plays a key role in determining long-term performance. Firms with high strategic orientation tend to experiment, innovate, and adapt more rapidly to shifting market conditions (Wales *et al.* 2020). In the MSME context, especially in constrained environments, strategic behavior can compensate for limited physical and financial capital. Empirical studies show that strategic orientation correlates positively with innovation, risk-taking, and performance (Saptariani *et al.* 2023). However, MSMEs in rural and island areas often lack formal strategic planning due to low managerial education and inadequate exposure to market dynamics. This absence limits the firm's ability to respond to emerging opportunities, even when financial access is available. The inclusion of strategic orientation in a comprehensive model of financial performance is thus essential.

Innovation, particularly incremental and process-based innovation, serves as a key driver of MSME resilience. In developing regions, innovation does not always entail high-tech transformation but may include product modifications, new marketing methods, or supply chain adaptation (Muller *et al.* 2020; Zulkarnain & Priyono, 2022). Innovative firms are often more attractive to lenders, as they signal forward-looking behavior and growth potential. The challenge lies in equipping island-based MSMEs with the skills, resources, and confidence to pursue innovation in the absence of robust support ecosystems. Limited infrastructure, low internet penetration, and minimal access to training constrain innovation capabilities. Nonetheless, empirical evidence suggests that even small-scale innovation enhances financial performance when coupled with strategic alignment and financing support.

Access to finance emerges as the central mediating mechanism that translates internal capabilities into performance outcomes. Studies by Beck and Demirgüç-Kunt (2022) confirm that firms with greater access to capital demonstrate higher profitability, employment generation, and market expansion. Yet, financial access is unevenly distributed, often biased toward urban enterprises with formal records and collateral. In remote economies like Nias, physical bank presence is sparse, and digital solutions have limited reach. This infrastructural deficit compounds behavioral barriers, resulting in systemic exclusion. Furthermore, many MSMEs are unaware of credit scoring systems, product requirements, or loan structuring processes. Without tailored financial inclusion strategies, these businesses remain locked out of formal finance and unable to leverage their internal strengths.

The Resource-Based View (RBV) offers a theoretical lens to interpret these dynamics, framing internal capabilities as potential sources of competitive advantage when effectively mobilized. According to Barney (1991), resources must be valuable, rare, inimitable, and non-substitutable to contribute to sustained performance. Financial literacy, innovation, strategic behavior, and cultural alignment meet these criteria in varying degrees. However, the value of such resources is contingent on access to systems that allow their deployment. Thus, RBV must be adapted to include contextual enablers such as access to finance in regions characterized by resource scarcity. By doing so, the model evolves from a static framework to a dynamic, context-sensitive construct. Empirical research applying RBV in MSME contexts remains limited, particularly in geographically disadvantaged areas. Most studies focus on urban or national-level samples, failing to capture how localized constraints affect resource utilization. This limits theoretical generalizability and policy applicability. In the case of island economies, the role of geography, culture, and institutionality demands closer scrutiny. By situating the study in Nias, this research addresses a critical omission in the MSME literature. It demonstrates how context mediates the relationship between internal capabilities and financial outcomes.

The proposed model incorporates financial literacy, inclusion, innovation, strategic orientation, and financial culture as antecedents, with access to finance as a mediating variable and financial performance as the outcome. This configuration reflects both theoretical propositions and empirical insights from literature. Each construct is operationalized using validated scales and adapted to the Indonesian MSME context. This model aims to fill the conceptual and empirical void in understanding how financial outcomes are shaped by an intricate web of internal and external factors. The application in a small island setting makes the contribution particularly timely and relevant. The policy implications of this model are far-reaching. It suggests that enhancing MSME financial performance requires integrated interventions that address cognitive, behavioral, and infrastructural barriers. Financial education programs, if designed with cultural sensitivity and local relevance, can improve financial engagement. Concurrently, expanding access to finance through mobile banking, credit cooperatives, and micro-loan schemes can activate dormant capacities. Strategic training and innovation hubs may also foster long-term growth behavior. Without this alignment of internal capacity and external opportunity, efforts to boost MSME development risk ineffectiveness. Donor agencies, financial institutions, and local governments all have roles to play in operationalizing this model. For example, credit programs should consider not just collateral but also entrepreneurial behavior, literacy, and cultural fit. Innovation programs must be decentralized and inclusive, targeting remote areas through partnerships with educational institutions and NGOs. Meanwhile, measurement and evaluation frameworks must capture the multifaceted nature of MSME resilience, moving beyond simplistic indicators such as credit uptake or loan size. A more holistic understanding enables better policy calibration and outcome tracking. This study positions itself as a response to long-standing calls for contextualized, empirically grounded models of MSME development. By focusing on the Nias Archipelago, it not only contributes to theory but also to practice. The proposed model integrates behavioral, cultural, strategic, and financial elements in a way that reflects the lived realities of entrepreneurs in structurally excluded regions. In doing so, it offers a replicable framework for future research and policy in similarly disadvantaged geographies.

1. Research Background

Financial literacy has emerged as a foundational determinant influencing the financial performance of MSMEs, especially in marginalized regions. Scholars have argued that financial literacy contributes not only to informed decision-making but also to an enterprise's ability to access formal finance. Ismail *et al.* (2022) demonstrated that financially literate entrepreneurs exhibit stronger budgeting behaviors, credit management, and risk evaluation, which in turn enhance firm performance. This link is especially critical in rural or island economies, where institutional support is sparse. Dsouza *et al.* (2023) further emphasized that in contexts like India and Southeast Asia, literacy significantly predicts loan uptake and repayment behavior. Nevertheless, research reveals that financial literacy among island-based MSMEs remains relatively low, limiting their engagement with formal institutions. Studies by Ferrer *et al.* (2020) revealed that regional disparities in financial knowledge obstruct business scalability in disadvantaged communities. Consequently, the role of financial literacy must be situated within broader contextual and behavioral paradigms. A lack of basic financial competence not only restricts access but also diminishes the value of institutional interventions.

Financial culture complements literacy by shaping the attitudes, norms, and collective behaviors of MSMEs toward money and finance. Unlike literacy, which is cognitive, financial culture is deeply embedded in social systems, religious values, and communal traditions. In traditional economies, decision-making around credit, savings, and investment is often influenced by non-economic considerations. Darmawan *et al.* (2023) found that MSMEs in Indonesia often avoid formal financing due to cultural discomfort with interest-bearing loans and reliance on kinship-based networks. Suryani and Purwana (2022) also identified that informal values around debt aversion and mistrust in banks continue to inhibit financial integration. These findings are critical, as they show that without addressing cultural congruence, financial policies may face low uptake. Moreover, Yusoff *et al.* (2020) emphasized that financial interventions must respect and incorporate localized financial behavior for success. Thus, financial culture is not merely a backdrop variable but an interactive element in financial ecosystem design. It mediates how financial tools and strategies are interpreted and adopted by MSMEs. Acknowledging cultural heterogeneity is essential for inclusive MSME development models.

Innovation plays a pivotal role in driving MSME competitiveness, particularly in constrained environments such as island economies. While often associated with high-tech urban enterprises, innovation in these regions takes more incremental and adaptive forms. Zulkarnain and Priyono (2022) note that process improvements and localized product adjustments are primary innovation pathways for MSMEs in remote Indonesia. Muller *et al.* (2020) similarly found that even small-scale innovation efforts correlate strongly with creditworthiness and performance indicators. Innovative behavior signals forward-looking management and potential for growth,

making firms more attractive to lenders. Nguyen and Luu (2021) argued that innovation capacity enhances the firm's ability to overcome external financing barriers. However, lack of infrastructure, market connectivity, and exposure to competitive environments often suppress innovation in island settings. The capability to innovate, therefore, must be cultivated through context-aware support structures. Empirical studies suggest that innovation positively influences not only direct firm growth but also indirectly facilitates access to finance. This dual effect reinforces its importance in multivariate MSME performance models.

Strategic orientation, characterized by proactive planning, risk-taking, and opportunity recognition, is another internal capability closely linked to financial outcomes. Firms with high strategic orientation are often better positioned to navigate market turbulence and institutional voids. Wales *et al.* (2020) emphasized that strategic posturing enhances long-term adaptability and stakeholder engagement. In the MSME context, especially in developing economies, strategic orientation reflects managerial foresight and operational coherence. Saptariani *et al.* (2023) found a strong relationship between strategic orientation and performance in Indonesian MSMEs, mediated by access to finance. However, in geographically isolated regions, strategic behavior is rarely institutionalized due to low managerial exposure and education. Setyawati and Rahayu (2023) argued that MSMEs in island economies often operate intuitively, lacking formal business strategies. Embedding strategic orientation in development models requires tailored training and ecosystem support. The inclusion of strategic orientation as a latent construct in MSME finance models enhances their predictive and explanatory power. It also aligns with the RBV perspective that internal, intangible resources are essential for sustainable advantage. Access to finance remains a central mediating variable that links internal MSME capabilities to actual performance outcomes. Studies confirm that even financially literate or strategically oriented MSMEs cannot achieve growth without tangible financial support. Herath *et al.* (2022) demonstrated that access to finance significantly mediates the relationship between innovation capability and business performance. Beck and Demirgüç-Kunt (2022) added that access disparities are especially pronounced in peripheral economies where institutional presence is weak. In Nias and similar island contexts, formal banking services are often geographically and culturally inaccessible. Tambunan (2020) emphasized that mobile finance and community-based models have shown promise in overcoming these barriers. Nevertheless, infrastructure gaps, digital illiteracy, and regulatory hurdles persist. The mediating role of finance thus reflects both structural exclusion and behavioral adaptation. Policies must not only increase access points but also integrate financial education and culture. Without addressing the multidimensional nature of exclusion, MSME finance strategies risk ineffectiveness.

2. Materials and Methods

This study adopts a quantitative approach using Structural Equation Modeling - Partial Least Squares (SEM-PLS) to test the multivariate relationships among latent constructs. SEM-PLS was selected for its suitability in handling non-normal data, moderate sample sizes, and latent variables, and for its ability to evaluate complex, mediated relationships. The analysis was conducted using SmartPLS version 4.0 in two stages: assessment of the measurement model and testing of the structural model, ensuring validity and reliability. The research was conducted on MSMEs in the Nias Islands, North Sumatra, Indonesia - a region selected due to its geographical remoteness and limited financial infrastructure. A purposive sampling technique was used to ensure diversity in sector, business age, and scale. The survey yielded 210 valid responses, exceeding the minimum SEM-PLS sample size requirement. Data were gathered via a cross-sectional questionnaire, distributed both online and offline. The questionnaire items were adapted from established scales: financial literacy (Lusardi & Mitchell, 2014), financial inclusion (Beck & Demirgüç-Kunt, 2022), innovation and strategic orientation (Teece, 2018; Wales *et al.* 2020), financial culture (Suryani & Purwana, 2022), access to finance (Herath *et al.* 2022), and financial performance indicators such as profitability, liquidity, and growth. A five-point Likert scale was employed. A pilot test with 30 MSMEs refined the instrument for cultural clarity and contextual relevance. Enumerators were trained to support respondents, particularly those with low literacy levels. Data preprocessing included outlier detection via Mahalanobis distance and treatment of missing values using Little's MCAR test and mean substitution. Measurement model validity was confirmed through Cronbach's Alpha, Composite Reliability (CR > 0.7), Average Variance Extracted (AVE > 0.5), Fornell-Larcker criterion, HTMT ratio (< 0.85), and multicollinearity checks (VIF < 5.0). All criteria were satisfactorily met. The structural model was tested by examining R^2 , f^2 , Q^2 values, and bootstrapping with 5,000 subsamples. R^2 values of 0.69 (access to finance) and 0.73 (financial performance) indicated strong explanatory power. Path coefficients revealed significant effects of financial literacy, inclusion, innovation, strategic orientation, and financial culture on access to finance, which in turn significantly affected financial performance. Mediation effects were assessed using the Variance Accounted For (VAF) approach. To

minimize common method bias, procedural remedies (e.g., item randomization, separation of constructs) and statistical controls (Harman's single-factor test, collinearity diagnostics) were applied. Ethical clearance was obtained from the institutional review board. Informed consent was collected from all participants, and data confidentiality was ensured through anonymization and encrypted storage. Sensitive questions were framed with cultural sensitivity to maintain ethical and contextual integrity.

3. Research Methodology

Data analysis using SEM-PLS resulted in a structural model that is statistically significant and has strong explanatory power. The coefficient of determination (R^2) of 0.69 for financial access indicates that 69% of the variance in financial access can be explained by five key constructs: financial literacy, financial inclusion, innovation, strategic orientation and financial culture. Meanwhile, the R^2 of 0.73 for financial performance indicates that more than two-thirds of the variance in MSME performance can be predicted by this model. The predictive relevance (Q^2) values for both endogenous constructs are above the 0.35 threshold, confirming good predictive power. In addition, the effect size (f^2) values indicate that financial inclusion and financial access have a moderate to large influence on the dependent variable. This result shows the significant contribution of each construct to the overall model structure. The path coefficients between constructs reveal statistically significant relationships with a 95% confidence level. In general, the model is valid and applicable to explain the financial performance of MSMEs in a geographical context such as Nias. The effect of financial literacy on access to finance is positive and significant, with a coefficient of 0.34. This finding suggests that MSMEs with better financial literacy tend to be better able to access formal sources of financing. Knowledge of interest rates, inflation and risk management are important factors in determining their financial decisions. In the context of remote areas like Nias, financial literacy plays a role as a link between business potential and access to working capital. Businesses that understand how financial institutions work are more confident in accessing loans. The ability to read contracts, manage cash flow and plan budgets contributes to the ease of obtaining credit. These results support previous literature that financial literacy is an important enabler in the MSME ecosystem. Therefore, literacy acts as a resource that can be developed to strengthen the competitiveness of small businesses.

Financial inclusion shows the strongest direct effect on financial access, with a coefficient of 0.41. This suggests that the existence of an inclusive financial system, such as digital banking and microfinance services, encourages MSME actors to access formal financial services. Infrastructure that allows easy account opening, cashless transactions, and access to microloans are the main driving factors. This finding supports an inclusion policy approach that emphasizes expanding services to remote areas. MSME players in Nias who have access to digital services are more likely to take advantage of financing opportunities. This result aligns with global findings that financial inclusion strengthens small business growth in developing countries. In the local context, financial inclusion that is mobile or community-based shows high effectiveness. Therefore, technology and locality-based interventions are urgently needed to boost financial penetration in 3T areas. Innovation also has a significant positive influence on access to finance, with a path coefficient of 0.29. MSMEs that demonstrate innovative capabilities in product or process development tend to be more trusted by financial institutions. Innovation is an indicator that the business has good growth prospects and is able to withstand market pressure. For lenders, innovating MSMEs are seen as business partners that have the potential to increase added value. In the context of a region like Nias, innovation does not necessarily mean the use of advanced technology, but also the adaptation of business processes to local conditions. For example, creative use of local raw materials or community-based marketing are relevant forms of innovation. This finding is in line with previous studies that emphasize innovation as a credibility booster for small businesses. The ability to introduce novelty in a limited market is a positive signal for access to financing.

Strategic orientation shows a strong relationship with access to finance with a coefficient of 0.36. This indicates that MSMEs that are proactive, responsive to market opportunities and have long-term planning tend to be more successful in obtaining financial support. A clear and flexible business strategy is considered to reduce the risk of business failure by creditors. In decision-making, MSME actors who demonstrate strategic planning find it easier to establish financial partnerships. These findings strengthen the argument that strategic behavior contributes to business capability in a high-risk environment. Strategic orientation reflects preparedness for external change and resilience to uncertainty. For financial institutions, this signals important managerial readiness. Therefore, a structured strategy can be a valuable intangible asset in building business credibility. Financial culture is also shown to significantly influence access to finance, with a coefficient value of 0.31. Cultural values such as preference for formal debt, saving habits and trust in financial institutions influence the financial behavior of MSME actors. In traditional societies like Nias, perceptions of loans are often influenced by

social and religious norms. An aversion to formal debt can reduce the propensity of businesses to access credit even when it is available. These results suggest that culture-based approaches need to be considered in the design of financial interventions. For example, collaboration with traditional or religious leaders in financial education can increase people's openness to formal services. Financial culture is a psychosocial factor that bridges the gap between access and utilization of finance. Therefore, the cultural dimension has an important position in the financial inclusion framework. The access to finance shows the greatest direct influence on the financial performance of MSMEs, with a coefficient of 0.45. This emphasizes that access to working capital and investment financing has a direct impact on the ability of businesses to improve profitability, liquidity and growth. The availability of funds enables business expansion, product diversification and improved operational efficiency. In conditions of limitation such as in Nias, financing is a key determinant of the ability of small businesses to survive and thrive. This finding is in line with the theory that financing functions as a lever for internal business capabilities. MSMEs that have access to external funds are able to accelerate their business strategies. Thus, financing is not just a complement, but a game changer for business growth. The mediating role of access to finance shows the importance of this variable as a strategic intermediary in the performance model.

In addition to the mediative effect, some variables also show a direct effect on financial performance. Innovation has a direct effect with a coefficient of 0.27, which indicates that the ability of businesses to create or adapt innovations has an impact on improving business performance. Innovation contributes to competitive advantage, cost efficiency, and opening new markets. Strategic orientation has a slightly larger direct effect of 0.30, suggesting that proactive attitudes and future-oriented decision-making directly benefit financial outcomes. This finding confirms that internal capabilities can have a significant impact without access to finance as an intermediary. This suggests that knowledge-based resources and strategies can stand alone as determinants of performance. Under conditions of limited access to finance, innovative capabilities and long-term strategies still provide opportunities to improve performance. Both findings are consistent with the RBV assumption that intangible resources can create value if mobilized effectively. Financial culture shows a direct effect on business performance, although not as large as other constructs, with a coefficient of 0.22. This suggests that the norms and values that guide financial behavior have an impact on overall business performance. For example, MSME actors with a financial culture that emphasizes spending discipline, debt responsibility and future orientation show better performance indicators. In informal ecosystems like Nias, the role of culture is significant as it governs decision-making that is not always rational or data-driven. Financial culture also determines how businesses deal with crises, build social networks and prioritize investments. This direct influence shows that while culture is not always a direct policy intervention, it is still a powerful internal driver. Therefore, it is important for policy designers to consider this aspect in their efforts to improve business performance. A culture that supports a long-term financial orientation has real implications for business outcomes. Mediation analysis using the Variance Accounted For (VAF) approach shows that access to finance acts as a partial mediator in the relationship between financial literacy, innovation and strategic orientation with business performance. VAF values ranged from 39% to 62%, indicating that some of the influence of these constructs on performance is channeled through access to finance. This means that while internal capabilities can directly influence outcomes, their impact is stronger when accompanied by the availability of finance. For example, an innovative MSME actor who does not have access to capital may struggle to implement their ideas. Conversely, access to financing enables optimal realization of innovative strategies and plans. This mediating role demonstrates the importance of an integrated approach that links aspects of internal capabilities with institutional support. This concept reinforces the theory that competitive advantage arises not only from resources, but also from the ability to access and manage those resources effectively. For the financial inclusion and financial culture constructs, the results indicate full mediation, meaning that the effect on performance only occurs through access to finance. Without access to capital or adequate financial services, the value of financial inclusion or culture cannot directly translate into improved performance. This finding reflects the fact that financial inclusion and culture only provide behavioral prerequisites but are insufficient if not facilitated by a responsive financial system. Thus, policy interventions that rely solely on financial education or cultural literacy will not be sufficient without expanding concrete access to business capital. This full mediation suggests that inclusion and culture require conduits to contribute to outcomes. In a context like Nias, this means financial institutions need to be truly present and active in the community, not just nominally. The role of local financial institutions is crucial in bridging the gap between cultural norms and financial realities. This structural model shows high explanatory power compared to similar models in urban or mainland contexts. The high R^2 s for business performance and access to finance reflect that the combination of internal and external factors in the model is representative enough to explain the dynamics of MSMEs in the islands. Unlike previous models that focus on one or two main variables, this multivariable approach captures the complexity of

interactions between dimensions. This approach validates the idea that business performance in lagging regions cannot be explained solely by macroeconomic factors or single policies. The integration of internal capabilities and institutional structures yields a more accurate and contextualized picture. This makes a significant contribution to the theory of locality-based small business development. Such an approach is relevant for adoption in other regions with similar geographic and social characteristics. The predictive power of the model is also confirmed through the high Q^2 value, indicating that the model is able to accurately predict changes in access and financial performance. These results reinforce the claim that the SEM-PLS approach is not only capable of testing theoretical relationships but also providing predictive tools for policy interventions. In the context of development planning, this predictive ability is crucial for designing programs that are data-driven and measurable. For example, if it is known that improving literacy will significantly improve business access and performance, then resource allocation can be directed towards focused training programs. The accuracy of predictions also allows for longitudinal impact evaluation in MSME development programs. Therefore, SEM-PLS is not only an analytical tool, but also a planning tool. The accuracy of this model provides a strong foundation for evidence-based policy interventions. The practical implications of the findings include the need for an integrated policy design, covering cognitive, institutional and cultural dimensions. Financial literacy programs should be designed not just as a transfer of information, but as a process of behavior formation based on local context. Financial inclusion must consider geography and cultural factors to be widely accepted by communities. Financial institutions need to increase participatory approaches and build trust, especially in areas with a history of financial exclusion. Innovation strategies and business orientation need to be included in MSME coaching programs to enable sustainable growth. Financial culture needs to be respected and aligned with the formal financial system to avoid resistance. Overall, the policy approach needs to be multilevel and multisectoral. Only then can the performance of small businesses in marginalized areas be significantly improved. The results of this study also offer opportunities for replication and adaptation of the model to other regions with similar challenges. Islands in eastern Indonesia, rural areas, and indigenous territories can use this framework as an evaluative and intervention reference. Further validation through longitudinal studies and a combination of qualitative methods will enrich the understanding of the dynamics of financial behavior in local communities. Adjustment to the local context in the measurement instruments is strongly recommended so that the results obtained reflect the reality of the community. The findings also open up room for the development of new indicators that incorporate cultural and institutional elements more explicitly. With a strong empirical basis, this model can be an important contribution to the context-based MSME literature. Furthermore, the utilization of these results by policy makers and field practitioners is expected to accelerate equitable growth of small businesses. The model also provides theoretical and practical justification for locality-based and sustainable development efforts.

4. Discussion

The findings of this study reinforce the argument that access to finance plays a central role in activating the internal resource potential of MSMEs, especially in the context of an island economy like Nias Islands. The Resource-Based View (RBV) approach places access to finance not only as external capital, but as a link that bridges internal capabilities with business outcomes. Financial literacy, innovation, financial culture and strategic orientation contribute directly and indirectly to financial outcomes. In areas of infrastructure constraints and institutional exclusion, access to finance is a key differentiator between stagnant and thriving enterprises. This empirical model proves that finance acts as a strategic mediating mechanism that can enhance the effectiveness of intangible resources. The interaction between literacy and access to finance, for example, shows that knowledge alone is not enough if not followed by adequate capital distribution channels. Therefore, the function of access to finance in this model is transformative.

Financial literacy in this study is shown to have an influence on the ability of business actors to reach financing sources. This supports the theory that literacy plays a role in financial decision-making, budget planning and selection of appropriate financial products. For MSMEs in Nias, low financial literacy is often the main barrier to accessing financing from formal institutions. Lack of basic knowledge about interest systems, collateral or payment deadlines makes businesses reluctant to take financing risks. Literacy not only improves technical skills, but also affects confidence and readiness to interact with the formal financial system. Thus, financial education should be a priority program in local economic development. These results reinforce the need for community-based literacy approaches that are socially and culturally relevant. Locally based education is more effective than centralized national programs. Financial inclusion shows the greatest influence on access to finance, demonstrating the importance of infrastructure development and financial services that reach the lower economic strata. Mobile banking, fintech platforms and community-based cooperatives contribute greatly to expanding the

reach of services. In a geographical context like Nias, the presence of conventional banks is very limited and does not reach all sub-districts. Therefore, technology-based financial inclusion is a relevant alternative solution. Policy interventions should be directed towards expanding this access through regulatory support, fiscal incentives, and partnerships between the public and private sectors. This approach has proven effective in other developing countries, including the Philippines and Bangladesh. Integrating digital services with local cultural preferences is a promising approach. Successful financial inclusion depends on being sensitive to local socio-economic conditions. The effect of innovation on access to finance provides a new perspective that adaptive and creative behavior is one of the factors that increase lenders' confidence in small businesses. In areas with high investment risk, innovation is an indicator that businesses are able to read market dynamics and adapt to change. MSMEs that undertake product differentiation, process efficiency, or new market penetration are considered to have more promising prospects. This changes the risk perception of financial institutions towards MSMEs. This research supports the view that innovation not only drives performance but also opens the door to access to external resources. In Nias, forms of innovation are often contextual and based on local wisdom, such as the utilization of marine products or traditional agriculture. Therefore, policy approaches cannot rely on one definition of high-tech-based innovation. The development of locally based innovation is crucial in the context of small islands. Strategic orientation has a strong correlation with both access to finance and financial performance, suggesting that MSME actors with a long-term orientation and proactive behavior tend to be more resilient in managing risk. Businesses that set clear goals, conduct market evaluations and build networks are more likely to attract external financing. This indicates that managerial behavioral dimensions are no less important than structural factors. A systematic business strategy increases credibility in the eyes of lenders. Many MSMEs in remote areas still rely on intuition and tradition in making business decisions, which are often undocumented. Strategic orientation requires strengthening managerial capacity through training and business mentoring. Local governments and non-profit organizations can act as facilitators in shaping the strategic orientation of MSME actors. Without good planning capacity, access to financing will not be effectively utilized. Financial culture plays an important role in shaping the perceptions, attitudes and financial decisions of MSME actors. In communities with strong traditional norms such as in Nias, borrowing and lending practices are often based on social trust rather than legal agreements. This creates a reliance on informal financing channels and limits the penetration of formal financial institutions. Negative perceptions of interest, risk concerns and communal values tend to reduce interest in formal finance. This research underscores that the success of financial policy is not only determined by market structure, but also by cultural fit. Thus, policy interventions need to pay attention to elements of social values and norms that influence financial behavior. Community-based financial literacy programs delivered by traditional leaders or religious leaders can bridge the gap between the formal system and social reality. In this context, culture is not an obstacle, but a strategic medium in the distribution of financial knowledge and participation. Access to finance is shown to play a significant mediator role in linking internal resources with the financial performance of MSMEs. This study shows that the effect of innovation, literacy and strategic orientation on performance is only optimal when followed by the ease of obtaining capital. This means that internal capabilities do not necessarily generate performance without external support. In an ecosystem that lacks financing, this potential cannot be fully realized. This model explains the importance of synergy between strengthening internal capacity and expanding access to finance in MSME development strategies. The absence of either can lead to business stagnation or vulnerability to external shocks. This mediation explains the systemic dynamics within the microenterprise environment in the islands that are prone to financial exclusion. Therefore, development approaches that focus on only one dimension risk creating structural imbalances. Another interesting finding is the full mediation between financial inclusion and financial culture on performance, indicating that both variables only contribute to financial outcomes if businesses successfully access finance. This means that even inclusive financial values or systems are not enough if they are not coupled with tangible financing channels. This reflects the reality that many MSME actors understand the importance of financing but lack the pathways to access it in practice. To address this challenge, financial institutions need to develop more flexible and community-based financing schemes. This approach has been successfully implemented in several rural areas in Southeast Asia and East Africa. Local institutions such as cooperatives and MFIs have the potential to bridge the gap between cultural values and formal systems. By understanding local dynamics, financial institutions can play a more inclusive and socially relevant role.

The direct effects of innovation and strategic orientation on financial performance reinforce the theory that adaptive behavior and long-term planning are key strengths of MSMEs in the face of uncertainty. While limited access remains a challenge, MSMEs with innovation and the right strategy are able to create added value. Differentiated products, efficient production processes and active market penetration strategies provide a

competitive advantage. This emphasizes the importance of supporting the development of MSMEs' internal capacity, not only in terms of capital. Training, mentoring, and business incubation programs can strengthen the position of MSMEs in local and regional markets. This approach has been successfully implemented by several entrepreneurship development foundations in the ASEAN region. Internal strengthening will increase the readiness of businesses to utilize external resources when they become available. Therefore, capacity building and access to finance must go hand in hand. The high R^2 values for access to finance and financial performance reflect the model's strong explanatory power for small business dynamics in the islands. The model integrates individual, structural and cultural variables that are often separated in MSME studies. By using a multivariate approach, the linkages between these elements can be mapped holistically. This provides an empirical basis for more comprehensive policy design. This approach is more relevant in the context of marginal economies, where variables influence each other simultaneously. An integrated model approach also helps avoid partial or decontextualized policy solutions. In the long run, the model can be replicated in other regions with similar characteristics to Nias. The results highlight the need for geographically and socially specific intervention design. Not all approaches that work in urban areas can be directly applied in remote areas. The social structure, informal networks and lifestyle of island communities should be key considerations in policy formulation. MSME strengthening programs should use a participatory approach that involves local stakeholders. Partnerships between local governments, microfinance institutions and local communities are key to success. Involvement of traditional or religious leaders can increase acceptance of formal-based financial programs. Thus, financial inclusion strategies are not only based on infrastructure, but also on psychosocial aspects and community trust.

The RBV approach in this study has been extended to include cultural and geographical variables as part of the internal resource dynamics. Literacy, financial culture, and strategic orientation in this context are resources that are not only cognitive, but also social and contextual. Thus, RBV no longer only explains competitive advantage based on scarce and irreplaceable resources, but also on adaptability to local environmental conditions. This shows that strategic management theory can be contextualized in a peripheral economic environment. The successful adaptation of this theory is a significant theoretical contribution in the future development of RBV. The model also adds complexity to resource analysis by considering local dynamics. This study fills a gap in the literature by providing empirical evidence on the mediating mechanisms of access to finance in geographically marginalized contexts. Often MSME studies focus on urban areas or countries with well-established financial systems, thus failing to capture the structural challenges in disadvantaged areas. By focusing on Nias, this study brings a new perspective that is crucial for theory and policy development. Regions like Nias need more attention in the discourse of small business development, not only as policy objects, but as economic entities that have their own dynamics. This study provides important practical and theoretical contributions to understanding the reality on the ground. MSME development policies in regions like Nias should not only be top-down, but should open up space for local innovation and social adaptation. Uniformity of assistance or financing programs will only result in partial effectiveness. Strategies based on local needs can deliver more sustainable results. National governments and international donors can adopt a strategic decentralization approach in designing economic interventions. Programs that are modular, flexible and contextual will be more easily accepted by communities. Therefore, collaboration between local and national actors needs to be strengthened through participatory planning and adaptive monitoring mechanisms. Overall, this discussion shows that the financial performance of MSMEs in the islands cannot be separated from the dynamics of access to finance, culture, literacy, innovation and managerial strategies. All these elements work simultaneously in a complex and constrained system. The multivariate model developed in this study successfully explains the interaction between these variables empirically and contextually. Thus, economic development in marginalized areas must adopt a systemic and multidimensional approach that does not rely solely on the financing aspect. In the context of sustainable development, understanding the local socio-economic reality is an important foundation for successful interventions and policies.

Conclusions and Further Research

This research proves that the financial performance of MSMEs on islands such as Nias is not only determined by access to finance but is also strongly influenced by internal factors such as financial literacy, innovation, strategic orientation and financial culture. The five variables interact in a complex way in influencing financial performance, with access to finance acting as the main mediator in the model developed. Financial literacy and financial inclusion have a significant influence on the ability of MSMEs to obtain financing. The higher the level of literacy and engagement in the formal financial system, the greater the opportunity for MSME actors to access productive sources of financing. However, literacy and inclusion alone are not enough without the availability of financial

infrastructure that effectively reaches remote areas. Innovation and strategic orientation are also shown to contribute directly and indirectly to the financial performance of MSMEs. Innovation drives efficiency and competitiveness, while strategic orientation improves the adaptability of businesses in the face of market changes. Both strengthen the attractiveness of MSMEs in the eyes of financial institutions and investors. Financial culture, a variable often overlooked in formal studies, has been found to play an important role in shaping businesses' perceptions and behavior towards risk and financing. In local contexts such as Nias, a financial culture that supports transparency, responsibility and trust in financial institutions is critical to the success of formal financial interventions. Overall, this study emphasizes the importance of an MSME development approach that focuses not only on access to funds, but also on strengthening internal capacity, literacy, business strategies, and cultural sensitivity. The multivariate model developed offers a framework that can be replicated for other regional contexts with similar geographical and institutional characteristics.

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Credit Authorship Contribution Statement

Maria Magdalena Bate'e: Conceptualization, Methodology, Data Collection, Formal Analysis, Writing – Original Draft. Dr. Bate'e led the formulation of the research questions, constructed the conceptual framework, designed the data collection instruments, and carried out the fieldwork. She also conducted the data analysis using SEM-PLS and wrote the initial draft of the manuscript.

Khaira Amalia Fachrudin: Supervision, Validation, Writing – Review & Editing, Funding Acquisition. Dr. Fachrudin provided overall supervision of research design and analytical strategy. She also validated the statistical methodology and contributed to refining the structure and arguments in the manuscript during the review process.

Syahyunan: Resources, Investigation, Project Administration, Writing – Review & Editing. Dr. Syahyunan coordinated access to MSME respondents in the Nias Islands and managed the field team. He also ensured logistical execution of the study and contributed to editing the manuscript, especially in aligning theoretical discussions.

Amlys Syahputra Silalahi: Software, Data Curation, Visualization, Formal Analysis. Mr. Silalahi handled data preprocessing, performed SmartPLS 4 modeling, and produced tables and diagrams. He was responsible for ensuring data integrity and supported the statistical robustness of the findings.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Declaration of Use of Generative AI and AI-Assisted Technologies

The authors declare that they have not used generative AI and AI-assisted technologies during the preparation of this work.

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Exploring Social Media's Power in Enhancing Brand Continuance Intention: Cosmetic Industry

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Abstract: This study aims to examine the impact of social media marketing (SMM) strategies on the intention to continue using cosmetics in Ho Chi Minh City. The research framework is grounded in social media marketing theory, focusing on its relationship with customer experience (CUE) and continuance intention (CI). The study also explores the mediating roles of brand awareness (BAW), attitude toward the brand (ATB), and product satisfaction (SAT). Data was collected through an online Google Forms survey, with 516 respondents who are cosmetics users. The analysis was conducted using the partial least squares structural equation modeling (PLS-SEM) approach. The findings reveal that all independent variables - SMM, BAW, ATB, SAT, and CUE - significantly influence continuance intention. Among these, product satisfaction (SAT) has the strongest impact, followed by brand awareness (BAW), attitude toward the brand (ATB), social media marketing (SMM), and customer experience (CUE), respectively. The results highlight the crucial role of enhancing product quality to ensure customer satisfaction, which is fundamental for driving continuance intentions. In addition, leveraging social media marketing to strengthen brand management, foster positive brand attitudes, and improve brand awareness also plays a significant role in encouraging consumer loyalty. This study contributes to the growing body of literature on social media marketing by providing a context-specific evaluation of its impact on continuance intention within Vietnam's cosmetics industry. However, the study is geographically limited to Ho Chi Minh City, which may affect the generalizability of the findings to other regions. Future research could broaden the scope to include different cities, industries, or consumer demographics. The findings offer actionable insights for cosmetics businesses to optimize social media marketing strategies, enhance product quality, and improve customer satisfaction to foster brand loyalty and continuance intention. The study emphasizes the role of social media in shaping consumer behavior, which can further influence sustainable business practices and consumer engagement in the digital era.

Keywords: social media marketing; intent to continue using; brand awareness; attitude towards the brand; satisfaction; customer experience.

JEL Classification: M31; L66; O33; A12.

Introduction

We are living in an era where the Internet, information technology, and social networks are gradually becoming indispensable, not only in business activities but also in daily life - particularly in online shopping. According to statistics from VnEconomy, the technology, home care, fashion, and beauty industries accounted for the highest output and revenue in the first and second quarters of 2024. The same source reports that, in the third quarter of

2024, total cosmetic sales on the Shopee platform alone increased by approximately 3,186 billion VND—an increase of about 12.2% compared to the second quarter. With the widespread use of the Internet and social networks, information is becoming increasingly easy to access and disseminate. In general, when consumers have a demand for a product, they often search for information online. Cosmetics consumers are no exception. They tend to read articles, watch advertisements or review videos, and consider the experiences shared by previous users or key leaders (KOLs). These sources of information shape their perception - positive or negative - of a cosmetic brand and, ultimately, influence their decision to try and remain loyal to that brand.

Recognizing the importance of social media marketing (SMM) in building brand image and driving product acquisition, it is evident that Vietnam's online market has grown significantly. With 77.93 million Internet users - accounting for 79.1% of the total population - the country presents a highly promising market (Vnetwork, 2024). The advancement of technology and the widespread adoption of social media have given rise to new marketing methods. Tran and Ngo (2023), for example, conducted a nationwide survey involving 102 marketing and communications professionals across industries between February and April 2023. The findings reveal that 99% of businesses are currently applying social media in their marketing and business activities.

Social media marketing enables consumers to share experiences and form online brand communities, thereby enhancing brand awareness, engagement, and satisfaction. Chen and Lin (2019) suggest that participation in online communities strengthens the bond between consumers and brands, which in turn fosters continuance intention. Similarly, Moslehpour *et al.* (2022) highlight that social media not only enhances consumers' purchase intentions but also promotes repeat purchase behavior - particularly in industries such as healthcare and beauty. To contribute to this growing body of research, our team chose the topic "Exploring Social Media's Power in Enhancing Brand Continuance Intention: The Cosmetic Industry" as the focus of this study. Through this research, we aim to provide deeper insights and practical implications for businesses operating in the cosmetics sector.

This study is novel in that it integrates social media marketing, brand awareness, brand attitudes, satisfaction, and customer experience into a comprehensive framework to explain continuance intention in Vietnam's cosmetics industry - a context that has been underexplored in prior literature. While much of the existing research on social media marketing has focused on purchase intentions or short-term consumer engagement, this study shifts the perspective toward long-term consumer behavior by examining continuance intention. By adopting a mixed-method approach and drawing on context-specific data from Ho Chi Minh City, the research not only validates established theories but also provides new insights into how digital marketing strategies can be optimized to strengthen consumer loyalty. These contributions are significant for both academia and practice, as they extend the theoretical understanding of continuance behavior while offering actionable implications for cosmetic firms seeking to leverage social media as a sustainable tool for customer retention.

1. Literature Review

1.1. Concept

In a previous study, Pertiwi *et al.* (2023) defined the intention to continue using as a consumer's desire to acquire products that they had previously used. Bhattacharjee (2001) has shown that the intention to continue using represents the customer's final decision about reusing the product or service, based on the positive experiences they have had. Setiawan & Prasetyaningtyas (2023) has emphasized that the social media marketing factor has a strong influence on the intention to continue using. Research by Monfort *et al.* (2025) shows that brand awareness and product satisfaction both play an important role in forming the intention to continue using. Another study by Boakye (2015) has shown that customer experience is a determining factor in the intention to continue using. Pertami & Sukaatmadja (2021) clarified that attitude towards the brand is also a significant factor influencing consumers' intention to continue using it.

The term "media" generally refers to channels used for conveying information, content, and publications, often serving advertising purposes. Meanwhile, "social" emphasizes interaction and connection among individuals. Combining these aspects, Kaplan and Haenlein (2010) define social media as "a group of Internet-based applications built on the technological foundations and principles of Web 2.0, enabling users to create and share content." From these perspectives, social media can be understood as Internet-based platforms that facilitate both information sharing and interpersonal interaction. Depending on users' purposes, they can take the form of social networks, professional networking sites, or commercial marketplaces.

Saravanakumar & SuganthaLakshmi (2012) defined social media marketing as the use of social media channels to promote a business's products. This is a new trend and way to help businesses grow quickly and get in touch with their target customers. According to research by Putri & Hermawan (2021), it has been argued that

social media marketing is part of digital marketing and the understanding of marketing activities in the online system in the interaction between sellers and consumers. Research by Fayvishenko *et al.* (2023) shows that social media marketing contributes to increasing brand value and expanding customer reach through content posted on social platforms.

According to Olcer *et al.* (2023), cosmetics are products that can be applied to the body (such as skin, nails, hair, hair, lips, genitals, teeth, and mouth) to clean that area for the purpose of deodorizing and looking and keeping the body in tip-top shape. Ergin *et al.* (2011) has stated that cosmetics are beauty products, which encompass any product that is used to care, clean, and improve the appearance of the human body, they are often used by women to enhance physical attractiveness Guthrie *et al.* (2008). In the study, Draelos (2021) further emphasized the role of makeup products such as mascara, lipstick, and eye color in improving personal image. According to the authors, these products not only help boost confidence levels but also assist individuals in improving their appearance.

1.2. Theoretical Models

The proposed TCT model is developed from the integration of three existing models: the Technology Acceptance Model (TAM), the Expectation - Confirmation Model (ECM), and the Cognitive Model (COG). The TCT model explains the factors influencing consumers' intention to continue using cosmetic products. It comprises six elements: confirmation, perceived usefulness, perceived ease of use, attitude, satisfaction, and continuance intention (Liao *et al.* 2019).

Davis (1986) introduced the TAM model in research on information technology usage behavior. The TAM model explains how consumers decide to continue using new technology based on their perceptions of usefulness and ease of use. In the context of this study, the TAM model provides a foundation for analyzing how social media marketing factors - such as content and user experience - affect consumers' intention to continue using a cosmetic brand.

Bhattacharjee (2001) proposed the ECM model to describe users' continuance behavior. According to this model, customer satisfaction is influenced by two key factors: perceived usefulness and confirmation. In turn, customer satisfaction directly impacts consumers' intention to continue using cosmetic products.

1.3. Social Media Marketing and Awareness

According to Nuseir *et al.* (2023), social media marketing has a major influence on consumer perceptions of brands. Simbolon *et al.* (2022) analyzed the use of Instagram as an advertising platform in building brand awareness and its impact on purchase decisions for Bulog products on Shopee. Their findings reveal that social media marketing through Instagram significantly enhances brand awareness. Similarly, Stojanovic *et al.* (2018) suggest that the intensity of brand engagement on social media positively affects brand awareness. Based on this, the research team proposes the following hypothesis:

H1: Social media marketing influences consumer perceptions of cosmetic brands.

1.4. Social Media Marketing and Attitudes

Tan *et al.* (2013) found that the effectiveness of social media marketing has a positive relationship with consumer attitudes, including purchase intention. Vo *et al.* (2025) also showed that social media marketing directly and positively influences consumers' feelings toward brands. Similarly, Luna-Nevarez and Torres (2015) emphasized the importance of understanding factors that shape attitudes, beliefs, and behavioral intentions in the context of social media marketing, as consumers are regularly exposed to brand content and advertisements. More recently, Filipović (2025) demonstrated that social media marketing exerts a positive and significant impact on consumer attitudes. Nabivi (2025) demonstrated that informative, entertaining, and relevant SMM content - particularly when emphasizing eco-friendly aspects - can enhance consumers' positive attitudes toward a brand. In contrast, research by Adekeye *et al.* (2025) revealed that frequent exposure to e-cigarette advertisements on social media normalizes usage behavior, thereby fostering favorable attitudes among adolescents toward such products. Thus, although the direction of the effect may vary depending on the type of content, empirical evidence suggests that SMM plays a powerful role in shaping consumer attitudes. Therefore, the research team proposes the following hypothesis:

H2: Social media marketing influences consumers' attitudes toward cosmetic brands.

1.5. Social Media Marketing and Satisfaction

Kumar *et al.* (2024) defined customer satisfaction as an overall evaluation based on the experience of purchasing and using products or services, determined largely by product attributes and perceived quality. Qurrata *et al.* (2021) highlighted the positive role of social media marketing in shaping consumer satisfaction, while Hanaysha (2017) reinforced that SMM helps create positive customer experiences. Moreover, customer satisfaction is crucial as it allows businesses to gather consumer feedback (Mojoodi *et al.* 2025). Ding (2022) further argued that SMM positively impacts satisfaction and increases social media activity, thereby helping firms attract new customers and improve performance. Social media marketing has been widely recognized as an important driver of user satisfaction, particularly in service and tourism contexts. The study by Wilopo and Nuralam (2024) demonstrated that specific dimensions of social media marketing activities, namely interaction and trendiness, significantly enhance users' satisfaction by fostering engagement and delivering up-to-date, relevant content. When users perceive that a brand actively interacts with them and continuously provides trendy information, they are more likely to develop positive experiences, which translates into greater satisfaction. Thus, the following hypothesis is proposed:

H3: Social media marketing influences user satisfaction with cosmetic brands.

1.6. Consumer perceptions and Continuance Intention

Sasmita and Suki (2015) showed that brand awareness strengthens purchase decisions when consumers immediately recall a brand. Keller (1993) emphasized that perceptions of brand quality, reputation, and image strongly shape consumer satisfaction and continuance behavior. Oliver (1999) and Yoo *et al.* (2000) similarly found that positive brand perceptions enhance satisfaction and encourage continuance intention, whereas negative perceptions decrease it (Dunuville & Pathmini, 2016). Hence, brands must focus on reputation and image to foster long-term loyalty. Kuo *et al.* (2009) confirmed that brand awareness is directly linked to continuance intention, a finding also supported by Homburg *et al.* (2015). Based on this, the research team proposes:

H4: Brand awareness influences consumers' intention to continue using cosmetic products.

1.7. Attitudes and Continuance Intention

Wu *et al.* (2025) argue that attitudes consist of cognitive, affective, and behavioral components. A positive consumer attitude increases brand recall and purchase likelihood. Tong *et al.* (2024) noted that brands with favorable attitudes enjoy higher market share, while Yoo *et al.* (2000) linked brand loyalty to long-term consumer commitment. Rafiq *et al.* (2020) stressed that repeat purchases depend on a brand's credibility and ability to meet expectations, and Liang (2017) confirmed that satisfaction from prior purchases fosters repeat purchase intention. Luthfitawati and Sutejo (2025) also emphasized that brand loyalty represents a strong, optimistic attitude that supports long-term continuance. The study by Shetu (2025) on Generation Z consumers' mobile shopping applications confirmed that positive shopping attitudes significantly enhance continuance intention, both directly and indirectly through behavioral intention. This finding suggests that when users develop favorable evaluations toward mobile shopping apps, they are more likely to maintain long-term engagement and repeatedly use the platforms. Accordingly, the hypothesis is:

H5: Attitudes toward a cosmetic brand influence consumers' intention to continue using it.

1.8. Satisfaction and Continuance Intention

Wu & Mvondo (2025) defined customer satisfaction as the outcome of comparing expectations with actual performance. Giantari *et al.* (2021) observed that satisfaction arises when product quality meets or exceeds expectations. Previous research Boakye (2015) has consistently shown that satisfaction is a critical determinant of continuance intention, especially in the cosmetics sector. Thus, the hypothesis is:

H6: Customer satisfaction affects continuance intention in the cosmetics industry.

1.9. Customer Experience and Continuance Intention

Lemon and Verhoef (2016) defined customer experience as a multidimensional construct reflecting consumers' perceptions, emotions, and interactions with a company's products and services throughout the buying process. Walter *et al.* (2010) further described customer experience as both direct and indirect interactions with businesses, services, and other consumers. Ferreira *et al.* (2025) found that positive experiences increase the likelihood of repurchase, while McLean and Wilson (2016) highlighted that poor experiences reduce it. Wang *et al.* (2025) showed that positive reviews posted online also enhance purchase intentions among other consumers.

Similarly, Peng and Bai (2025) confirmed the positive effect of customer experience on continuance intention. Based on this, the following hypothesis is proposed:

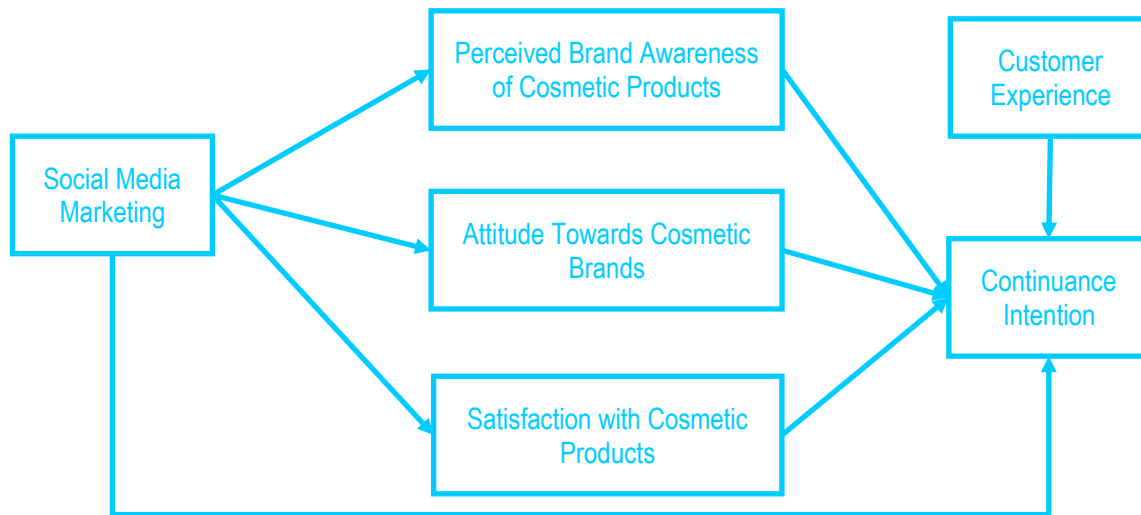
H7: Customer experience influences continuance intention.

1.10. Social Media Marketing and Continuance Intention

Chong *et al.* (2024) concluded that social media marketing significantly influences continuance intention. This finding aligns with other studies showing that SMM positively impacts consumers' likelihood of continuing to use a brand (Subawa *et al.* 2020). Therefore, the hypothesis is:

H8: Social media marketing influences consumers' continuance intention.

Figure 1. Proposed research model



2. Method

The research team adopted a two-phase methodology, integrating qualitative and quantitative approaches to ensure a comprehensive understanding of the factors influencing consumers' intention to continue using cosmetic brands.

In the qualitative phase, a preliminary study was conducted to explore the conceptual foundations and identify key social media factors affecting consumer behavior. This phase began with an extensive literature review of relevant academic articles, research papers, and industry reports. Insights from the literature were refined through focus group discussions involving eight participants ($N = 8$), selected based on their familiarity with social media and their experience as cosmetic brand consumers. These discussions helped identify critical social media elements. Based on these findings, the research team developed a theoretical framework, formulated hypotheses, and designed measurement scales for the subsequent quantitative phase.

In the quantitative phase, a formal study was carried out to empirically test the hypotheses and evaluate the impact of the identified factors. Data were collected via an online survey (Google Forms) from a diverse sample of 516 respondents who actively use cosmetic products and engage with brands on social media. The survey employed structured questions measured on a five-point Likert scale, ranging from strongly disagree to strongly agree. The collected data were analyzed using SmartPLS software, applying partial least squares structural equation modeling (PLS-SEM). This approach enabled the assessment of relationships between social media marketing strategies, mediating variables, and continuing intention toward cosmetic brands.

By combining qualitative insights with rigorous quantitative analysis, the study offers a holistic understanding of the interplay between social media marketing and consumer behavior in the cosmetics industry.

3. Research Results

3.1. Descriptive Statistics

To collect data, a questionnaire was randomly distributed to individuals in Ho Chi Minh City, covering diverse occupations, age groups, and genders. A total of 556 responses were obtained, of which 516 were valid for analysis. Among the respondents, 24.8% were male and 75.2% were female. In terms of age, the largest group was between 18 and 25 years old. Regarding education, most respondents held a university or college degree (80.8%), while the smallest proportion had only completed high school (3.6%). In terms of occupation, most

respondents were students (72.8%), followed by office workers (11.3%). The remaining participants included civil servants, traders, freelancers, and other professions. Concerning relationship status, the largest proportion was single (51.6%), followed by those in a relationship (28.4%) and married respondents (20%).

Table 1. Survey Sample Description Statistics

Characteristic		Frequency	Rate (%)
Gender	Male	138	24,8%
	Female	418	75,2%
Age	18 to 25 years old	404	72,7%
	26 to 35 years old	90	16,2%
Education	36 to 45 years old	27	4,9%
	Over 45 years old	35	6,2%
	High School	20	3,6%
	University/College	449	80,8%
Income	Postgraduate	87	15,64%
	Less than 5 million	335	60,3%
	5 to 15 million	136	24,5%
	15 to 25 million	33	5,9%
Profession	Over 25 million	51	15,2%
	Students	405	72,8%
	Civil servants/public employees	11	2%
	Office Staff	63	11,3%
	Trading business	35	6,3%
	Freelance workers	37	6,7%
Relationship Status	Other Industries	5	0,9%
	Single	287	51,6%
	Dating	158	28,4%
	Married	111	20%

3.2. Testing the Measurement Model

The constructs, including Attitude toward the Brand (ATB), Awareness of the Brand (AWB), Customer Experience (CUE), Satisfaction (SAT), and Social Media Marketing (SMM), were first assessed for internal consistency reliability. The results showed that all constructs had Cronbach's Alpha coefficients above 0.7, which is widely regarded as an acceptable threshold for good reliability. This indicates that the items within each construct are highly correlated and consistently measure the intended latent variable.

As presented in Table 2, the composite reliability (CR) coefficients ranged from 0.833 to 0.864. These values are well above the recommended threshold of 0.7, further confirming that the measurement items demonstrate strong reliability. In addition, all outer loadings exceeded 0.545, suggesting that each observed variable makes a significant contribution to its respective construct. More importantly, most loadings were above 0.7, which indicates that the observed variables are both meaningful and acceptable in representing their latent constructs. This ensures that the measurement indicators remain reliable across repeated testing conditions.

The convergent validity of the scale was examined using the average variance extracted (AVE). As shown in Table 2, all AVE values were greater than 0.5, which demonstrates that each construct explains more than 50% of the variance of its indicators. This result confirms that the constructs achieve good convergence and are well-suited for analysis using the PLS-SEM approach.

Table 2. Aggregate Reliability Assessment

Element	Cronbach's Alpha	rho_A	Composite Reliability	Average Variance Extracted (AVE)	Outer loadings
ATB	0.734	0.732	0.833	0.556	0.724 - 0.785
AWB	0.774	0.776	0.855	0.596	0.722 - 0.799
CUE	0.797	0.832	0.864	0.615	0.722 - 0.859
SAT	0.771	0.781	0.853	0.592	0.704 - 0.821
SMM	0.730	0.746	0.846	0.648	0.769 - 0.845

In Table 3 and Table 4, the discriminant validity of the measurement model was evaluated using both the heterotrait – monotrait (HTMT) ratio of correlations and the Fornell–Larcker criterion. The HTMT values ranged from 0.163 to 0.807, all below the critical threshold of 0.90, thereby supporting the presence of discriminant validity among the constructs. Furthermore, the Fornell–Larcker criterion was satisfied in all cases. Specifically, the square root of each construct's AVE (diagonal elements) was greater than its correlations with other constructs (off-diagonal elements). This confirms that each construct shares more variance with its own indicators than with other constructs, thereby validating the distinctiveness of the scales.

Table 3. Fornell - Larcker discriminant validity

Element	ATB	AWB	CUE	SAT	SMM	CI
ATB	0.746					
AWB	0.227	0.772				
CUE	0.190	0.196	0.785			
SAT	0.352	0.226	0.255	0.769		
SMM	0.201	0.180	0.120	0.230	0.805	
CI	0.358	0.296	0.267	0.657	0.253	0.756

Table 4. HTMT

Element	ATB	AWB	CUE	SAT	SMM	CI
ATB						
AWB	0.301					
CUE	0.249	0.243				
SAT	0.468	0.298	0.311			
SMM	0.272	0.248	0.163	0.301		
CI	0.461	0.368	0.317	0.807	0.317	

Taken together, these results provide strong evidence for the reliability, convergent validity, and discriminant validity of the measurement model. Thus, the constructs used in this study demonstrate robust psychometric properties, ensuring that the measurement framework is both valid and reliable for subsequent structural model testing.

3.3. Testing the Structural Model

One of the inherent limitations of quantitative research using survey data lies in the representativeness of the sample relative to the overall population. Due to resource constraints and time limitations, this study employed a sample of 556 participants, of which 516 responses were valid. Consequently, there are certain restrictions on the generalizability of the findings. To mitigate this issue, the authors applied the bootstrapping technique, which resamples the data with replacement, thereby creating a larger simulated dataset and enhancing the robustness of the results.

An essential step in evaluating the research model is the assessment of multicollinearity among independent variables. Multicollinearity is considered absent when the variance inflation factor (VIF) is less than 5. As shown in Table 5, the VIF values in this study ranged from 1.000 to 1.238, clearly demonstrating the absence of multicollinearity among the constructs. This result indicates that the independent variables do not excessively correlate with each other, ensuring the stability of the regression estimates.

The coefficient of determination (R^2) was used to measure the explanatory power of the model. R^2 values typically range from 0% to 100%, with higher values indicating greater predictive accuracy. According to Table 5, the adjusted R^2 for the dependent variable (Y) was 47.3%, meaning that nearly half of the variance in Y is explained by the predictors: ATB, AWB, CUE, SAT, and SMM. This demonstrates that the proposed model has a moderate level of explanatory power and that these factors serve as meaningful predictors of consumer intention.

To further evaluate the effect size of each predictor, Cohen's f^2 statistic was employed. Cohen (1988) classifies f^2 values of 0.02, 0.15, and 0.35 as small, medium, and large, respectively. As shown in Table 5, the independent variables exerted varying levels of influence on the dependent variable, ranging from small to large

effects. However, the impact of ATB, CUE, and SMM was found to be negligible, indicating that these variables contribute less explanatory power compared to others.

The statistical significance of the hypothesized relationships was assessed using the t-value and bootstrapping procedure. A t-value greater than 1.96 indicates statistical significance at the 5% level ($p < 0.05$). The bootstrapping results revealed that the variables ATB, AWB, CUE, SAT, and SMM all exerted significant effects on Y, supporting their hypothesized influence. Additionally, the SMM variable demonstrated a significant effect on ATB, AWB, and SAT, also at the 5% significance level.

Based on these findings, the study concludes that the empirical results provide sufficient evidence to accept hypotheses H1 through H8, thereby validating the proposed research framework.

Table 5. PLS - SEM Structural Model Inspection

Element	Original Sample (O)	VIF	f2	Standard Deviation (STDEV)	T Statistics (O/STDEV)	P Values	Result
ATB -> Y	0.106	1.195	0.018	0.038	2.789	0.005	Accept
AWB -> Y	0.119	1.115	0.024	0.036	3.312	0.001	Accept
CUE -> Y	0.073	1.103	0.009	0.035	2.058	0.040	Accept
SAT -> Y	0.558	1.238	0.481	0.035	16.098	0.000	Accept
SMM -> ATB	0.201	1.000	0.042	0.045	4.513	0.000	Accept
SMM -> AWB	0.180	1.000	0.034	0.048	3.782	0.000	Accept
SMM -> SAT	0.230	1.000	0.056	0.044	5.205	0.000	Accept
SMM -> Y	0.074	1.091	0.010	0.032	2.316	0.021	Accept
$R^2_{adj}Y = 0.473$; $R^2_{adj}ATB = 0.039$; $R^2_{adj}AWB = 0.031$; $R^2_{adj}SAT = 0.051$							

When considering ATB, AWB, and SAT as mediating variables, the results show that the SMM variable exerts a positive impact on Y, with beta coefficients of 0.021, 0.021, and 0.128, respectively. Furthermore, the p-values for these relationships are all below the 0.05 threshold, indicating statistical significance. These findings highlight that brand awareness (AWB), brand attitudes (ATB), and customer satisfaction (SAT) serve as critical mediators through which social media marketing (SMM) influences consumers' intention to continue using cosmetic brands. In other words, SMM does not directly determine consumers' behavioral intention but rather operates indirectly by shaping their perceptions of the brand, their attitudes toward it, and their satisfaction with the product. This result emphasizes the importance of designing effective social media marketing strategies that not only promote awareness but also foster favorable brand attitudes and enhance customer satisfaction, thereby strengthening long-term consumer commitment to cosmetic brands.

Table 6. The role of intermediate variables

Element	Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	T Statistics (O/STDEV)	P Values
SMM -> ATB -> Y	0.021	0.022	0.009	2.344	0.019
SMM -> AWB -> Y	0.021	0.022	0.009	2.339	0.019
SMM -> SAT -> Y	0.128	0.130	0.027	4.829	0.000

4. Discussions

4.1. Discussion of Findings

This research model was conducted to examine the influence of social media marketing (SMM) on consumers' intention to continue using cosmetic brands in Ho Chi Minh City. The results revealed five factors that positively affect consumers' behavioral intention, ranked in descending order of influence as follows: Satisfaction, Awareness, Attitude, Social Media Marketing, and Customer Experience. Furthermore, the findings show that the SMM factor also exerts a positive effect on three mediating variables - Satisfaction, Awareness, and Attitude - which subsequently shape consumers' continued intention.

Based on the PLS-SEM analysis, the results indicate that the factor of Satisfaction has the strongest influence on consumers' intention to continue using cosmetics ($\beta = 0.558$). This finding suggests that customers

who are satisfied with cosmetic products are significantly more likely to make repeat purchases compared to dissatisfied customers. This result is consistent with earlier studies, such as Zeithaml *et al.* (1996), which emphasized the role of satisfaction in customer retention, as well as more recent studies by Rajeh (2021), and Purohit *et al.* (2022).

The second most influential factor is Awareness ($\beta = 0.119$). This indicates that brand awareness positively shapes consumer intentions. When customers perceive a cosmetic brand positively, they are more likely to develop satisfaction with the product, which ultimately increases their likelihood of continued use. This finding aligns with the theoretical foundations laid by Oliver (1999) and Yoo *et al.* (2000) and is also supported by empirical evidence from Dunuwille & Pathmini (2016), and Sasmita & Suki (2015).

The third-ranked factor is Attitude ($\beta = 0.106$). This highlights the significant role of consumers' attitudes toward a cosmetic brand in shaping their behavioral intentions. A positive attitude toward the brand leads to a greater willingness to continue purchasing and using its cosmetic products. This finding is in line with prior research by Stadthanner *et al.* (2022), and Masrahi *et al.* (2021), which also confirmed the importance of brand attitudes in predicting consumer loyalty and repurchase intention.

The Social Media Marketing factor itself is also found to have a positive impact ($\beta = 0.074$). This underscores the role of SMM in encouraging repeat purchase behavior. When firms intensify their social media marketing efforts - through interactive campaigns, influence collaborations, and user-generated content - consumers are more likely to continue using the cosmetic products promoted. These results are consistent with the findings of Subawa (2020), which demonstrated that well-designed SMM activities enhance customer engagement and loyalty.

Finally, Customer Experience ($\beta = 0.073$) also contributes positively, albeit to a lesser extent. This suggests that a positive and memorable experience during the process of purchasing and using cosmetic products fosters consumers' willingness to repurchase. This result supports the findings of Liu & Zhao (2024), which emphasized the importance of customer experience in shaping long-term purchase intentions.

In addition, the study further confirmed that the SMM factor significantly influences Attitude, Awareness, and Satisfaction ($\beta = 0.180$; 0.201 ; 0.230 , respectively). These mediating variables play a crucial role in explaining how social media marketing indirectly affects consumers' intention to continue using cosmetic brands. In other words, while SMM exerts a direct effect, its stronger influence is realized through shaping brand awareness, brand attitudes, and customer satisfaction, which subsequently enhances the likelihood of long-term consumer commitment.

4.2. Managerial Implications

Through the topic "Exploring Social Media's Power in Enhancing Brand Continuance Intention: The Cosmetic Industry", the research team summarized the influence of independent variables on the dependent variable based on the Original Sample results. Among the examined factors, Satisfaction had the greatest influence on consumers' intention to continue using cosmetic brands, while Customer Experience had the least impact. The factors were ranked in descending order of influence as follows: Satisfaction, Awareness, Attitude, Social Media Marketing, and Customer Experience.

Based on the Beta coefficients, the team identified the degree of impact each factor had in order to provide managerial implications for businesses. These findings can guide firms in understanding consumer preferences when social media marketing plays a role and also provide practical insights for improving consumers' purchase intentions.

The analysis results highlight that Satisfaction is the most influential factor affecting the intention to continue using cosmetic brands. The higher the level of customer satisfaction, the stronger the intention to repurchase. Satisfaction is the decisive factor in whether customers continue buying; when products and services meet or exceed expectations, consumers are more likely to remain loyal. In the cosmetics industry, achieving customer satisfaction requires not only high product quality but also continuous attention to customer feedback to address shortcomings in both product and service. To improve services, businesses should consider establishing a professional customer care team. Positive reviews, timely responses, and proactive engagement on social media channels can enhance satisfaction, foster greater brand attachment, and provide valuable input for product and service improvement.

The second most influential factor is Awareness. Brand awareness is a crucial first step in attracting and impressing customers. The higher the recognition, the greater the opportunity for customers to trust and purchase from a brand - particularly in the highly competitive cosmetics industry. Increased awareness strengthens brand presence and encourages repeat purchases. In today's digital landscape, platforms such as

Facebook, Instagram, and TikTok make it easy for consumers to recognize brands through posts, advertisements, or influencer (KOL) content. Therefore, businesses should strengthen advertising and PR strategies and collaborate with credible influences to boost brand visibility and recognition.

The third factor is Attitude. Attitude is often shaped by customers' initial purchase experiences. Positive experiences create favorable attitudes, fostering customer confidence and long-term loyalty. Negative experiences, however, can lead to customer attrition. In the cosmetics industry, businesses must not only maintain product quality but also create consistently positive service attitudes. Monitoring and managing social media feedback, promptly addressing complaints, and ensuring high-quality media content are essential strategies to sustain positive customer attitudes and brand loyalty.

Social media Marketing also plays an important role in maintaining brand engagement. Effective social media strategies leave lasting impressions, keeping brands top-of-mind for consumers. Social media platforms are not only channels for product promotion but also spaces for interaction, feedback, and relationship-building. Strong brand–consumer relationships developed through these interactions encourage customers to return. To retain customers and build long-term relationships, businesses should focus on designing trend-driven, meaningful social media strategies and fostering community through active engagement.

Finally, Customer Experience was found to have the least influence on brand continuance intention. Although customer experience includes interactions such as shopping, product usage, and service encounters, in the context of social media, its direct impact is less significant. This may be because customers increasingly interact with brands online rather than in physical stores. As a result, awareness, satisfaction, and social media marketing tend to play stronger roles in shaping brand continuance intentions in the cosmetics industry. Nonetheless, customer experience remains a supporting factor. To optimize it, businesses should focus on enhancing online experiences, simplifying the shopping process, ensuring accessible customer support, and improving post-purchase services.

4.3. Limitations and Future Research Directions

After completing the study, the authors identified several limitations. First, the use of a convenience sampling method led to the exclusion of many survey responses that were not suitable for the study's scope. Second, the sample size was relatively small, which may not accurately capture or generalize the research findings. Third, the scope of the study was restricted to Ho Chi Minh City, meaning the results are only representative of this geographical area. Finally, due to time constraints, although the study identified several factors influencing consumers' intention to continue using cosmetics, other potentially relevant variables remain unexplored. To address these limitations, the authors propose several directions for future research. Increasing the sample size will help reduce sampling errors and enhance the credibility of the results. Expanding the research scope to include other cities across Vietnam will allow for regional comparisons and produce findings that are more representative at the national level. Additionally, future studies should investigate other variables that may affect consumers' intention to continue using cosmetics. Such efforts will provide a more comprehensive understanding of how social media marketing influences brand continuance intention in the cosmetics industry.

Conclusions

The results showed that all observed factors were consistent with previous studies, with the order of influence on the dependent variable being Satisfaction (SAT), Attitude (ATB), Awareness (AWB), Social Media Marketing (SMM), and Customer Experience (CUE). In addition, SMM was found to positively influence three mediating factors, namely SAT, AWB, and ATB. From these findings, several managerial implications can be drawn for businesses in the cosmetics industry. In terms of satisfaction, companies should build a professional customer care team, enhance customer interaction, and respond promptly to inquiries or complaints. Regarding awareness, cosmetic firms need to strengthen advertising strategies and collaborate with reputable celebrities or influencers to improve brand recognition. With respect to attitude, businesses should closely monitor and manage customer feedback on social networks, resolve complaints quickly to prevent negative publicity, and continuously improve the quality of brand content shared online. In terms of social media marketing, companies can retain customers and foster long-term relationships by building online communities and encouraging interactive engagement. Lastly, customer experience should be enhanced throughout the entire online journey, including improvements in the shopping process, timely customer service, and post-purchase support. However, despite these contributions, the study has several limitations. The use of a convenience sampling method required the removal of unsuitable responses, resulting in time loss during data collection. The relatively small sample size also limited the accuracy and generalizability of the results. Furthermore, the research was confined to Ho Chi Minh City, restricting its

representativeness, and the limited research duration prevented the exploration of other potentially relevant factors. To address these shortcomings, future research should expand the sample size to increase reliability, extend the study's geographical coverage to include other cities in Vietnam for broader comparisons, and investigate additional variables that may influence consumers' intention to continue using cosmetic brands. By doing so, subsequent studies can provide more comprehensive and in-depth insights, offering valuable references for businesses in the cosmetics industry to design appropriate strategies and effectively utilize social media marketing to strengthen brand loyalty and customer retention.

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Credit Authorship Contribution Statement

Nguyen Thi Phuong Giang: Conceptualization, Investigation, Methodology, Project administration, Software, Formal analysis, Writing – original draft.

Nguyen Binh Phuong Duy: Software, Formal analysis, Writing – original draft, Supervision, Data curation, Validation, Writing – review and editing, Visualization, Funding acquisition.

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Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Declaration of Use of Generative AI and AI-assisted Technologies

The authors declare that they have not used generative AI and AI-assisted technologies during the preparation of this work.

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Digital Adoption and Price Discovery in Shadows: Evidence from Indian IPO Grey Markets between 2016-2025

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Abstract: This study examines the role of digital adoption and price discovery through informal IPO markets in India. Due to price anomalies, sentiments around the IPO listing day are channelised through Informal markets known as grey markets. This study verifies the determinants of grey market IPO prices and their linkages with the formal market IPO under-pricing. Apart from dominant market and firm-specific factors, it examines how digital adoption variables such as digital payment usage and new demat accounts affect the IPO prices in both channels. In the post-pandemic period, there is a surge in the number of IPOs offered and participation of institutions and individuals in IPOs. Grey market allows traders to bid on IPO applications before they are officially listed, helping to assess under-pricing in issue prices, if any. This study uses data of 1,155 IPOs that went public in India between 2016 and 2025. Using OLS models, the study examines the relationships among variables, and findings indicate that both grey market activity and digital adoption directly influence listing day prices, confirming that under-pricing is predictable through informal channels. Investors should consider these factors, in addition to fundamental aspects, when making IPO investment decisions.

Keywords: grey market premium; IPO market; listing day premium; firm-specific factors; under-pricing.

JEL Classification: G10; G11; C31; C30.

Introduction

The grey market refers to an unofficial or informal market where Initial Public Offer (IPO) share applications with the likelihood of allotment are traded. The trade in the grey market happens largely in cash and in person, directly without any presence of intermediary. This type of market is quite prevalent in emerging countries. Investors gauge market sentiment regarding the shares offered and assess their potential demand. Shares are traded in lots at prices commonly known as “Kostak” or “Sauda.” These prices are typically quoted at a premium or discount compared to the issue price. It is generally considered a proxy for the listing day price. Participants in the IPO market track grey market prices to speculate on the listing day gains and accordingly decide whether to apply for an IPO or not. It involves a huge risk as it is an unregulated market. However, it acts as an indicator for decision-making too among investors. There is less known fact about the extent to which grey market prices influence the listing day price, eventually affecting investors' gains or losses. It is essential to assess the influence of grey market premiums when controlled by the issue price on the listing day gains.

In this digital era, IPO markets are vibrant places where companies seek to raise capital, attracting not only institutional investors but also a wide array of traders and short-term investors who eagerly anticipate capitalizing on the immediate listing date returns. Further, the thrill of the listing day, which is often characterized by some significant price movements, remains a primary attraction, particularly during bullish market sentiment when investor enthusiasm is relatively high. There are a number of factors that influence the extent of gains realized on listing day including the ease of investments and dematerialization of financial securities. The ease of investments has grown manyfold due to internet access and digital adoption in the financial markets. Besides, the dematerialization of shares that allows mobile and online trading increased the number of participants considerably overtime. The informed investors seek early profit opportunities, especially in IPO markets, where price efficiency and information asymmetry are considerably high (Fu *et al.* 2025). In recent times, especially in emerging economies, grey market trading has become a platform for price discovery (Krishnamurti *et al.* 2012). In particular, India is witnessing a substantial increase in digital adoption in financial markets, reflected by the rise in digital payments and new demat accounts over the past decade. (Kumar *et al.* 2025). This digital shift has made IPO subscriptions more accessible, leading to higher trading volumes and fresh market sentiments.

Furthermore, the listing and pre-listing day price volatility in the regulated and grey markets are witnessing tremendous growth in recent times. Also, the factors affecting the listing day gains are not clearly explained. More often, the firm specific characteristics play a crucial role in determining the IPO prices. These include predominantly the financial indicators, such as RoA, ROCE, PE and promoter shareholding ratios (Zhang & Neupane, 2023). In addition, the effect of earnings performance before listing has an influence on the IPO pricing (Suresha B *et al.* 2023). The general market conditions, overall market sentiments, investor risk appetite, and the level of market volatility also play a significant role in determining the level of IPO under-pricing (Aggarwal *et al.* 2009). During a favourable market momentum amidst the IPO period, investors are more likely to participate in the IPO, reducing the level of under-pricing. While unfavourable market conditions like bearing may increase the level of under-pricing as investors become more risk-averse and demand a higher return to take on additional risk. The market conditions also impact the level of participation from QIBs, RILs, and NIIIs, affecting the demand for the IPO and listing day performance. Findings have also shown that access to vital information for investors influences an IPO's performance, particularly when QIBs are assumed to have access to insider information (Bansal & Khanna, 2012). The grey markets in India are emerging as a strong predictor of the IPO pricing. It plays a significant role in determining the listing day IPO price. The grey market premium (GMP) is the difference between the IPO allotment price and the closing price of the stock in the grey market before listing. It signals market expectations and demand for stock. A higher GMP typically indicates strong investor sentiment and a high likelihood of listing day gain.

As there is an active and growing grey market presence in the country, price discovery is shifting from formal to informal channels. Grey market dynamics may influence the price trends in the formal markets. Though factors that influence GMP and listing day gain have been researched extensively in developed countries there are no specific studies in emerging economies such as India specifically verifying the price spillover between these markets. In the last two decades, India has experienced tremendous growth in digital adoption in financial markets, and its influence on GMP and listing day is less known. This knowledge is essential for informed decision-making. This study aims to verify factors determining GMP and IPO Listing Day gains, particularly focusing on unexplored factors such as digital adoption, macroeconomic factors, and other company and market-specific factors. The outcomes of this study help both investors and policymakers in decision-making.

1. Literature Review

IPO market performance and factors determining IPO under-pricing are a matter of research interest both for finance practitioners and academicians. Multiple theories attempted to explain the underlying causes of this phenomenon and identify the key factors that influence IPO listing day prices. Some of the most commonly cited determinants of IPO under-pricing include the level of asymmetric information between issuers and investors, the degree of risk associated with the issuing firm, and the level of demand for the IPO (Perera & Kulendran, 2015). According to the signalling theory, the level of under-pricing is positively related to the level of asymmetric information, as issuers with private information about their firms' true value may use under-pricing as a signal to convey this information to investors, thereby reducing the adverse selection problem and increasing the likelihood of a successful IPO (Yarram, 2014). Overoptimism about the post-listing performance causes the IPO price (Paleari & Vismara, 2007). Sentiments of retail investors at the subscription phase and willingness to overpay signal higher demand and listing day under-pricing (Dorn, 2009). IPO underwriter reputations and the number of patents held by the issuing firm signal post-listing firm performance (Deb, 2013). The degree of Information disclosure in red herring prospectuses affects the IPO performance (Sherif *et al.* 2016).

Furthermore, the prospect theory suggests that under-pricing is a function of the level of risk associated with the issuing firm, which is often measured by its volatility, leverage, or industry classification. Predominantly, some factors are external and internal to the issuing company. For instance, market factors are uncontrollable factors for a firm but have a significant impact on its valuations (Ghosh *et al.* 2012). Empirical findings identify several firm-specific characteristics that correlate with IPO under-pricing, such as the firm's age, turnover, pre-IPO leverage, and the share held by promoters. The literature consistently points out that younger firms tend to experience higher levels of under-pricing due to greater uncertainty about their future performance. Moreover, the composition of ownership, particularly the proportion of shares held by promoters, has been shown to mitigate the adverse effects of information asymmetry (Ljungqvist & Wilhelm, 2005). A higher promoter share can signal confidence to investors, thereby potentially reducing under-pricing (Rani, 2014). Similarly, the predictability of listing day price and price inefficiencies in the market confirmed the existence of forecasting errors and earnings management (Abdulai & Sharifzadeh, 2015). Further evidence proves the relationship between firm size and IPO oversubscription and states that firm size has a significant and negative influence on oversubscription. Large firms with a proven track record face information asymmetry and do not need to underprice their IPOs to attract investors or prevent oversubscription (Tajuddin *et al.* 2017). The influence of grey market premium and finds that GMP has a positive influence on the listing day price (Chandu *et al.* 2024). Few studies confirm sentiments around the grey market transform to the formal market IPO pricing. Short selling in the grey market signals probable under-pricing on the listing day (Krishnamurti *et al.* 2012). The existence of the grey market before the official listing day injects an element of pre-market price discovery, allowing potential investors to express their interest and willingness to pay for the shares before they are available on the primary exchange (Lowry *et al.* 2010). The pre-IPO financial performance is strongly correlated with listing day performance, particularly the Return on Net Worth (RoNW) and Price-Earnings (P/E) ratio, which are critical for investor decision-making (Shenoy & Srinivasan, 2018). Research on the relationship between issue size and average bid price in the pre-issue market shows that issue size affects performance on the first day of listing. During the pre-issue phase, prices are primarily determined by a small group of investors, while larger market participants influence post-listing prices (Gao *et al.* 2020). Institutional investors through block trades are at advantage over others in IPO markets in determining prices (Pukthuanthong-Le & Varaiya, 2007). Similarly, issue size and listing day market condition has a strong influence on IPO performance (Deng & Zhou, 2015). The rate of subscription by retail to institutional investors signals the probable listing day open price (Banerjee & Rangamani, 2015). Macro-economic variables such as local government bond yields has influence IPO prices but capital market indicators not necessarily influence IPO values. (Meluzin *et al.* 2015). Investors often find it challenging to determine the importance of different pieces of information needed for decision-making. Among all types of information, accounting data is particularly crucial for investment decisions, as it directly influences share prices in both IPOs and secondary markets (Jeroh & Edesiri, 2015). Among the crucial accounting information, solvency and profitability ratios are widely used for stock valuation. Particularly, the Debt-to-Equity ratio, Liquidity ratio, and Return on Assets (ROA) and Return on Equity (ROE) are the most important for decision-making (Setiawanta *et al.* 2020).

The literature indicates that information asymmetry and market or firm-specific factors significantly influence IPO pricing. However, there's limited evidence of the strength of grey market variables to forecast price and volume. More research is needed to explore the relationship between formal and informal markets, especially

in emerging economies. Further, in the emerging economies, market dynamics are quite different. Empirically, it is unknown how far the grey market and growth in digital adoption affects IPO prices. Further, it is essential to know the role of Net Portfolio Investments (NPI) and Net Foreign Direct Investment (NFDI) on IPO prices in India. In this study, an attempt has been made to verify the relationship among these variables. This knowledge is useful for traders and investors to make informed decisions.

2. Data and Methodology

2.1. Research Variables

This study attempts to verify the relationship between the grey market and the formal market IPO listing day gains. It explains factors determining IPO grey market returns and their influence on listing day prices. In addition to market and firm-specific variables, the study also evaluates the significance of digital adoption in the economy on both the grey market and formal market performance on IPO listing days. The analysis employs a cross-sectional linear regression model to examine the relationship between the grey market prices, IPO listing day performance, and firm-specific and market-related variables. A paired sample Student test and the Wilcoxon test were employed to investigate the mean differences between the variables. Listing day price (LDP) and Listing Day Gain (LDG) percentage at close in NSE at t_0 and Grey Market Premium (GMP) at t_1 are considered as the dependent variables of the study. Fundamental financial predictors and market-specific factors are considered in the study. Further digital adoption was measured by proxying digital payments and new demat accounts. Also, the study verifies final market macro factors such as net portfolio investments and net foreign direct investments. Table 1 shows the variables examined in this study.

Table 1. Explanation of research variables

Variables	Acronym	Variable explanation
Market Factors		
Volatility Index	vix	Monthly Volatility Index value
Nifty monthly Returns	nmr	Monthly closing returns of the NSE index
Listing day Price	ldp	Listing day open price at NSE
Listing Day Gain	Ldg	% difference between listing day closing and issue price
Issue-Specific Factors		
Total Application	ta	Total bids received or total overall subscription rate
Issue Price	ip	Public offer price band
NII	nii	NII Subscription Rate
RII Subscription Rate	rii	RII Subscription Rate
Grey Market Factors		
%Grey Market Premium	%gmp	% difference between the issue price and the grey market price
Firm-Specific Factors		
Return on Capital Employed	roce	immediate previous year's annual return on capital employed
Debt/Equity	de	Pre-issue debt/equity ratio
P/E Ratio	per	Pre-issue Price to Earnings Ratio
Promoter Holding Pre-Issue	promopre	Pre-issue period promoter shareholding
Promoter Holding Post Issue	promopost	Pre-issue period promoter shareholding
Digital Adoption and Macro Factors		
Digital payments	digipay	Net Monthly digital payments made in all modes
New Demats	newdemat	Month-wise Number of new demat accounts opened
Net Foreign Direct Investments	nfdi	Net Foreign Direct Investments
Net Portfolio Investments	npi	Net Portfolio Investments

2.2. Sample Size

The study covers all the main board IPOs that were issued between 2016 to 2025. The study examines a total of 1,155 initial public offerings (IPOs) in the Indian IPO market since 2016, covering over 17 prominent sectors.

These IPOs were listed on the Bombay Stock Exchange (BSE) and the National Stock Exchange (NSE). Financial data for the companies involved was sourced from the red herring prospectus documents submitted to the Securities and Exchange Board of India (SEBI).

Additionally, grey market prices were gathered from the platforms of IPO Watch (<https://ipowatch.in/ipo-grey-market-premium-latest-ipo-gmp/>) and Investor Gain (<https://www.investorgain.com/gmp/ather-energy-ipo/1237/>) brokers.

2.3. Research Models

The study verifies the relationship between the dependent and independent variables by analysing the aggregate sample of IPOs using the following regression models:

Grey market premium is computed with the help of the following equation. Ip is the issue or offer price and CP t-1 is the closing price in the grey market before the listing day of the IPO.

$$GMP\% = \left(\frac{CP_{t-1}}{ip} - 1 \right) \times 100 \quad (1)$$

Listing day gain percentage is computed with the help of the following equation. Ip is the issue or offer price and listing day CP t-1 is the closing price in the formal market on the listing day of the IPO.

$$LDG\% = \left(\frac{Listing\ day\ CP_{t-1}}{ip} - 1 \right) \times 100 \quad (2)$$

2.4. Ordinary Least Squares (OLS) Models

$$ldp = a + \beta_1 (gmp\%) + \beta_2 (nmr) + \beta_3 (vix) + \beta_4 (nii) + \beta_5 (rii) + \beta_6 (ta) + \beta_7 (ip) + \beta_8 (roce) + \beta_9 (de) + \beta_{10} (per) + \beta_{11} (promopre) + \beta_{12} (promopost) + \mu_i \quad (3)$$

$$ldp\% = a + \beta_1 (gmp\%) + \beta_2 (nmr) + \beta_3 (vix) + \beta_4 (nii) + \beta_5 (rii) + \beta_6 (ta) + \beta_7 (ip) + \beta_8 (roce) + \beta_9 (de) + \beta_{10} (per) + \beta_{11} (promopre) + \beta_{12} (promopost) + \mu_i \quad (4)$$

$$gmp\% = a + \beta_1 (ldp) + \beta_2 (nmr) + \beta_3 (vix) + \beta_4 (nii) + \beta_5 (rii) + \beta_6 (ta) + \beta_7 (ip) + \beta_8 (roce) + \beta_9 (de) + \beta_{10} (per) + \beta_{11} (promopre) + \beta_{12} (promopost) + \mu_i \quad (5)$$

$$gmp\% = a + \beta_1 (vix) + \beta_2 (nmr) + \beta_3 (ldp) + \mu_i \quad (6)$$

$$gmp\% = a + \beta_1 (ta) + \beta_2 (ip) + \beta_3 (nii) + \beta_4 (rii) + \mu_i \quad (7)$$

$$gmp\% = a + \beta_1 (promopre) + \beta_2 (promopost) + \beta_3 (roce) + \beta_4 (der) + \beta_5 (per) + \mu_i \quad (8)$$

Where, vix is the volatility index, nmr is nifty monthly returns, ldp is the listing day price, ldg is listing day gain, ta is total application, ip is issue price, nii is net institutional investors, rii is retail individual investors, gmp% is grey market premium, roce is return on capital employed, der is debt/equity ratio, per is p/e ratio, promopre is promoter holding pre-issue and promopost is promoter holding post issue.

2.5. Cross-Sectional Models

In a sample of 1,155 IPOs across 17 sectors, the distribution shown in Table 2 reveals that the manufacturing sector has the highest percentage (22.42%), followed by IT (12.38%) and pharmaceuticals (8.68%), while hospitality (1.81%) and automobiles (1.81%) have the lowest.

It can be observed from Table 2 that the manufacturing sector is the largest, representing over 22% of the total, indicating a robust industrial presence. Following closely are the IT and pharmaceuticals & healthcare sectors, which comprise approximately 12% and 9%, respectively, highlighting an increasing emphasis on technology and healthcare. Moderate representation is seen in the financial services, retail, and miscellaneous sectors, each accounting for around 6-8% of the companies. Meanwhile, smaller sectors such as consumer goods, logistics & transportation, infrastructure, energy, and real estate & construction make up about 3-5% of the total.

In this study, to understand the differences at the sectoral level and confirm the relationship among top sectoral IPOs, the study considered the manufacturing (N=259), information technology (N=143) and pharma & healthcare sector's (N=100) IPO performance in both formal and informal markets. In this model the study considered LDG% and GMP% as the dependent variables and others as predictors.

Table 2. Sector-wise Sample Size of the study

Code	Sector	Count	%
1	Financial Services	78	6.753%
2	IT	143	12.381%
3	Pharmaceuticals & Healthcare	100	8.658%
4	Consumer Goods	56	4.848%
5	Energy	39	3.377%
6	Real Estate & Construction	42	3.636%
7	Manufacturing	259	22.424%
8	Media & Entertainment	34	2.944%
9	Retail	71	6.147%
10	Metals & Mining	24	2.078%
11	Agriculture	38	3.290%
12	Logistics & Transportation	50	4.329%
13	Hospitality & Tourism	21	1.818%
14	Infrastructure	51	4.416%
15	Textiles	41	3.550%
16	Misc	87	7.532%
17	Automobile	21	1.818%
		1155	

$$ldg\%_{mft,it,ph} = a + \beta_1 (gmp\%) + \beta_2 (nmr) + \beta_3 (vix) + \beta_4 (nii) + \beta_5 (rii) + \beta_6 (ta) + \beta_7 (ip) + \beta_8 (roce) + \beta_9 (de) + \beta_{10} (per) + \beta_{11} (promopre) + \beta_{12} (promopost) + \mu_i \quad (9)$$

$$gmpt\%_{mft,it,ph} = a + \beta_1 (ldp) + \beta_2 (nmr) + \beta_3 (vix) + \beta_4 (nii) + \beta_5 (rii) + \beta_6 (ta) + \beta_7 (ip) + \beta_8 (roce) + \beta_9 (de) + \beta_{10} (per) + \beta_{11} (promopre) + \beta_{12} (promopost) + \mu_i \quad (10)$$

3. Empirical Results and Discussions

The study uses OLS regression to present results categorized into market factors, issue-specific factors, grey market factors, and firm-specific factors. It employs both aggregate and specific factor models to analyse how independent variables influence listing day performance and grey market premium.

In Model 3, results show that both market-specific and firm-specific variables significantly impact IPO performance on their listing day, measured through Listing Day Price (LDP) and Listing Day Gain% (LDG%). The analysis shows that the LDP is strongly influenced by the Gross Market Price (GMP%), which has a positive effect of 84.55%. This confirms the grey market premium's significant impact on listing day performance. Other factors, including Issue Price (IP), Net Institutional Investment (NII), pre-issue Promoter Holdings (Promopre), and Return on Capital Employed (ROCE), also positively influence the LDP, though to a lesser extent. In contrast, Retail Investor Interest (RII) and the Debt-to-Equity Ratio (DER) negatively affect the LDP. Overall, the model demonstrates a strong explanatory power with an R-squared value of 92.9%.

We confirm the results for Model 4 as well, particularly the predictive strength of GMP% ($R^2=70.5\%$) on the listing day performance.

In Model 5, we examine the factors that influence the GMP%. Our findings show that Total Assets (TA), Input Price (IP), Net Institutional Investors (NII), Retail Individual Investors (RII), Promoters holding in Pre-issue (Promopre), Return on Capital Employed (ROCE), Debt-to-Equity Ratio (DER), and Listing Day Price (LDP) all have a statistically significant impact on GMP%.

This confirms that both company-specific and market-specific factors directly affect the grey market premium in the informal market. In the specific factor model, it is found that, except for the volatility index, all other variables have a statistically significant influence on the GMP%. Issue-specific factors have strong explanatory strength ($R^2=57.7\%$) on the changes in the GMP%, followed by firm-specific factors ($R^2=20.1\%$). However, the predictive strength of market factors is very low ($R^2=.14\%$).

Table 4. OLS regression results of Listing Day Performance and Grey Market Premium

Predictors	Aggregate Factor Model			Specific Factor Model		
	Model 3: DV=LDP N=1155	Model 4: DV=LDG% N=1155	Model 5: DV=GMP% N=1155	Model 6: DV=GMP% N=1155	Model 7: DV=GMP% N=1155	Model 8: DV=GMP% N=1155
	β	β	β	β	β	β
Intercept	-81.292	-0.1	0.053	0.225	0.106	0.357
Market Factors						
VIX	12.589	0.103***	-0.032	0.004		
NMR	56.384	0.249	-0.039	0.36*		
LDP	-	-	0.000***	0.008***		
Issue-Specific Factors						
TA	0.000***	0.000	0.000***		0.009***	
IP	1.111***	-0.045	0.003***		-0.018***	
NII	0.122***	0.000***	1.000***		0.019***	
RII	-0.110***	0.001***	0.001***		0.001***	
Grey Market Factor						
GMP%	84.559***	0.705***	-			
Firm-Specific Factors						
Promopre	1.100***	0.002	-0.001***			-0.001***
Promopost	-0.319	0.009	0.001			0.003***
ROCE	0.559***	0.004***	0.003***			0.009***
DER	-39.155***	-0.083***	0.034***			0.002
PER	0.005	0	0.003			-0.014***
R ²	0.929	0.53	0.609	0.014	0.577	0.201
AIC	13676	363	-831	219	-756	-19.3
DW Stat	1.84	1.89	2.09	1.79	2.04	1.88
F	1246	107	148	5.66	392	57.9

*, **, and *** represent the 10%, 5%, and 1% two-tailed significance level, respectively.

Table 5 highlights the sectoral differences in the variables affecting the Listing Day Gain (LDG) and the Grey Market Premium (GMP%). In the IT sector, the model variables account for 66.1% of the variation in LDG for IPOs. Specifically, the promopre in the formal IPO market and the GMP% are significant factors influencing LDG in this sector. For the Pharma and Health sector, 52.2% of the variation in LDG can be explained by the model variables. Here, the VIX, NII, ROCE, and GMP% significantly impact LDG. In the manufacturing sector, the model variables explain 63% of the variation in LDG for IPOs. In this sector, VIX, NII, and DER have shown to have a significant positive influence on LDG.

When analysing the predictability of various factors on the Grey Market Premium (GMP%) across different sectors, it is observed from table 5 that 71.8% of the changes in GMP% for IT sector IPOs can be explained by the model variables. Factors such as TA, IP, RII, Promopre, Promopost, and ROCE have a significant influence on GMP%. For IPOs in the Pharma and Health sector, 65.9% of the changes in GMP% can be explained by the model variables. Important factors in this sector include TA, IP, RII, DER, and LDP. In the Manufacturing sector, 69.0% of the changes in GMP% can be attributed to the model variables, which include TA, IP, RII, Promopost, ROCE, DER, and LDP.

Table 5. Regression results of the sectoral sample

Sector	Information Tech		Pharma & Health		Manufacturing	
	DV=LDG% N=143	DV=GMP% N=143	DV=LDG% N=100	DV=GMP% N=100	DV=LDG% N=259	DV=GMP% N=259
Predictor	β	β	β	β	β	β
Intercept	-0.357	0.344	-0.034	0.059	-0.017	-0.033
TA	0.000	0.000***	0.000	0.000***	0.000	0.000***

Sector	Information Tech		Pharma & Health		Manufacturing	
	DV=LDG% N=143	DV=GMP% N=143	DV=LDG% N=100	DV=GMP% N=100	DV=LDG% N=259	DV=GMP% N=259
VIX	0.036	-0.031	0.332***	-0.026	0.248***	-0.037
NMR	-0.240	-0.605	0.361	0.052	0.513	-0.173
IP	0.005	0.000***	0.005	0.001***	0.001	0.004***
NII	0.000	0.000	0.001***	0.000	0.000***	0.008
RII	0.000	0.001***	0.001	0.001***	0.000	0.001***
Promopre	0.007***	-0.007***	0.003	-0.001	0.002	-0.002
Promopost	-0.005	0.004***	-0.005	0.001	-0.003	0.003***
ROCE	0.004	0.009***	0.008***	0.002	0.000	0.007***
DER	-0.061	0.019	-0.077	0.053***	-0.074***	0.044***
PER	0.001	0.000	0.000	0.001	0.007	0.000
GMP%	1.129***	-	0.942***	-	1.173***	-
LDP	-	0.000	-	0.000***	-	0.001***
R ²	0.661	0.718	0.522	0.659	0.633	0.691
AIC	87.2	-95.8	-11.1	-190	113	-228
DW Stat	2.23	1.98	2.07	2	2.23	
F	21.1	27.6	7.91	14	35.4	45.8

*, **, and *** represent the 10%, 5%, and 1% two-tailed significance level, respectively.

3.1. Issue Price Effect on GMP and LDG

Understanding the role of IPO price band and its relationship with IPO subscription decisions, particularly of Retail Individual Investors (RIIs) and Non-Institutional Investors (NIIs) is imperative.

Table 6. Issue size effect on Listing Day gain and grey market premium

Predictor	IP<250		IP>250,<500		IP>500	
	DV=LDG% N=900	DV=GMP% N=900	DV=LDG% N=135	DV=GMP% N=135	DV=LDG% N=120	DV=GMP% N=120
	β	β	β	β	β	β
Intercept	-0.209	0.034	-0.004	0.164	-0.015	0.208
TA	0.000	0.000***	-0.002	0.000***	-0.002	0.000***
VIX	0.124***	-0.038	0.016	-0.061	0.017	-0.057
NMR	0.196	-0.027	0.714	-0.363***	0.267	-0.219
IP	0.000	-0.003***	0.000	0.003***	-0.006	-0.001***
NII	0.000***	0.000***	0.000***	0.000***	0.001***	0.000***
RII	0.001***	0.001***	0.002	0.001***	0.002***	0.001***
Promopre	0.003	0.000	-0.016***	0.004***	-0.012***	0.002
Promopost	-0.001	0.006	0.018***	-0.006***	0.015***	-0.004
ROCE	0.004***	0.005***	0.005	-0.004***	0.004	-0.004***
DER	-0.097***	0.099***	-0.098	0.032	-0.075	0.004
PER	0.001***	0.003***	-0.002	0.000	-0.004	0.000
GMP%	0.711***	-	0.986***	-	0.826***	-
LDP	-	0.002***	-	0.000***	-	0.000***
R ²	0.534	0.683	0.644	0.796	0.675	0.804
AIC	383	-693	-53.8	-233	-68.4	-275
DW Stat	1.94	2.06	1.59	1.84	1.55	2.01
F	84.7	159	12.5	26.9	18.5	36.5

*, **, and *** represent the 10%, 5%, and 1% two-tailed significance level, respectively.

Retail investors often shy away from high price band IPOs as compared to institutional investors, resulting in their reduced participation in both formal and informal markets (Deng & Zhou, 2015). NIIs and Qualified Institutional Buyers (QIBs) possess greater bargaining power due to their larger investment volumes, allowing them to influence prices and participate in higher-priced IPOs. Despite low volumes, RIIs participate in the grey market seeking higher returns. Often, institutional investors stay away from grey markets due to regulations. This volume differentiation affects the GMP and LDGs. This study aims to examine how various factors affect the LDG% and GMP% within a specified price band. Based on the mean observations, it is noted that the categorical price band ranges are as follows: less than INR 250, between 250 and 500, and above 500.

It can be observed from the empirical results of the OLS-based regression models 9 and 10 that the predictive strength of the grey market is weaker for issue prices (IP) under 250 compared to higher price ranges. Notably, the grey market premium (GMP%) demonstrates a higher R-squared value of 80.4% when the issue price exceeds 500. In contrast, this value drops to 68.3% for issue prices below 250. However, the model fits better for issue prices between 250 and 500. This analysis confirms the impact of the issue price on the listing day gain (LDG) and grey market premium (GMP).

3.2. Impact of Digital Adoption and Foreign Investments

Emerging markets are experiencing a significant increase in digital adoption, as evidenced by the growth in digital payments (Digipay). This trend indicates that entering and exiting capital market transactions has become easier. Another strong indicator of capital market growth is the rise in new dematerialized (Newdemat) accounts being opened, which suggests a potential increase in trading volume and demand for initial public offerings (IPOs). The increase in digital adoption and the number of new accounts in the capital markets directly impact volumes from Retail Individual Investors (RII), Non-Institutional Investors (NII), and the total number of applications received for IPOs. From a macroeconomic perspective, factors such as Net Portfolio Investment (NPI) and Net Foreign Direct Investment (NFDI) have a direct influence on trading in both grey and formal market systems.

$$ldg\% = a + \beta_1 (npi) + \beta_2 (nfdi) + \beta_4 (digipay) + \beta_5 (newdemat) + \mu_i \quad (11)$$

$$gmp\% = a + \beta_1 (npi) + \beta_2 (nfdi) + \beta_3 (digipay) + \beta_4 (newdemat) + \mu_i \quad (12)$$

Table 7. Table showing the effect of digital adoption on listing day gain and grey market premium

Predictor	Digital Adoption & FI	
	DV=LDG% N=1155	DV=GMP% N=1155
	β	β
Intercept	0.968	0.848
Digipay	-0.013	-0.0089
Newdemat	-0.049**	-0.042***
NPI	-0.013	-0.008
NFDI	0.056*	0.048***
R ²	0.174	0.194
AIC	49.6	28.5
DW Stat	2.28	2.01
F	3.06	3.5

Note. H_a μ Measure 1 - Measure 2 $\neq$ 0

*, **, and *** represent the 10%, 5%, and 1% two-tailed significance level, respectively.

Table 7 presents regression results for the impact of digital adoption on LDG% and GMP% for a sample of 1155 observations. The R² values are relatively low (0.174 for LDG% and 0.194 for GMP%), indicating that the models explain a limited proportion of the variance in the dependent variables. We observe opening of new demat accounts is marginally significant for LDG% ($\beta = -0.049$, $p = 0.052$) and significant for GMP% ($\beta = -0.042$, $p = 0.047$). The negative coefficients suggest that an increase in new demat is associated with a decrease in both LDG% and GMP%. NFDI is marginally significant for LDG% ($\beta = 0.056$, $p = 0.097$) and significant for GMP% ($\beta = 0.048$, $p = 0.049$). The positive coefficients suggest that an increase in NFDI is associated with an increase in both LDG% and GMP%. Digipay and NPI are not significant for either LDG% or GMP%, signifying that there is no statistically significant relationship.

Table 8 exhibits the paired Samples t-test results, it can be observed that LDG vs. GMP% the p-value is insignificant, which suggests that the null hypothesis ($H_0: \mu \text{ LDG} - \mu \text{ GMP\%} = 0$) cannot be rejected. This

indicates no significant difference between the means of LDG and GMP%. As the means are equal, it confirms that LDG% and GMP% are highly correlated and GMP% can act as a strong predictor for LDG%.

Table 8. The paired samples t-test results of digital adoption on listing day gain and grey market premium with size effect

Pairs		Student's t	Wilcoxon W	Cohen's d	Rank biserial r
		Statistic		Effect Size	
LDG	GMP%	-0.408	272112***	-0.012	-0.185
Newdemat	NII	-5.576***	278***	-0.6617	-0.782
	RII	-5.817***	307***	-0.6904	-0.76
Digipay	NII	27.822***	2016***	3.5053	1.00
	RII	27.822***	2016***	3.5053	1.00

However, wilcoxon's median statistics are significant, and therefore null is rejected, confirming there is a significant difference. With regard to Newdemat vs. NII the p-value is less than 0.001, which suggests that the null hypothesis ($H_0: \mu \text{ Newdemat} - \mu \text{ NII} = 0$) can be rejected. This indicates a significant difference between the means of Newdemat and NII. The p-value for Newdemat vs. RII is less than 0.001, and thus the null hypothesis ($H_0: \mu \text{ Newdemat} - \mu \text{ RII} = 0$) is rejected, indicating a significant difference between their means. Similarly, the p-value for Digipay vs. NII is also less than 0.001, and thus the H_0 ($H_0: \mu \text{ Digipay} - \mu \text{ NII} = 0$) is rejected and showing a significant mean difference. Additionally, for Digipay vs. RII, the p-value is less than 0.001, confirming a significant difference between their means as well.

Conclusion

This study attempted to verify the factors influencing IPO grey market premium and listing day gains in India. Further, it examines the role of the issue price effect and digital adoption on the grey market premiums and listing day gains. Firstly, the relationship between IPO grey market and listing day performance is quite evident. Findings confirm that IPO grey market premium has an influence on listing day performance and thus validates the existence of price anomalies in the formal IPO market in India. The grey market premiums attract retail participation with speculative motives driving the sentiments based on anticipated demand and supply for trade. It is confirmed that the grey market sentiments significantly affect listing day performance and signals, in most cases, the under-pricing phenomenon. Though the debate over the necessity of shadow markets continues, as determining fair IPO prices remains challenging due to limited information for retail investors. Secondly, the grey market premiums are influenced by market volatility, return on capital employed, and price earnings ratio. It confirms that pre-issue financial performance indicators and institutional subscription rates are key determinants of grey market prices. Additionally, non-financial direct investment impacts IPO pricing, while new demat accounts, digital payments, and the New Payment Infrastructure (NPI) do not significantly affect GMP or listing day gains.

This study enhances our understanding of price discovery in the IPO market. Price discovery fundamentally depends on the demand and supply of shares, as well as company-specific information. A novel finding of this research is that, in addition to these factors, the grey market serves as a proxy for prices, influencing investor sentiment on the listing day gains. The findings of this study strongly validate expectancy theory and asset pricing principles. Furthermore, this study's findings establish a strong foundation for understanding the information asymmetry and price irregularities between formal and informal markets that investors should consider in the IPO market.

Policy Implications and Further Research

This study provides compelling evidence of how the grey market impacts IPO listing day prices and urges the attention of policymakers to formulate strategies to eliminate grey market influence and price discrepancies. Attempts are needed to avoid short-selling and limit speculative activities that can destabilize the IPO market. Listing day or week early gains are often not sustainable. Due to greed or anxiety of a price fall, investors engage in profit-bookings. The prices tend to fall sharply in the days that follow. Efforts are needed to curb the grey

market, which is largely intended for speculative activities. IPO markets should reflect a fair price for stocks and encourage long-term investments.

Scope for Further Research

This study does not provide liquidity and volatility-related aspects of the IPO market. This provides avenues for future research focused on understanding the intricacies of liquidity and volatility that occur on listing days. Beyond the influence of market dynamics and firm-specific characteristics, it would be beneficial to explore various macroeconomic factors that may also play a significant role in these phenomena. Such investigations could provide a more comprehensive understanding of the market environment during these critical periods.

Credit Authorship Contribution Statement

Suresha B: Conceptualization, Investigation, Methodology, Project administration, Software, Formal analysis.

Krishna T. A: Methodology, Software, Formal analysis, Writing – original draft, Data curation, Validation.

Elizabeth Renju Koshy: Writing – review and editing, Methodology, Supervision, Visualization.

Rejoice Thomas: Supervision, Data curation, Validation, Writing – review and editing, Visualization.

Karthick C: Supervision, Data curation, Validation, Writing – review and editing, Visualization.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Declaration of Use of Generative AI and AI-assisted Technologies

The authors declare that they have not used generative AI and AI-assisted technologies during the preparation of this work.

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Democratic Transition and Independence of the Central Bank: The Case of Tunisia

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Abstract: After the revolution, the demands of the Tunisian people in terms of democracy, transparency, and independence of institutions have not stopped. It is in this context that the pressure exerted by the Tunisian parliament to revise the statute of the Central Bank of Tunisia (CBT) to demand more independence. This study aims to assess the degree of independence of the CBT before and after the democratic transition that characterizes the political life of the country. The degree of independence has been assessed according to the calculation of the legal index based on the evolution of the statutes governing the organization and missions of the CBT since its creation. The calculations carried out on the basis of the various statutes made it possible to notice a significant improvement in the degree of independence, and this, in accordance with the theoretical predictions, the more the country tends towards democracy, the more the independence of the Central Bank is required. Overall, the democratic transition has had a favorable effect on the evolution of the degree of independence of the CBT, as evidenced by the improvement recorded in the score in 2016.

Keywords: tunisian revolution; democratic transition; the legal index; different statuses of CBT.

JEL Classification: E58; E50.

Introduction

The Central Bank is a monetary policy body, and nowadays it plays an important role in price and financial stability. The nature of its tasks, the responsibilities entrusted to it, its various other functions and its operation vary from one country to another and more precisely from one degree of democracy to another (Jézabel, 2012).

The inflation crises in developed countries in the 1970s, the transformations of the international financial system and the advent of globalized capital markets in the 1980s have changed the conditions under which monetary policy is exercised and the expectations of the general public (Jézabel, 2012).

Initially seen as instruments of government economic and financial policy, central banks in countries with developed financial markets have become independent authorities dedicated primarily to the maintenance of a fundamental public good: price stability. In other countries, central banks have remained an instrument aimed more directly at supporting economic activity (Duchaussoy, 2016).

Several arguments have been put forward in the economic literature in favor of Central Bank independence as an essential factor justifying price and monetary stability and making it possible to achieve real economic growth in the medium and long term (Vignolles, 2012).

The experience of certain countries, particularly the most developed, shows that their mode of political organization largely determines the status attributed to the Central Bank. Indeed, the more a country's regime tends towards the separation and balance of powers, and therefore towards democracy, enshrined in the rules of good governance, the more independent the Central Bank is (Duchaussoy, 2016).

This question of Central Bank independence is, however, complex for developing countries, particularly because of the divergence of the objectives of the Central Bank from those of pressure groups and even of society as a whole. It would therefore be interesting to dig deeper into the issue of the independence of a Central Bank, especially in the context of the political and economic transition currently characterizing Tunisia, in order to decide on the effectiveness of this independence.

This paper is organized as follows. Section 2 provides a historical overview of the Central Bank's independence. Section 3 presents previous literature reviews. Section 4 describes the evolution of the CBT's regulatory framework and statutes before and after the transition. Section 5 presents the basic methodology used in this paper. Section 6 discusses the analyses and results. Section 7 draws conclusions.

1. Historical Overview of Central Bank Independence

The 1990s were marked by a relatively generalized move towards the adoption of an independent Central Bank. The particularity of this evolution is not in independence itself but in the extent of its diffusion.

Indeed, independent central banks have existed for several decades, such as the Bundesbank (1957) or the Swiss bank (Cukierman, 1994).

Thus, Central Bank independence became the most frequent option in several countries: New Zealand (1990), Italy (1993), and France (1994).

With the creation of the European Central Bank (ECB) (1999), the countries participating in the euro had to adapt the statutes of the central banks to the independence of the ECB. The same evolution is also observed in the Eastern countries: Hungary (1991) and Russia (1993).

Finally, emerging and developing countries have followed the same trend, at least at the legal level, sometimes on the advice of the International Monetary Fund (IMF).

This evolution can be explained by different elements:

- The international monetary context (the end of the Bretton Woods system and the difficulties of the European Monetary System) as well as the shortcomings of the monetary rules having pushed economists to identify new solutions to ensure monetary stability.
- The success of the Bundesbank and the Swiss National Bank in the fight against inflation was an interesting precedent that needed to be explored further. Indeed, when drafting the ECB's statutes, legislators were inspired by the texts and laws governing the German bank (Aguir, 2013).

2. Literature Review

Since 1980, several economists have tried to develop some indices to measure the degree of independence of the Central Bank. Bade and Parkin (1982) base their index on political independence, which is defined as the ability of the Central Bank to choose its policies without the influence of the government. Alesina (1988) analyzes the independence of the Central Bank from the point of view of the intervention of the Central Bank in financing the budget deficit. Grilli et al (1991) used 15 variables reflecting political and economic independence. They introduced more comprehensive indices for Central Bank independence. They applied this index to a sample of 18 developed countries over the period 1950-1989. Cukierman *et al.* (1992) developed a legal index of Central Bank independence, which reflects the degree of independence that the legislator confers on the central bank. This investigation was based essentially on the legal texts concerning the organization of the activities of the central bank. In this context, several studies have been conducted on the evolution of the degree of independence of the Central Bank in several countries. Crowe and Meade (2007) show that the degree of Central Bank independence increased sharply between the period 1980-1989 and 2003. Dincer and Eichengreen (2014) using *de jure* indicators of Cukierman *et al.* (1992), show that central banks are overall more independent in 2010 than they were in 1998. Masciandaro and Romelli (2015) show a decline in the degree of economic independence of central banks after the global financial crisis in connection with the stronger involvement of central banks in financial stability issues. Haan and Eijffinger (2017) confirm recent assessments of the degree of independence after the crisis using *de jure* and *de facto* indicators (based on central bankers' turnover).

3. The Evolution of the CBT 's Regulatory Framework and Statutes before and after the Transition

3.1. Before the Transition

September 19, 1958: Promulgation of the law number 58-90 on the creation and organization of the Central Bank of Tunisia.

November 3, 1988: Global reform of the organic texts of the CBT, law number 1988-119 of November 3, 1988, having allowed:

- Replacing the functions of the two deputy governors and the secretary general by that of a vice-governor in charge of assisting the governor;
- To further clarify the role of the CBT in order to defend the value of the national currency and to ensure its stability;

- Prohibit the CBT from participating in the capital of resident companies and transfer to the State all its holdings in these companies.

April 2000 (Law number 2000-37 of April 4, 2000):

- Extension of the scope of intervention of the Central Bank of Tunisia by allowing it to take in pension to banks of negotiable public bills as well as any claim or value on companies and individuals on a list determined by its board of directors;

- Authorization for the CBT to participate in the share capital of companies whose purpose is the management of common banking services.

May 2006: Amendment of the organic law creating the CBT, law number 2006-26 of May 15, 2006.

The main contributions concern:

- The redefinition of the attributions of the Central Bank of Tunisia whose main mission is, henceforth, to ensure price stability.
- Strengthening of the transparency policy.
- Strengthening of the independence of the CBT.
- Strengthening of control and audit operations.

3.2. After the Transition

After the January 14 revolution, and in the perspective of a democratic transition approach based on the separation of powers, the functional independence of the Central Bank has been, in a practical way, strengthened, and this, in accordance with a consensus between the stakeholders, namely the Presidency of the Republic and the Government.

- The constituent law number 2011-6 of December 16, 2011, relating to the provisional organization of public powers, by its article 26, has improved the degree of organic independence of the Central Bank of Tunisia.

- Changing the method of appointment and dismissal of the Governor, who is appointed by a republican decree after consultation between the President of the Republic and the Head of Government. This appointment becomes effective only after its approval by the majority of the members present at the National Constituent Assembly during the 15 days following the presentation of the proposal to the assembly.

- The National Constituent Assembly shall have the power to remove the Governor from office at the request of at least one-third of its members.

- The members of the Board of Directors of the Central Bank of Tunisia are appointed by a republican decree after consultation between the President of the Republic, the Head of Government and the President of the National Constituent Assembly. This same procedure must be followed in the event of dismissal.

- Law number 2016-35 of 25-04-2016, on the statutes of the Central Bank of Tunisia (published only in Arabic in the Jort number 35 of 29-04-2016) - Repeals and replaces the law number 58-90 of 19-09-1958).

4. Method

4.1. Objective: To prove that Tunisia's democratic transition has allowed the Central Bank to achieve greater independence.

4.2. Measure of independence: According to the legal index of Cukierman (1992), known as CWN and from the main regulations of the Central Bank of Tunisia from the 1958 law until the law of 2016.

4.3. Presentation of the model: This index is made up of four characteristics and each characteristic is made up of a set of sub-indexes. Each sub-index is assigned a score and specified by a weight.

4.4. Methodology: based on an examination of the various Central Bank statutes from 1958, 1988, 2006 and 2016, a score was assigned to each sub-index corresponding to each year.

4.5. Function: an overall function was constructed in accordance with the legal index to measure the degree of independence of the Central Bank of Tunisia.

Global function : $G_{xt} = I_{xt} + F_{xt} + O_{xt} + L_{xt}$

G_{xt} : global function to calculate the degree of independence for each year.

I_{xt} : function of calculation of the degree of independence of the first characteristic (the independence of the managers).

F_{xt} : function to compute the degree of independence of the second characteristic (monetary policy formulation).

Oxt: function for calculating the degree of independence of the third characteristic (objectives assigned to the Central Bank).

Lxt: function for calculating the degree of independence of the fourth characteristic (limitation of credits to the government), x denotes the weight corresponding to each characteristic; t represents the time horizon (1958, 1988, 2006, 2016).

Feature-specific function:

$FS = \sum St*P$ where FS: represents the specific function of lxt, Fxt, Oxt, and Lxt.

S: score assigned to each sub-index of each feature.

P: weight assigned to each sub-index of each characteristic.

5. Results and Analysis

5.1. Management Independence

Independence was assessed through the following sub-indexes :

- Term of office.
- Procedure for appointing the governor.
- Conditions for removal of the governor or board members.

Table 1. Independence of Officers

Year	Weight		1958		1988		2006	2016
			Organic number 58-90	law	Amendment law number 1988-119		Amendment law 2006-26	Law number 35-2016
Independence of Management	0,20	Score FS	0,088		0,088		0,088	0,142
a) Term of office	0,05	Answer	6 years		6 years		6 years	6 years
		Regulatory reference	art 9		art 9		art 9	art 46
		Score	0,75		0,75		0,75	0,75
b) Procedure for Appointing the Governor	0,05	Answer	Executive (decree)	power	Executive (decree)	power	Executive power (decree)	Collective decision (executive and legislative)
		Regulatory reference	art 8		art 8		art 8	art 46
		Score	0		0		0	0,75
c) Conditions for removal of the governor or board members	0,05	Answer	Executive power without condition of reason					Legislative power without condition of motive +Proposal of the head of government
		Regulatory reference	art 9		art 9		art 9	art 46
		Score	0		0		0	0,33
d) Are there any other duties that the governor or board members may perform?	0,05	Answer	No		No		No	No
		Regulatory reference	art 20		art 20		art 20	art 54
		Score	1		1		1	1

5.1.1 Justification of the Scores Attributed

▪ According to article 9 of the 1958, 1988 and 2006 statutes and article 46 of the 2016 statutes, the governor is appointed for a term of six years, which justifies the assignment of a score of 0.75.

▪ According to article 8 of the Statutes of 1958, 1988 and 2006, the governor is appointed by the executive branch, which justifies the allocation of a score of 0. In addition, according to article 46 of the Statute 2016, the governor is appointed under the terms of article 78 of the Constitution, which provides that this appointment is made on the proposal of the head of government and after approval of the absolute majority of the majority of members of the Assembly of People's Representatives. The corresponding index score is 0.75.

▪ According to article 9 of the 1958, 1988 and 2006 statutes, the governor can only be relieved of his duties by decree of the executive branch without any reason, which justifies the attribution of the mark 0. But according to article 46 of the 2016 statutes, the governor can only be relieved of his duties by the legislative branch without any reason, which justifies the attribution of the mark 0.33 provided by the index.

▪ Regarding the answer to the question about the possibility for the Governor and the members of the Council to exercise other functions, the different laws of 1958, 1988 and 2006 did not mention it in an explicit way. However, article 20 of the above-mentioned statutes provides that in the exercise of their functions, the councilors are independent of the services, associations, unions or organizations to which they may belong.

Despite the absence of an explicit prohibition and referring to article 20, note 1 was retained.

With respect to the 2016 statute and according to its article 54, there is an explicit prohibition for the governor and council members to exercise other functions, which justifies the attribution of the note 1.

5.1.2 Interpretation

The leadership independence score increased from 0.088 to 0.142. This shows that the democratic transition in Tunisia, which resulted in a new regulation of the CB, has given managers more independence.

The increase in the score is explained by the change in the procedure for appointing and terminating the governor, which was through the various previous regulations (1958, 1988, 2006) at the discretion of the executive branch (President of the Republic) and has just been modified in 2016 by a consent of the executive branch after approval of the legislative branch.

5.2. Monetary Policy Formulation

It was assessed through the following sub-indexes:

- Who formulates monetary policy?
- The weight of the CB in the resolution of conflicts with the government.
- The involvement of the CB in the budget process.

Table 2: Monetary Policy Formulation

Year	Weight		1958	1988	2006	2016
			Organic law number 58-90	Amendment law number 1988-119	Amendment law 2006-26	Law n° 35-2016
Monetary policy formulation	0,15	Score FS	0,017	0,017	0,034	0,100
a) Who sets monetary policy?	0,05	Answer	Government Advisor art 34	Government Advisor art 34	Little power art 33	Alone art 8
		Regulatory reference Score	0,33	0,33	0,67	1
b) Weight of the Central Bank in the resolution of conflicts with the government	0,05	Answer	Executive power decides unconditionally (CB informs the President of the Republic)			The bank has the last word art 2
		Regulatory reference Score	art 34	art 34	art 34	
		Score	0	0	0	1
c) Participation of the CB in the budget process	0,05	Answer	Doesn't intervene	Doesn't intervene	Doesn't intervene	Doesn't intervene
		Regulatory reference	No text could justify the intervention of the CB in the budgetary process, however, article 33 speaks of the possibility for the CB to propose to the government any measure likely to exert a favorable action on the public finances.			
		Score	0	0	0	0

5.2.1 Justification for the Scores Assigned

▪ According to article 34 of the 1958 and 1988 statutes, the Central Bank is the government's advisor in the formulation of monetary policy, which justifies the assignment of a score of 0.33. With the law of 2006 and according to its article 33, the Central Bank was assigned the general mission of preserving price stability and to achieve this mission it is required to "ensure monetary policy" thus giving it some power in the formulation of monetary policy. This justifies the attribution of a score of 0.67.

▪ With regard to the 2016 statute, it was mentioned in article 8 that the Central Bank alone formulates monetary policy, which justifies the attribution of a grade of 1.

▪ According to article 34 of the 1958, 1988 and 2006 statutes, the executive branch decides unconditionally in the case of a conflict between the Central Bank and the government, which justifies the awarding of the grade 0. Whereas according to the 2016 statute and according to article 2, the Central Bank has the final say in conflicts between the Central Bank and the government. It is independent in the achievement of its objectives and the performance of its functions justifying the assignment of the grade 1.

▪ Concerning the participation of the Central Bank in the budgetary process, there is no text that could justify the intervention of the CB in the budgetary process. However, article 33 speaks of the possibility for the CB to propose to the government any measure that could have a favorable effect on public finances. This lack of justification for their intervention in the process justifies the assignment of a score of 0.

5.2.2 Interpretation

The score obtained for the degree of independence of the Central Bank in the formulation of monetary policy increased from 0.017 in 1958 to 0.1 in 2016. This improvement reflects the gradual evolution at the legal level towards a greater involvement of the CB in the formulation of monetary policy.

5.3. Objectives assigned to the Central Bank

Table 3. Objectives assigned to the Central Bank

Year	Weight		1958	1988	2006	2016
			Organic law number 58-90	Amendment law number 1988-119	Amendment law 2006-26	Law number 35-2016
Objectives assigned to the Central Bank	0,15	Score FS	0,000	0,090	0,120	0,150
		Answer	Objectives other than price stability (control of money circulation and credit distribution)	The stability of the value of money	Price stability	Price stability and having the last word in case of a conflict of objectives
	0,15	Regulatory reference Score	art 33 0	art 33 0,6	art 33 0,8	art 7 1

5.3.1 Justification of the score assigned

According to article 33 of the Statute of 1958, the Central Bank has an objective other than price stability (control of money circulation and credit distribution), which justifies the assignment of the score of 0.

On the basis of the law of 1988 and according to the same article, the Central Bank has as an objective the stability of the value of money, which justifies the attribution of the score of 0,6. Since 2006, the Central Bank's objective has been price stability, which justifies the awarding of a score of 0.8.

With regard to the 2016 law, according to article 7, the Central Bank's priority or essential objective is price stability. At the same time, it participates in the preservation of financial stability allowing the achievement of the objectives of the economic policy of the State, particularly in terms of growth and employment. Referring to the scores attributed by the index to the different proposals, the score of 1 has been retained.

5.3.2 Interpretation

The score for the objectives assigned to the Central Bank rose from 0 in 1958 to 0.090 in 1988, to 0.120 in 2006 and to 0.150 in 2016, reflecting a gradual improvement in the Central Bank's independence in setting its objective of price stability.

5.4. Limits on Government appropriations

They were assessed through the following sub-indexes:

- Monetary advances to the government.
- Advances against securities.
- Borrowing conditions (maturity, interest, amount).
- Potential borrowers from the Central Bank.
- Limits of Central Bank loans to the government.
- Maturity of loans.
- Interest rates on advances.
- Is the Central Bank allowed to buy or sell government securities on the primary market?

Table 4. Credit or Government Limits

Year	Weight		1958 Organic law number 58-90	1988 Amendment law number 1988-119	2006 Amendment law 2006-26	2016 Law number 35- 2016
Limitation of government appropriations	0,50		0,132	0,199	0,475	0,475
a) Cash advances to the government	0,15	Answer Regulatory reference Score	Strict limits art 50 0,67	Strict limits art 50 0,67	No advance art 47 bis 1	No advance art 10 1
b) Advances against securities	0,10	Answer Regulatory reference Score	No limits art 49 0	Strict limits New art 48 0,67	Not allowed art 47 bis 1	Not allowed art 10 1
c) Borrowing conditions (maturity, interest, amount)	0,10	Answer Regulatory reference Score	The government art 49 0	The government New art 48 0	Not allowed art 47 bis 1	Not allowed art 10 1
d) Potential borrowers from the CB	0,05	Answer Regulatory reference Score	The public sector art 43 0	The public sector New art 41 0	Not allowed New art 41 1	Not allowed art 26 1
e) The limits on CB's contribution to the government are defined as	0,025	Answer Regulatory reference Score	Government Revenue art 50 0,33	Government Revenue art 50 0,33	Not allowed art 47 bis 1	Not allowed art 10 1
f) Loan maturity	0,025	Answer Regulatory reference Score	< 1 year art 50 0,67	< 1 year art 50 0,67	Not allowed art 47 bis 1	Not allowed art 10 1
g) Interest rates on advances should be	0,025	Answer Regulatory reference Score	No mention 0,25	No mention 0,25	Not allowed Not defined 1	Not allowed 1
h) Is the CB allowed to buy or sell government securities on the primary market?	0,025	Answer Regulatory reference Score	No Not defined (only the rediscount) 0	No art 47 bis 0	No art 47 bis 0	No art 10 0

Interpretation

The score rose from 0.0132 in 1958 to 0.199 in 1988 and stabilized at 0.475 from 2006 onwards, as a result of the Central Bank's prohibition on granting credit to the government.

5.5. Discussions

The results obtained call for the following observations on our part:

- The degree of independence of the Central Bank recorded a progressive evolution during the study period from 0.236 in 1958 to 0.393 in 1988 and to 0.716 in 2006 to rise to (0.867) in 2016.

Table 5. Evolution of the degree of independence of the Central Bank of Tunisia

Year	Weight	1958	1988	2006	2016
		Organic law number 58-90	Amendment law number 1988-119	Amendment law 2006-26	Law number 35-2016
Independence of Management	0,20	0,088	0,088	0,088	0,142
Monetary policy formulation	0,15	0,017	0,017	0,034	0,100
Objectives assigned to the Central Bank	0,15	0,000	0,090	0,120	0,150
Limitation of government appropriations	0,50	0,132	0,199	0,475	0,475
Overall Score (Degree of independence)	1,00	0,236	0,393	0,716	0,867

▪ The Central Bank of Tunisia has been endowed, since its creation, with a certain margin of independence from the government. This has continued for a long period of time and has even been reinforced by setting, by law, the term of office of the governor at six years.

However, the problem of accountability of the Central Bank has persisted, particularly because the Governor has remained subject to the authority of the President of the Republic, which has made his independence relative, even ambiguous.

▪ This clearly shows that the independence of the Central Bank of Tunisia has not been acquired at any time (score below 1), including after 2011, that is to say, during the period of democratic transition that Tunisia is experiencing.

▪ Indeed, the possibility of making advances to the treasury, the conduct of a discretionary monetary policy, the appointment of all members of the board of directors by decree as well as the appointment and dismissal of the governor of the Central Bank by the president of the republic (especially before 2016) without any logical basis, etc., are only tangible evidence that the autonomy of the monetary authority is absent, or at least very limited.

▪ Since the Revolution (provisional constitution 2011), the Governor of the Central Bank has been regularly invited by the Finance Committee of the Assembly of People's Representatives and sometimes in plenary session to give his point of view on the laws that his institution or the government has filed with the legislator. This has been confirmed by the new statute of the Central Bank in its article 30, reflecting an improvement in the democratic aspect of the independence of the Central Bank of Tunisia.

▪ In addition, the governor of the Central Bank has also been invited to speak before the elected officials on important issues affecting the economic activity since 2011, a procedure affirmed by article 29 of the new law 2016 to justify that a certain level of independence of this institution does not mean the absence of any democratic control.

▪ Overall, the democratic transition has had a favorable effect on the evolution of the degree of independence of the Central Bank, as evidenced by the improvement in the score from (0.716) in 2006 to (0.867) in 2016.

▪ It should also be noted that in the context of the transition since 2011, which has been marked by institutional instability and recurrent changes in leadership, the independence of the Central Bank as displayed by its new statutes and the neutrality of its leaders, could protect this institution from frequent changes in political life and therefore ensure the stability of monetary policy.

▪ However, the attribution to the Central Bank of the objective of financial stability alongside the fundamental objective of price stability, risks obliging the Central Bank to practice non-conventional policies of massive money creation, which generate inflation.

Conclusions and Further Research

The idea of this article is to evaluate the degree of independence of the Central Bank of Tunisia before and after the democratic transition that characterizes the political life of the country.

The degree of independence has been assessed according to the calculation of the legal index based on the evolution of the statutes governing the organization and missions of the Central Bank since its inception.

The calculations made on the basis of the different statutes of the Central Bank have shown a significant improvement in the degree of independence, in accordance with theoretical predictions: the more the country tends towards democracy, the more the independence of the Central Bank is required.

The Central Bank of Tunisia has ensured, with reference to its new status (2016), price stability as a primary objective with a contribution to the achievement of financial stability, transparency and accountability, and a confirmation of its mission in financing the government.

Indeed, the establishment of mechanisms of good governance and transparency within the Central Bank, considered the main factors of economic success, especially in the context of democratic transition, allows to reassure both the general public and investors. The main objective is to achieve real economic growth in the medium and long term, which will preserve the interests of all stakeholders and improve social welfare.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Declaration of Use of Generative AI and AI-Assisted Technologies

The authors declare that they have not used generative AI and AI-assisted technologies during the preparation of this work.

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Annex

Table. Construction of the legal index

Characteristics	Weight	Score
1/ Independence of management	0,20	
a) term of office	0.05	
≥ 8 years		1,00
6 to 8 years		0,75
5 years		0,5
4 years		0,25
< 4 years or at the discretion of the appointing official		0,00
b) procedure for appointing the governor	0.05	
-CB Board of Directors		1,00
-collective decision of the CB, executive and legislative branches		0,75
-legislative power		0,5
-Executive power collectively (e.g. Council of Ministers)		0,25
-one or two representatives of the executive		0,00
c) conditions for removal of the governor or members of the board	0.05	
-not provided for by law		1,00
-for reasons unrelated to monetary policy		0,83
-at the discretion of the Board of Directors of the CB		0,67
-at the discretion of the legislature for reasons related to monetary policy		0,5
-at the discretion of the legislature without a requirement for cause		0,33
-at the discretion of the executive branch for reasons related to monetary policy		0,17
-at the discretion of the executive branch without a requirement for cause		0,00
d) may the governor or members of the board perform any other duties?	0.05	
-no		1,00
-Only with prior authorization of the executive power		0,5
-no regulations in this area		0,00
2/ Monetary policy formulation	0,15	
a) who formulates monetary policy?	0,05	
- the bank on its own		1,00
- the bank participates but has little power		0,67
- the bank is an advisor to the government		0,33
- the bank has no power		0,00
b) weight of the Central Bank in the resolution of conflicts with the government	0,05	
-the bank has the final say on its objectives as defined by law		1,00
- the government decides on matters that do not affect the statutory objectives of the CB or in the event of internal conflict within the CB		0,80
- a tripartite council (CB, executive and legislative branches) resolves disputes		0,60
- the legislature has the final say in monetary policy disputes		0,40
- the executive branch has the final say in monetary policy disputes, but according to a planned process and with possible protest from the CB		0,20
- the executive power decides unconditionally		0,00
c) participation of the CB in the budget process	0,05	
- CB plays an active role		1,00
-the CB does not intervene		0,00
3/ Objectives assigned to the Central Bank	0,15	
- price stability mentioned as the sole or priority objective, with the CB having the		1,00

Characteristics	Weight	Score
last word in case of conflicting objectives (other objectives: full employment, etc.)		
- price stability is the only objective		0,80
- the stability of the value of money is mentioned among other objectives such as the soundness of the banking system		0,60
- the stability of the value of money is associated with other objectives that are incompatible with it		0,40
- no objective specified		0,20
- objectives other than price stability		0,00
4/ Limitations on government appropriations	0,5	
a) monetary advances to the government	0,15	
- no advances are allowed		1,00
- advances allowed but within strict limits (e.g. maximum advances 15% of government revenues)		0,67
- advances allowed with rather loose limits (e.g. maximum advances beyond 15% of government revenues)		0,33
- no legal limits		0,00
b) advances against securities	0,10	
- not allowed		1,00
- allowed but within strict limits (e.g. maximum advances 15% of government revenues)		0,67
- permits with rather loose limits (e.g. maximum advances over 15% of government revenues)		0,33
- no legal limits		0,00
c) loan conditions (maturity, interest, amount)	0,10	
- set unilaterally by the CB		1,00
- specified by the CB's bylaws		0,67
- negotiated by the government with the CB		0,33
- imposed by the government		0,00
d) potential borrowers from the CB	0,05	
- all levels of government		1,00
- the public sector (all levels of government plus public enterprises)		0,67
- both the public and private sectors		0,33
- central government only		0,00
e) the limits on CB's contribution to government defined as	0,025	
- amounts of money		1,00
- portions of the capital or liabilities of the CB		0,67
- government revenue fractions		0,33
- fractions of government expenditures		0,00
f) maturity of loans	0,025	
- < 6 months		1,00
- < 1 year		0,67
- > 1 year		0,33
- not defined in the law		0,00
g) interest rates on advances should be	0,025	
- > to the minimum rates		1,00
- = market rate		0,75
- < maximum rates		0,50
- no mention of interest rates		0,25
- no interest charged on advances to the government		0,00

Characteristics	Weight	Scoe
h) is the CB allowed to buy or sell government securities in the primary market?	0,0025	
- yes		1,00
- no		0,00



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Assessing the Evolving Landscape of Anti-Money Laundering Laws in China and Their Impact on Banking Institutions

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Abstract: This study explores the evolution of China's anti-money laundering (AML) framework and evaluates its implications for banking institutions. It critically examines how Chinese banks navigate the complex web of compliance obligations in the face of evolving financial crime techniques. The paper draws on statutory developments, policy reports, high-profile enforcement cases, and scholarly literature. It specifically investigates key components of AML implementation including customer due diligence (CDD), suspicious transaction reporting (STR), and record-keeping obligations, with a focus on technological integration and enforcement gaps. China's AML framework has significantly expanded in both scope and institutional reach. However, challenges persist in enforcement consistency, technological adoption, and handling of cross-border transactions. The operational burden and compliance costs for banking institutions remain high, particularly for smaller banks with limited resources. Technological tools like AI and big data analytics offer promising solutions but require stronger integration and policy support. This study provides a comprehensive assessment of AML compliance challenges within China's banking sector and identifies practical recommendations to enhance regulatory enforcement, support innovation adoption, and promote international collaboration. It offers valuable insights for policymakers, financial institutions, and academics focused on financial crime prevention.

Keywords: anti-money laundering; banking compliance; financial regulations; suspicious transaction reporting; regulatory enforcement.

JEL Classification: K42; G28; G21; F38, O53.

Introduction

Money laundering is a cross-border problem which erodes financial stability, facilitates crime, and erodes economic integrity. As one of the world's most powerful economies, China has long grappled with the challenge of curbing illegal financial outflows while maintaining the stability of its financial system. China's rapidly developing economy, expanding market of digital finance, and big-sum cross-border transactions have created opportunities for money launderers to take advantage of loopholes in regulations (Ahuja *et al.* 2023). China has progressively tightened its Anti-Money Laundering (AML) law to enhance financial regulation and enhance

banking compliance accordingly. This research examines the evolution of AML law in China, the ensuing legal requirements of banks, and the impact of the regulations on banking operations and compliance.

Money laundering is the concealment of illegally acquired money as clean money, occasionally through sophisticated transactions to obscure the money's origin. It is done in three general phases: placement (injection of illegal money into the financial system), layering (creation of a chain of transactions to obscure the origin), and integration (cycling the money into the clean economy). Different methods of concealment involving underground banking, internet-based money transactions, and trade-based laundering are employed by criminals. Its massive financial infrastructure has made China an ideal target for such undertakings with filthy money usually attributed to corruption, tax avoidance, drug trades, and flight capital (He, 2024).

In efforts to regulate money laundering, China has implemented a three-tier supervisory framework, which covers the regulatory authorities, law enforcement authorities, and financial institutions. The People's Bank of China (PBOC) supervises Anti-Money Laundering, albeit in conjunction with the China Banking and Insurance Regulatory Commission (CBIRC) and China Securities Regulatory Commission (CSRC), with the objective of creating banking and finance compliance. China Anti-Money Laundering Monitoring and Analysis Centre (CAMLMAC) gather and verifies financial data to detect suspicious transactions. Customer due diligence (CDD), transaction monitoring, and reporting suspicious transactions have to be carried out by Chinese banks. Artificial intelligence (AI) and big data analysis have been utilised by the government since recent years as an effort to strengthen AML (Saxena & Kumar, 2023).

Despite ongoing attempts at regulation, several obstacles deter China from combating money laundering effectively. The most important of these is perhaps the complexity of underground banking systems, which conduct illegal transfers of funds outside the formal financial system. According to the PBOC, the size of these networks' illicit business stands at over ¥800 billion (\$110 billion) annually. The rapid growth of digital financial services, including mobile payments and cryptocurrency transactions, poses new risks that are difficult to manage. Although China has banned the trading of cryptocurrencies across the country, criminals continue to exploit decentralised finance (DeFi) platforms for illegal transactions. There is also limited cross-border cooperation, as money laundering across borders requires collaboration with overseas regulators. While China has enhanced coordination with the FATF and Interpol, it is still difficult to extradite financial offenders and freeze illicit overseas assets. Further, data protection and technical challenges thwart the release of transactional details by financial institutions to supervisory bodies, and this makes implementation of AML even more difficult (Zhou & Tang, 2023).

The overall aim of this study is to analyse the emerging AML regulatory landscape in China and the implications for banking institutions. In general, it tries to map the evolution of AML law, review legal requirements imposed on banks, and investigate the effect of such legislation on bank operations and compliance systems. By a review of some of the major legislative changes, such as the China Anti-Money Laundering Law and financial law amendments, the research tries to shed light on the effectiveness of China's AML system. It also discusses how banks perform customer due diligence (CDD), suspicious transaction reporting (STR), and compliance monitoring to ensure adherence to laws. Lastly, the research also hopes to examine the impact of AML legislation on banking efficiency, operational cost, and technology adoption in risk management. In analysing, the study will try to ascertain the success and failure of China's war against money laundering and provide suggestions for improvement in prevention of financial crime and regulation by regulators.

1. Evolution and Current Structure of AML Law in China

1.1 Legal History and Institutional Framework

China's anti-money laundering (AML) processes have evolved extensively in the last decades, driven both by domestic financial offenses and international pressure to harmonise AML processes to international standards (Ahuja *et al.* 2023). China's struggle against money laundering was in disarray before 2006, with no rational legal framework. Early AML processes were aimed at financial offenses related to corruption, fraud, and black-market foreign exchange dealings. The People's Bank of China (PBOC) spearheaded the initial control but published only guidance that required banks to conduct limited customer identity checks and report large cash transactions. However, the enforcement was weak, and banks lacked wide legal powers to adopt effective AML controls (Yu *et al.* 2024).

Upon recognising the necessity for a systematised system of law, China enacted the Anti-Money Laundering Law of 2006, a milestone in the fight against illegal financial activity within the nation. This law requires financial institutions to implement obligatory compliance procedures that involve customer due diligence (CDD), suspicious transaction reporting (STR), and record-keeping procedures. It also broadened the AML

regulations scope beyond banks to include insurance entities, security businesses, and even non-banking institutions involved in gargantuan transactions (He, 2024). The law also stepped up the oversight role of supervisory agencies, specifically the PBOC itself in monitoring compliance and also sanctioning institutions that failed to comply with AML regulations. China has tried to keep international standards in order as well.

The nation joined the Financial Action Task Force (FATF) in 2007 and has since then been implementing FATF standards for money laundering and terrorist financing. FATF compliance has seen China's Anti-Money Laundering legislation being amended again and again, with emphasis on issues such as cross-border money laundering, disclosure of beneficial ownership, and risk-based supervision (Saxena & Kumar, 2023). China also put in place the Basel Committee on Banking Supervision recommendations, particularly risk management by banks and cross-border cooperation. While there has been such development, China has been criticised in the area of poor usage of AML, particularly in the case of trade-based money laundering and underground banking systems. However, more recently, the country has taken steps to increase regulatory supervision and enhance the effectiveness of AML laws (Dhali *et al.* 2023).

1.2 Contemporary Regulatory Developments

China's existing AML regime is regulated by various regulatory bodies and a rigorous legal framework designed to bar money laundering. The People's Bank of China (PBOC) continues to be the focal point of AML, issuing guidelines, regulating financial transactions, and liaising with foreign agencies (Xin, 2024). The China Banking and Insurance Regulatory Commission (CBIRC) oversees that insurance companies and banks are AML compliant, whereas the China Anti-Money Laundering Monitoring and Analysis Centre (CAMLMAC) are a national financial intelligence unit, which analyses transactions and identifies suspicious transactions. These two institutions collaborate to strengthen AML supervisions, enhance financial transparency, and stifle illegal financial activities.

According to the AML law prevailing in China, banks are required to adopt a risk-based system so that they can be certain that they will combat money laundering. Banks and financial institutions are obligated to undertake customer due diligence (CDD) in identification of customers, carry out risk assessments on probable risks, and keep transactions for at least five years (Yang *et al.* 2023). High-risk customers, such as politically exposed persons (PEPs) and foreign financial institutions, must be subjected to intensified due diligence (EDD) procedures. Financial institutions must also conduct real-time monitoring of transactions and report suspicious transactions to CAMLMAC. Failure to comply with AML requirements can lead to severe penalties like fines, suspension of business, and revocation of business licenses.

The last few years have witnessed a series of amendments and increased enforcement actions for plugging loopholes in the law and increasing compliance (Cheng *et al.* 2024). In 2021, China has enacted new beneficial ownership transparency legislation that mandates companies to reveal their real owners to avoid the misuse of shell companies for money laundering. The authorities also stepped up cross-border financial movement monitoring, tightening control on capital outflow and increasing international collaboration with other financial intelligence agencies. The authorities carried out a nationwide AML inspection campaign in 2022, and it produced more than 3,000 investigations and more than ¥50 billion (\$7 billion) worth of illicit funds confiscated. There are fresh draft amendments to the AML Law that introduce stricter sanctions for non-compliance, such as additional fines on financial institutions that are ineffective in putting in place AML measures (Wang & Cahill, 2023).

Utilisation of fintech and artificial intelligence (AI) for supporting Anti-Money Laundering (AML) rules has also increased solidly. Regulators in China are utilising big data analytics, blockchain technology, and machine learning to detect better suspicious transaction patterns. AI-supported AML applications can filter bulk amounts of financial information in real-time, wherein probable patterns could be efforts for money laundering. Fintech companies like Internet payment companies WeChat Pay and Alipay are also under greater regulator scrutiny now with a requirement to improve AML controls. Bitcoin transactions have also been regulated by the state as it prohibited trading of digital currency as well as mining money in an effort to prevent digital cash from being used to fund crime. Much more needs to be accomplished as regards eradicating the risk of money laundering in China. Trade-based money laundering, clandestine banking systems, and the rapid development of money laundering techniques are still enforcement challenges. Yet, with continued reform, greater international cooperation, and the integration of new technology, China is making rapid progress in strengthening its AML system. The way forward for China's AML regulation is to further strengthen risk-based regulation, encourage more financial transparency, and close regulatory loopholes to construct a strong financial system.

2. Reporting Obligation on Bankers

Within China's rigorous Anti-Money Laundering (AML) environment, banks and financial institutions play a critical role in detecting, blocking, and reporting suspicious transactions. Regulators like the People's Bank of China (PBOC) and the China Anti-Money Laundering Monitoring and Analysis Centre (CAMLMAC) impose stringent reporting obligations on banks to ensure they are AML law compliant. The financial institutions must conduct customer due diligence (CDD), monitor and report suspicious transactions (STRs), and maintain proper financial transaction records. Banks must also operate effective internal compliance programmes that can preclude money laundering risk. Despite all this, identity verification issues, financial privacy concerns, and evolving methods used by criminals render AML enforcement difficult.

2.1 Customer Identification and Due Diligence

One of the easiest aspects of Chinese banks' AML compliance is accurate customer identification and due diligence (CDD) to avoid criminals from exploiting the financial system. Know Your Customer (KYC) regulations require banks and other institutions to identify customers prior to providing bank facilities to them. Banks must obtain significant identification documents such as government ids, business licenses of corporate accounts, residency proofs, and source of funds. These activities help curb risks associated with money laundering, terrorist financing, and fraud.

In addition to standard CDD, banks must perform Enhanced Due Diligence (EDD) on high-risk customers, including politically exposed persons (PEPs), foreign nationals, and businesses in industries susceptible to money laundering (e.g., real estate, gaming, and cryptocurrency trading). EDD involves more rigorous background checks, regular transaction monitoring, and higher reporting thresholds. For example, banks have to conduct periodic checks on high-risk accounts, confirm the genuineness of large transactions, and disclose beneficial ownership arrangements of businesses.

Banks are, however, grossly handicapped in verifying the identity of customers, especially with the rise of online banking, electronic transactions, and anonymous financial services. Criminals often use false identities, shell companies, and nominee account holders to circumvent KYC controls. Apart from this, China's very large informal economy and underground banking networks render verification challenging. In an attempt to eradicate such issues, financial institutions are stepping up efforts to adopt biometric verification, AI-driven identity verification, and blockchain-based KYC solutions to optimise the verification of customers and reduce AML risks.

2.2 Reporting Cash Transactions

To prevent large money laundering through cash transactions, Chinese regulations mandate the reporting of large cash transactions exceeding a specified limit by banks. Banks are under the People's Bank of China (PBOC) directives to report a cash withdrawal or deposit of over ¥50,000 (\$7,000) for individuals and ¥200,000 (\$28,000) for businesses, while foreign exchange transactions exceeding \$10,000 are also reportable. Such transactions must be reported by banks to CAMLMAC, including information on the customer's identity, the type of transaction, and red flags.

These reports help regulatory agencies recognise patterns of suspicious financial activity, such as smurfing (breaking up large transactions into small ones to go undetected) or structuring (breaking up money in large amounts just below the reportable threshold). Internal controls must be implemented by financial institutions to meet cash reporting transaction requirements. Bank employees are trained to detect suspicious cash deposits, rapid fund movement, and unusual patterns of transactions. Failure to report large cash transactions can result in serious fines, reputational damage, and legal proceedings against both the bank and its employees.

2.3 Suspicious Transaction Reporting

A part of AML compliance is the requirement of banks to report Suspicious Transactions (STRs). Suspicious transactions are financial transactions that demonstrate unusual behaviour, lack economic justification, or appear to be related to criminal activity. Common suspicious transactions include large, repeated cash deposits or withdrawals with no visible business justification, sudden international remittances to high-risk jurisdictions, complicated layering of transactions between various accounts, customers unwilling to provide information on the origin of funds, and transactions with notorious parties known to be engaging in financial crime or sanctions-listed parties.

If banks identify suspicious transactions, they are required to submit an STR to CAMLMAC within three business days. The filing must include customer information, transaction history, and a risk-based assessment of

why the activity is suspicious. The regulatory authorities will then investigate and take necessary action, such as freezing accounts, auditing, or collaborating with law enforcement agencies for further investigation.

Those banks failing to report suspicious transactions face severe penalties in the form of multimillion-dollar fines and even criminal prosecution. Employees who wilfully neglect STR requirements can be prosecuted and be subject to regulatory sanctions. To boost detection potential, financial institutions are installing AI-based monitoring systems that are able to track transaction conduct, detect aberrations, and send automated STR alerts.

2.4 Record-Keeping Requirements

Precise record maintenance is a determinant of AML compliance and regulation. Chinese banks are obligated by law to maintain customer transaction records for at least five years from the transaction completion date. Customer identification documents, transaction data, and suspicious transaction or compliance action correspondence are to be documented.

Regulatory bodies like PBOC and CBIRC periodically visit to review finance documents, verify adherence to the AML regulation, and inspect for any anomalies. Inadequate records might lead to regulatory penalties and heightened oversight of the institution's AML procedures. Banks must also ensure records are secure and readily accessible during auditing. Increasingly, banks are implementing cloud-based compliance software that allows for real-time surveillance and data recovery to strengthen AML enforcement.

2.5 Monitoring and Compliance Programmes

In the interests of maintaining up-to-date AML compliance, Chinese banks should implement strong internal compliance programmes in the form of transaction monitoring, employee training, and risk management systems. PBOC insists on the establishment of AML compliance departments, AML officers, and risk assessment procedures in-house for spotting potential money laundering activity. As more digital payments and fintech products take hold, banks increasingly depend on AI, blockchain, and analytics to provide AML monitoring. Artificial intelligence-powered transaction monitoring systems scan hundreds of thousands of financial transactions in real time and indicate suspected patterns for review by alert. Blockchain makes financial transactions more transparent and traceable, blocking fraud and illicit money transfer. Meanwhile, big data analytics helps banks to detect subtle connections between harmless-looking unrelated transactions and thereby improve overall AML regulation.

Training of employees and following good compliance culture are essential. Banks should provide periodic AML guidelines, reporting, and risk detection techniques training to the employees. The personnel who are handling the processing of high-risk transactions should receive training to spot red flags for money laundering frauds. Corporate culture influenced by compliance cannot be overstated - banks who fail to implement AML sensitiveness among their workers have better probabilities of experiencing regulatory violations and financial penalties.

3. Impact of the Law on Banks

China's Anti-Money Laundering (AML) law has had very widespread implications on banking institutions' operations by imposing serious compliance practices upon them. Despite the law being in favour of financial security and reducing illicit finance, it comes with operational costs to banks through excessive compliance charges, procedural alterations, and regulatory compliance fines. As there are always emerging advanced financial crimes, banks are forced to be dynamic and update their in-house processes periodically, utilise high-technology software, and improve their risk control mechanisms (Shi, 2024).

3.1 Operational Impact and Compliance Challenges

The enforcement of AML regulation has created a stringent penalties and compliance burden for Chinese banks. Chinese banks are required to spend a lot of money on establishing specialist AML compliance teams, installing high-technology surveillance equipment, and training staff in AML regulation. According to a report published in 2023 by the People's Bank of China (PBOC), compliance charges of Chinese major banks have increased over 35% in the past five years, as they require more advanced surveillance systems, legal consultations, and employee training. Mid-sized and small banks are more affected, as they seldom have the financial means to implement cutting-edge compliance systems (Howland, 2023).

Banking operations also need to be changed to facilitate customer identification and reporting obligations. Banks need to institute rigorous Know Your Customer (KYC) and Customer Due Diligence (CDD) measures prior

to customer onboarding. These entail proof of identity of the customers, tracking customer transaction behaviour, and incorporation of beneficial ownership disclosure in business accounts. Politically exposed individuals and customers from risky countries need Enhanced Due Diligence (EDD) procedures. These have generated administration burdens and delayed the duration needed for approval of accounts, enraging some consumers and hindering banking operations occasionally.

Moreover, AML regulation has also inhibited banking innovation and digital finance service. With the development of fintech, digital banking, and cryptocurrency use in China, AML law increased vigilance for digital payments in order to assist in excluding illicit finance. Banks have to implement real-time transaction monitoring, machine learning-based fraud blocking, and blockchain-based KYC features for compliance purposes (Hutukka, 2025). However, such compliance procedures occasionally dampen digital service innovation because regulatory monitoring of peer-to-peer lending websites, mobile payments platforms, and cryptocurrency exchanges hinders them. While fintech solutions are easy to access, they pose new money laundering threats, forcing banks to walk a fine line between compliance obligations and innovation.

3.2 Challenges in Compliance and Non-Compliance Risks

Complying with China's AML laws presents numerous challenges for banks, particularly in monitoring complex financial transactions, verifying customer identities, and keeping up with evolving criminal tactics. The largest challenge is discovering sophisticated money laundering schemes because money launderers are using multiple accounts, shell firms, and scattered financial systems in order to outsmart AML controls. Cryptocurrency flows and cross-border transactions make it difficult because digital currencies create new avenues of illicit money laundering.

Lack of competent AML professionals is another insurmountable challenge because banks cannot afford to recruit and retain compliance experts with financial crime investigation, regulatory reporting, and risk assessment capabilities (Dhali *et al.* 2023). With enough trained personnel in short supply, banks risk a high rate of human error in recognising suspicious transactions (STRs) and thus tempt regulators' sanctions.

The amount of financial data banks have to sift through also comes with the requirement of complex AI-based surveillance systems but they are expensive and difficult to integrate into the existing banking system. Disobedience of AML standards puts banks at risk of draconian monetary sanctions, reputation destruction, and takeover by regulators (Li, 2023). The PBOC and CBIRC have intensified supervision and inflicted draconian punishments on trailing financial institutions. Disobedience also welcomes criminal sanctions against bank managers, freezing of bank accounts, or revocation of bank licenses in dire cases. Reputational damage of an AML breach can be devastating as it undermines customer confidence, raises investor suspicions, and enhances foreign regulator scrutiny by foreign regulators like the Financial Action Task Force (FATF) (Saxena & Kumar, 2023).

3.3 Case Studies of AML Violations in Chinese Banks

A chain of high-profile misuses of AML at China's banking sector is an obvious sign of the risk of non-compliance. Industrial and Commercial Bank of China (ICBC) was one of them, which was fined \$50 million in 2020 for failing to strictly monitor suspicious foreign money laundering transactions. Probes indicated ICBC to have poor internal controls and not reporting suspicious financial transactions that included cross-border money transfers. The incident called for increased monitoring of transactions and reporting to the authorities.

Another was Bank of China (BOC) 2021 AML failure, where it was indicated to have received cash-based transactions of hundreds of millions of dollars without proper vetting. PBOC penalised BOC over ¥200 million (\$28 million) for AML regulation violations, including being in duty to be lenient when performing KYC checks and not reporting suspicious transactions. The bank was therefore compelled to transform its compliance programme, implement AI-driven anti-fraud features, and raise the bar on internal audits. This action highlights the importance of having in-place effective in-house compliance systems, good risk management, and making use of cutting-edge technology for detection and prevention of money laundering. Banks that are not compliant risk not only financial penalties but also loss of and harm to their business reputation over the long term and reputational loss (Hutukka, 2025). Over the next few years, China's banking sector must continue to make AML rules more stringent, invest in compliance training, and implement the best available financial crime detection technology to remain compliant with the regulator.

Conclusions and Further Research

China's Anti-Money Laundering regime has been reformed, with more profound financial regulation, enhanced institutional responsibility, and international AML standardisation. The implementation of the 2006 AML Law and amendments has consolidated the roles of financial institutions, and banks in general, to ban illegal financial activities. Nonetheless, amid the revolutionary advancement, there are already issues prevailing, such as increasingly complex money laundering operations, the compliance burden on financial institutions themselves, and inadequacies in enforcement tools.

With China persisting in advancing its fast-paced economic and technological development, surmounting the aforementioned challenges must become the norm for possessing sufficient, clean, and sustainable financial system. China's anti-money laundering law has thereby succeeded in bringing about financial clarity, strengthening controls, and deterring financial vices. Regulators, led by the PBOC and CBIRC, have also taken an active role in enforcing compliance through strengthened reporting demands, severe punishment for the defaulting parties, and boosted surveillance policies. Financial institutions have themselves made sincere efforts in upgrading customer due diligence (CDD), suspicious transaction reporting (STR), and record-keeping requirements. All these notwithstanding, there are substantial enforcement and compliance gaps. Banks in general, and small banks in particular, are burdened by the stratospheric expense of AML compliance, technology adoption limitations, and unavailability of AML professionals. Criminals continue to exploit regulatory loopholes via shell companies, shadow banking conduits, and crypto transactions to launder dirty money. Moreover, decentralised data-sharing networks and coordination lacunae among financial institutions and regulatory bodies render AML regulation enforcement cumbersome.

Impacts on banks and financial institutions have been substantial. Though AML rules have encouraged business openness and enhanced risk management in finances, they have also increased the cost of compliance, spurred business cost, and imposed more procedural burdens on financial transactions. Banks are now compelled to invest in the shape of AI-based monitoring systems, train staff to oversee AML compliance, and enhance more advanced risk management processes. For the fintech sector, AML rules have imposed tighter reins on online banking, peer-to-peer lending, and cryptocurrency. They sometimes inhibit financial innovation.

This paper adds value to the literature by providing one of the most detailed reviews of the way the AML framework in China has developed in regard to its reach and even institutional scope, and important critique of the practical consequences of this on banking institutions. This is contrasted with previous studies which have concentrated on a limited range of legal reforms or technical requirements, whereas the current study combines statutory progress, judicial practice cases and policy debate along with an analysis of operational issues in banks. The focus on technological integration especially the applicability of AI and big data to compliance monitoring - illuminates the potential and the gaps in the AML modality currently applied in China. Offering fresh information that is both theoretical and practical in nature to the regulators, financial institutions and international stakeholders in the prevention of financial crimes by indicating the areas of enforcement that are relatively inconsistent, cross-border cooperation is restricted, and compliance costs are caused to be disproportionately large (to a smaller bank).

Recommendations for Strengthening AML Frameworks

To get past existing issues and strengthen China's AML system even more, a multi-pronged approach focusing on enforcement, technology, cooperation, and international cooperation is required. Perhaps the most significant issue on China's AML front is the need for stronger and more consistent enforcement mechanisms. Although existing legislation is exhaustive, enforcement attempts are inconsistent in different banking institutions and financial sectors. To improve enforcement, regulatory agencies must increase on-site inspections and audits so that AML compliance controls exist in reality and not merely on paper. Penalties for non-compliance must be tougher, particularly for repeat offenders and large financial institutions that fail to report suspicious transactions. In addition, supervisory coverage must be extended to cover dangerous niches such as cryptocurrency trading platforms, digital payment systems, and peer-to-peer lending companies, which have greater vulnerability to financial ills. To facilitate enforcement, regulators such as the PBOC, CBIRC, and the Ministry of Public Security should increase coordination, even by establishing a centralised AML task force to coordinate investigations and fill gaps in supervision.

One of the essential components of an effective AML system is collaboration between financial institutions, regulatory agencies, and law enforcement authorities. Financial crimes are increasingly sophisticated, and there is a requirement for real-time information sharing and cooperation in detection and prevention. The establishment of a national AML intelligence-sharing system would allow banks, fintech firms, and regulatory

bodies to exchange STRs, risk assessments, and financial crime patterns in real time. Moreover, regulatory benefits can be created to encourage banks to voluntarily enhance their AML controls beyond regulatory standards, e.g., reduced fines or tax benefits for proactive compliance initiatives. To establish AML experience and acumen, banks may collaborate with colleges and regulatory bodies to create compliance training programmes such that banking professionals are current with changing trends in financial crime, technology advancements, and changing regulations. Furthermore, whistleblower protection legislation must be enhanced to inspire workers, auditors, and compliance officials to report tips on suspicious transactions without fear of reprisal.

As China's financial crimes become sophisticated, it must invest in advanced technology for AML enforcement. Big data capabilities, AI, and machine learning can automate real-time monitoring of transactions, flag suspicious fraud, and even calculate risk levels. Banks are required to integrate AI-powered transaction monitoring systems that are able to catch sophisticated patterns of suspicious transactions that rule-based systems would fail to capture. Blockchain is also able to shine and facilitate AML compliance. Through the integration of blockchain-based KYC and transaction authentication technologies, banks can make financial transactions more transparent and secure, minimising fraud and identity theft. They will also need to deploy biometric identification verification and AI-driven ID authentication systems like facial scanning and fingerprint recognition in order to complement CDD practices. Forming predictive analytics offerings based on historic transactional records and machine learning algorithms to foresee likely money laundering risks can further improve AML capabilities. Big data analysis allows banks and regulators to forecast and counteract threats of financial crime in advance.

Given China's increasing financial influence worldwide, international cooperation in applying AML is increasingly essential. Money laundering activities often involve international flows of funds across borders, with offshore accounts, cross-border money transfers, and multinational company structures, all of which call for international cooperation among countries. Efficient effort needs to be put into the promotion of cooperation with foreign AML bodies, such as the Financial Action Task Force (FATF), the Basel Committee on Banking Supervision, and the Asia/Pacific Group on Money Laundering (APG), in order to align China's AML regulations with international best practice and improve intelligence exchange. China would also have to give top priority to bilateral AML arrangements with high-risk jurisdictions, particularly where illicit financial flows are large, in order to facilitate faster extradition of financial criminals, near-real-time exchange of information, and cooperation in enforcement action. Cross-border transaction monitoring would also have to be enhanced, particularly in China's BRI countries, where the risk of financial crime has grown. Ensuring that cross-border financial institutions in China adhere to local and international AML standards will prevent arbitrage across borders and improve global financial integrity.

Credit Authorship Contribution Statement

Zeyu Zhao: Conceptualization, Investigation, Methodology, Project administration, Formal analysis, Writing – original draft, Data curation.

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Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Declaration of Use of Generative AI and AI-Assisted Technologies

The authors declare that they have not used generative AI and AI-assisted technologies during the preparation of this work.

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The Impact of Digitalization of Social Services on the Economic Efficiency of Public Expenditure

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Abstract: The digitalization of public administration is a key direction for improving the efficiency of budgetary resource use, especially in the field of social welfare. The implementation of digital technologies in social services contributes to the reduction of bureaucratic costs, acceleration of decision-making processes, and increased transparency of funding. The purpose of this study is to assess the impact of digitalization of social services on the economic efficiency of public spending. Methods of comparative analysis, regression modeling, and correlation assessment were used based on data from 15 countries in Europe, North America, and Asia. The study revealed a significant positive correlation between the level of digitalization and the reduction of administrative costs. In countries with a high level of digital services, administrative costs for social programs decrease to 2 - 3% of total social expenditures, while in countries with a low level of digitalization, these costs can exceed 8 - 10%. Moreover, the introduction of digital platforms, such as "Diia" in Ukraine, helps reduce the time required for processing social assistance applications by 40 - 50%, which aligns with trends in other digitally advanced countries. The results of the study have significant practical value for optimizing social spending and developing policies for the digital transformation of public services. Recommendations are proposed to address digital inequality, enhance cybersecurity, and expand digital literacy programs to ensure equal access to electronic social services. Future research prospects include analyzing the long-term economic effects of digitalizing social welfare and evaluating its impact on the social inclusion of various population groups.

Keywords: digitalization; social services; public expenditure; budget efficiency; administrative costs.

JEL Classification: H50; H83; O33.

Introduction

In the modern context, the digital transformation of public administration is becoming a key factor in increasing the efficiency of budget expenditures, particularly in the provision of social services. According to OECD (2024), in countries with well-developed digital infrastructure, over 90% of social services are available online. This enables the reduction of administrative costs and accelerates decision-making. At the same time, government spending on the digitalization of the social sector is growing: according to World Bank estimates (2024), in 2023, the average share of such spending in the GDP of developed countries exceeded 2%. Traditional mechanisms of managing social support are often accompanied by bureaucratic inertia, inefficient resource allocation, and high administrative costs (Androniceanu *et al.* 2022). The integration of digital technologies into social policy helps mitigate these issues by streamlining request processing, automating verification mechanisms, and enabling a personalized approach to the distribution of social benefits (Do-brolyubova, 2021). In academic discourse, the digitalization of social services is seen as a means of achieving sustainable development goals. It holds potential not only for economic but also ecological efficiency by optimizing resources and reducing the burden on both the budget and the environment (Voronina *et al.* 2024). Furthermore, global experience shows that digital platforms enhance governance efficiency, reduce administrative barriers, and ensure spending transparency (Bielialov *et al.* 2023).

Digitalization of social services helps reduce the state's operational costs. The implementation of electronic platforms, such as "Diia" in Ukraine, automates the processing of applications and reduces handling time (Ministry of Digital Transformation of Ukraine, 2024). This also minimizes the human factor, enhancing budget transparency and reducing corruption risks. Digital technologies also support evidence-based decision-making through big data analysis and social needs forecasting (Haug *et al.* 2024). However, digitalization challenges include digital inequality among the elderly and rural residents (Huang and Zhang, 2025), as well as the need for significant investments in cybersecurity and civil servant training (Negri and Dincă, 2023).

The scientific novelty of this study lies in the comprehensive analysis of the economic, administrative, and social aspects of the digitalization of social services. Unlike previous studies, this work uses regression analysis based on data from 15 countries with varying levels of digitalization, allowing for the identification of quantitative relationships between digital reforms and the economic efficiency of social expenditures. The research also highlights the problem of digital inequality, which remains one of the main barriers to the implementation of electronic public services.

The purpose of the study is to evaluate the impact of digitalization of social services on the economic efficiency of public spending by analyzing financial indicators, resource allocation efficiency, and the availability of digital services. To achieve this goal, the following objectives are set:

1. To analyze the dynamics of government budget spending on social services before and after the introduction of digital solutions. This task allows the assessment of changes in the structure and volume of budget expenditures associated with digitalization. Its completion will help determine whether there has been a reduction in administrative costs and an increase in the efficiency of financial resource use.
2. To study the impact of digital technologies on the speed and transparency of social service delivery. Completing this task will help establish whether digitalization contributes to the reduction of bureaucratic procedures, shorter application processing times, and decreased corruption risks - all important indicators of the efficiency of digital platforms in the social sector.
3. To assess the availability of digital social services for different population categories and identify barriers to their use. This task aims to determine how evenly digital technologies have been implemented in the social sector and which population groups might be excluded from this process. The results will help develop recommendations for overcoming digital inequality and improving access to electronic social services.

1. Literature Review

The digitalization of social services is an important direction in the modernization of public administration, enhancing the economic efficiency of expenditures while creating both advantages and challenges for the social sector. Akulov (2024) notes that digital technologies promote budget transparency and reduce administrative costs, which is particularly important for bureaucratic states. This position is well-founded; however, it should be considered that transparency alone does not guarantee expenditure efficiency without proper oversight by state institutions. Similar conclusions are presented in the work of Androniceanu (2023), who points out that although digital technologies can help optimize costs, their implementation requires significant investments, which are not always economically justified in the short term. This assertion is valid, as many countries face high initial

expenses for digital reforms; however, in the long term, such investments pay off through the reduction of administrative costs.

Bulavynets *et al.* (2024) emphasize the significant impact of digitalization on the quality of social services, noting that digital services provide a personalized approach and improve access to social assistance. At the same time, Considine *et al.* (2022) highlights the risks of automation, such as potential bureaucratic failures and digital discrimination. This criticism is justified, as automated systems may exclude certain categories of citizens from the process due to their insufficient digital literacy. Meanwhile, Danik *et al.* (2023) describe the characteristics of the digital economy in the context of military conflicts and emphasize that the digitalization of social services can become an important tool for supporting the population during crises.

Ihnatenko and Sadzaglishvili (2023) emphasize the problem of digital inequality, particularly among the elderly and rural residents. This aspect is extremely important, as the gap in access to digital technologies can negate the positive effect of digitalization for certain population groups. Dabbous *et al.* (2023) also points out the need for a comprehensive approach to implementing digital technologies in the social sector, with the main challenges being high infrastructure costs, the need for legislative changes, and ensuring cybersecurity.

An important aspect is the link between digitalization and the achievement of sustainable development goals (Castro and Lopes, 2022). The automation of social services can contribute to more efficient resource use and greater environmental sustainability of public expenditures. Similarly, Kryvovazyuk *et al.* (2023) argues that public-private partnerships can significantly increase the efficiency of digital reforms. This claim is well-founded, as the private sector often has more resources and technological capabilities to scale digital initiatives.

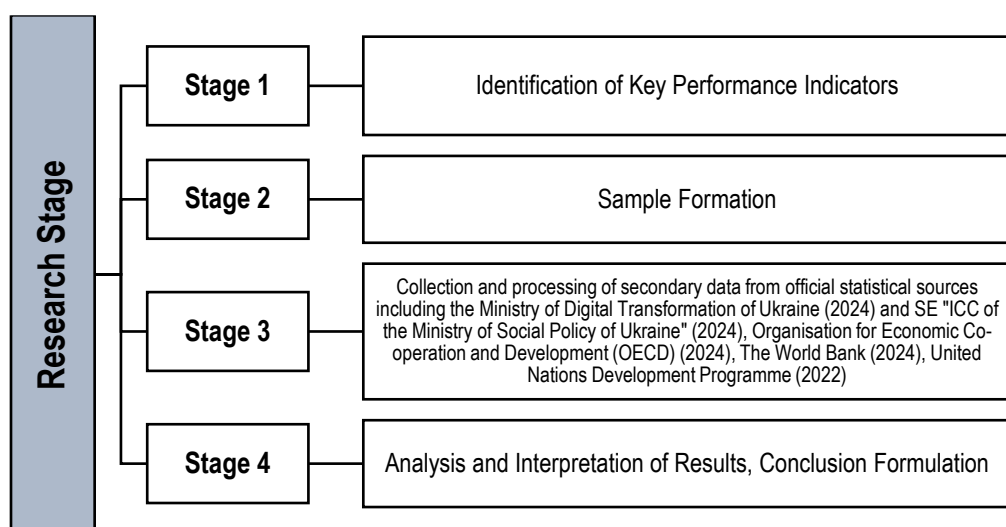
The literature review revealed several areas requiring further research. First, the issue of the long-term economic effect of social service digitalization remains underexplored. Studies mainly focus on short-term outcomes, while the assessment of long-term consequences for the budgetary system remains limited (Omar *et al.* 2024). Second, there are conflicting results regarding the impact of digitalization on citizens' trust in public institutions (Cherniaieva *et al.* 2023). Third, the issue of cybersecurity and data leakage risks in the process of digitalizing social services remains insufficiently studied (Shashyna *et al.* 2023).

In general, the literature review confirms that the digitalization of social services has the potential to improve the economic efficiency of public spending. However, the implementation of digital technologies is accompanied by several challenges, including digital inequality, automation risks, and the need for substantial investment. Future research should focus on evaluating the long-term consequences of digitalization, its impact on public trust in government institutions, and cybersecurity issues in the social services sector.

2. Methods

The research methodology is based on a comprehensive approach to analyzing the impact of the digitalization of social services on the economic efficiency of public spending. It incorporates quantitative assessment methods that enable an objective measurement of the effects of digital reforms. The study was conducted in several stages, as presented in Figure 1.

Figure 1. Research Stages



Source: Author's own development.

At the first stage, indicators characterizing the efficiency of public spending in the field of social services were identified. The main indicators included: the level of administrative costs, the speed of processing social assistance applications, and the accessibility of digital services (Ministry of Digital Transformation of Ukraine, 2024). At the second stage, data from 15 countries in Europe, North America, and Asia were selected to form the sample (details provided in Appendix 1). These countries represent varying levels of digital maturity and socio-economic development, allowing for a representative picture of the impact of digitalization on public spending. This makes it possible to assess digitalization in diverse contexts and identify general trends. Selection criteria included: availability of open data on the digitalization of social services, GDP per capita, and government social expenditure indicators. The sample size was determined regarding data representativeness and comparability across countries. At the third stage, secondary data covering the period from 2016 to 2023 were collected from official sources, government portals of various countries, and academic publications relevant to the topic. At the fourth stage, data were processed using mathematical modeling and statistical analysis methods.

A comparative analysis of public spending efficiency was conducted across countries with different levels of digitalization. The results allowed for the identification of key factors influencing the economic efficiency of digital social services. The methods used in the study include:

- Regression analysis – used to assess the relationship between the level of digitalization and changes in administrative government expenditures. Fisher's test was used to confirm statistical significance. The model included independent variables such as the level of digital service penetration, expenditures on digital transformation, and the proportion of the population using online services. The regression analysis was based on panel data from 15 countries with different levels of social service digitalization for the period 2016–2023. The multiple linear regression model had the following form:

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \varepsilon$$

where:

Y – change in administrative expenses on social services (as a % of total social expenditures); X_1 – level of digital service penetration (digitalization index, % of online services); X_2 – digital transformation expenditures (as a % of GDP); X_3 – proportion of the population using online social services (%); β_0 – constant; β_1 , β_2 , β_3 – estimated regression coefficients; ε – model residual error.

- Dynamic (trend) analysis – used to assess changes in social service expenditures depending on the level of digitalization. Long-term trends in expenditures were analyzed, and key aspects of digital transformation were identified, enabling an assessment of the impact of digital technologies on economic efficiency.

- Correlation analysis – conducted to assess the correlation between the level of digital accessibility and the social effectiveness of government programs. This allowed for evaluating the relationship between digitalization and improved access to social services.

The study was based on the analysis of official data and statistical calculations. Microsoft Office Excel (version 2016) was used for calculations, processing, and data analysis. Therefore, the proposed approach enables a comprehensive empirical assessment of the impact of social service digitalization on the economic efficiency of public spending. It provides the opportunity to identify the main factors determining the success of digital reforms and allows for the formulation of well-grounded recommendations for optimizing budget policy in the field of social welfare.

3. Results

A study of 15 countries with varying levels of digitalization (Appendix 1) revealed significant differences in the efficiency of social services. In countries with high digital maturity, over 90% of social services are available online, whereas in countries with low digitalization, this figure does not exceed 20%. As of 2022, Ukraine offered over 70 electronic services via the Diia platform, demonstrating significant progress. Administrative costs in leading countries amount to 2–3% of social spending, while in countries with low digitalization they reach 8–10%. The average application processing time in digitally advanced countries is 1–3 days, compared to 7–10 days in less digitalized ones. Aggregated data is presented in Table 1.

The dynamic analysis shows that digitalization improves the efficiency of social spending. In countries actively implementing electronic services, administrative costs grow more slowly. In Ukraine, their share in social spending decreased from 5.1% to 4.3% (2016–2021), and process automation minimized administrative cost growth. The introduction of digital tools significantly accelerated aid delivery: from 2019 to 2023, the average application review time decreased from several weeks to a few days thanks to the "Unified Information Space of

the Social Sphere" system and online services. A similar trend is observed in countries with developed digital infrastructure - gradual replacement of paper-based procedures with electronic ones increases administrative efficiency.

Table 1. Key indicators of social service efficiency by level of digitalization (average values by country group)

Indicator	High Level of Digitalization (Top 5 Countries)	Medium Level (Next 5 Countries)	Low Level (Last 5 Countries)
Share of Social Services Available Online	~95%	~60%	~20%
Administrative Costs (% of Social Spending)	~2%	~5%	~10%
Average Application Processing Time (days)	2–3	7–10	15–20

Source: compiled from OECD (2024), The World Bank (2024), Fedirko (2022), Millard (2023), Social Security Administration (2024).

To more deeply assess the influence of individual factors, a regression model was built. The dependent variable was the dynamics of administrative costs for social services. The independent variables were key digitalization indicators: the level of e-service penetration, the volume of investment in digital transformation, and the share of the population using online services. The model demonstrated good approximation quality (coefficient of determination $R^2 \approx 0.62$, meaning that 62% of changes in administrative costs are explained by digitalization), and its statistical significance was confirmed by the Fisher test ($F \approx 15$, $p < 0.001$). Table 2 shows the regression coefficient estimates. It was found that two of the three factors have a statistically significant impact: the level of digital service penetration and the share of online service users.

Table 2. Regression analysis results (dependent variable – change in administrative costs)

Independent Variable	Coefficient Estimate (k)	t-statistic	p-value
Level of Digital Service Penetration (Index)	–0.050	–2.8	0.008
Spending on Digital Transformation (% of GDP)	–0.001	–1.5	0.146
Share of Population Using Online Services (%)	–0.081	–2.3	0.031
Constant	0.012	0.5	0.617
Coefficient of Determination	0.62		

Source: calculated from OECD (2024), The World Bank (2024), Ministry of Digital Transformation of Ukraine (2024), United Nations Development Programme (2022).

The coefficients (k) for these variables are negative and significant (at the 5% level), indicating a reverse relationship: as the level of digitalization increases, administrative spending decreases. Specifically, the coefficient for "Level of Digital Service Penetration" is about –0.050 ($p \approx 0.01$), meaning that an increase in this index by 1 point leads to a 0.05 percentage point reduction in the share of administrative costs, all else equal. Similarly, a broader use of online services by the population is associated with reduced administrative costs ($k \approx -0.081$, $p < 0.05$). This aligns with expectations and previous observations that digitalization optimizes costs. At the same time, the indicator of spending on digital transformation did not show a statistically significant impact within this model ($k \approx -0.001$, $p > 0.1$). This could be due to a time lag between investments and outcomes or limitations of the sample. Overall, the regression analysis confirms a causal relationship between the implementation of digital technologies and increased economic efficiency of public social expenditures. As digitalization levels rise, there is a statistically significant reduction in non-productive (administrative) budget expenditures.

To assess the effectiveness of social service digitalization, trends in administrative costs and application processing time were analyzed in countries with different levels of digitalization during 2016–2023 (Table 3). After implementing e-services, administrative costs fell by 30–40%, and application processing time was reduced by 2–5 times, especially in digitally advanced countries. In countries with low levels of digitalization, the changes were less pronounced, highlighting the need for further reforms.

Thus, empirical results confirm that the digitalization of social services enhances the economic efficiency of public spending. All conducted analyses show a reduction in administrative costs and an increase in population coverage with social support.

Table 3. Dynamics of changes in social service efficiency before and after digitalization (average values)

Country Group by Digitalization Level	Share of Admin. Costs in Social Spending (%) (Before)	Share of Admin. Costs (%) (After)	Avg. Application Processing Time (days) (Before)	Avg. Processing Time (days) (After)
High Level (90% and above)	3.2	2.1	7–10	1–3
Medium Level (70–89%)	6.8	4.2	10–15	3–7
Low Level (Below 70%)	12.5	8.5	20–30	7–15

Source: calculated from OECD (2024), The World Bank (2024), Ministry of Digital Transformation of Ukraine (2024), United Nations Development Programme (2022).

However, challenges remain, particularly digital inequality among vulnerable groups. To ensure equal access to digital services, it is necessary to improve digital literacy, expand internet access, and enhance the usability of electronic services. Figure 2 presents the main conclusions of the regression analysis and corresponding recommendations for overcoming digital inequality and improving access to electronic social services.

Figure 2. Conclusions from the regression analysis and recommendations to overcome digital inequality

The implementation of digital social services contributes to the reduction of administrative costs ($k \approx -0,050$, $p < 0,01$)	Automation of administrative processes: further implementation of artificial intelligence for processing applications and simplifying procedures for interaction with citizens.
The expansion of public use of online social services is a key factor in reducing costs ($k \approx -0,081$, $p < 0,05$)	Digital literacy programs: conducting educational initiatives for elderly people, low-income populations, and residents of rural areas.
Investments in digital transformation have a delayed effect and do not lead to an immediate reduction in costs ($k \approx -0,001$, $p > 0,1$)	Government subsidies for digital infrastructure: funding for broadband internet in remote regions, providing free access to social services through public Wi-Fi hotspots.
The availability of digital services does not guarantee their use by all citizens (digital inequality)	Development of multichannel access: maintaining alternative ways of accessing social services (call centers, mobile offices, offline consultations).
A high level of digitalization has a positive impact on the transparency of social expenditures and reduces the level of corruption risks	Introduction of open registers and public monitoring systems: creation of digital dashboards with open data on the distribution of social benefits.

Source: Author's own development.

Therefore, for the effective implementation of digital social services, it is essential not only to improve technological infrastructure but also to address the issue of digital inequality. This includes promoting digital literacy, expanding internet access, and developing user-friendly and secure digital platforms. Additionally, it is important to ensure the adaptation of digital services for low-mobility and disabled population groups to support the inclusiveness of digital transformation.

4. Discussions

The research results confirmed the significant positive impact of digitalization of social services on the economic efficiency of public spending. The obtained data indicate that digital technologies contribute to the reduction of administrative costs, the acceleration of social assistance application processing, and the enhancement of transparency in public expenditures. These findings are consistent with the study by Dobrolyubova (2021), which stated that digitalization promotes the optimization of public administration and the reduction of unproductive expenses.

Comparison of our analysis results with other studies confirms a global trend toward increasing the efficiency of social policy through digitalization. In EU countries, the transition to e-governance has reduced the average processing time of applications by 40–60% (Androniceanu *et al.* 2022), while in Ukraine, thanks to the

"Diia" platform, this figure has decreased by 50% (Ministry of Digital Transformation of Ukraine, 2024). At the same time, the effectiveness of digitalization depends on a country's level of digital maturity: in developed states, administrative costs do not exceed 2–3%, whereas in countries with low levels of digitalization, they reach 8–10%. This aligns with the conclusions of Millard (2023), who emphasized the need for comprehensive institutional reforms to achieve the maximum economic benefits of digitalization.

In addition, Javoronok and Lopashchuk (2024) noted that digitalization reduces the shadow economy and optimizes social security. Our study confirms this, as digital tools minimize duplicate payments, automate applicant verification, and prevent fraud. Similar conclusions were drawn by Ma *et al.* (2022), who emphasized that digital technologies improve the efficiency of budgetary control. Our findings support this as well, since digital tools help to minimize duplicate payments, automate the verification of applicants, and prevent fraud.

However, it is important to note that digitalization of social services may introduce new challenges. In particular, the issue of digital inequality remains relevant (Huang and Zhang, 2025). Our results confirm that elderly individuals and residents of rural areas have limited access to digital services, which is also highlighted in the study by Ihnatenko and Sadzaglishvili (2023). Therefore, one of the recommendations is the development of state programs to improve digital literacy and the creation of alternative access methods to social services (e.g., mobile support centers).

Another important aspect is the need for investments in cybersecurity and personal data protection. Shashyna *et al.* (2023) emphasized that the expansion of e-governance is accompanied by an increase in the risk of unauthorized access to confidential information. Our study confirmed the necessity of improving protection standards for digital platforms, especially in countries that are just beginning active digitalization of the social sector. Similar results are demonstrated by Kryvovyazyuk *et al.* (2023), who stressed the importance of public-private partnerships in building secure digital infrastructure.

It is important to mention that our analysis has certain limitations. First, the sample is limited to 15 countries, which does not allow for full coverage of all possible variations in the impact of digitalization on the economic efficiency of public expenditures. Second, digitalization is a dynamic process, and its long-term effects may differ from those obtained in this study. Nonetheless, the findings have important practical significance for shaping public policy on the digitalization of social services. Primarily, it is advisable to expand digital literacy programs to ensure equal access to electronic services, especially among the elderly and rural populations. In addition, additional cybersecurity measures should be introduced, including improvements in personal data protection mechanisms and strengthening the resilience of digital infrastructure. The results can be used by government agencies to optimize budget expenditures, reduce administrative costs, and increase the transparency of social program funding.

Conclusions

The digitalization of social services is an important factor in improving the economic efficiency of public spending, as confirmed by the results of the conducted empirical research. The introduction of digital technologies contributes to the optimization of administrative processes, reduction in application processing times, lower bureaucratic costs, and greater transparency in the allocation of budgetary resources. The analysis showed that a country's level of digital maturity directly correlates with a decrease in the share of administrative costs in social programs. In countries with a high level of digitalization, these costs do not exceed 2–3%, whereas in states with poorly developed digital services, the figure reaches 8–10%.

It was established that the implementation of digital platforms, such as "Diia" in Ukraine, has helped reduce the processing time for social requests by up to 50%, aligning with the experience of EU countries. At the same time, the results of correlation and regression analysis confirmed a strong relationship between the level of digital service penetration and the overall efficiency of public spending. However, digitalization is not an instantaneous process and requires significant investments that have a delayed effect.

The results obtained have practical significance for the development of strategies for the digital transformation of social policy. The approaches proposed in this study can be used by public administration bodies to further optimize social spending and improve access to electronic services. In particular, the need to expand digital inclusion programs is substantiated, which would help reduce digital inequality among socially vulnerable population groups.

The scientific novelty of the research lies in the comprehensive analysis of the relationship between the digitalization of social services and the efficiency of public spending. This analysis includes a multidimensional assessment of the economic, administrative, and social aspects of digital reforms. Unlike previous studies, this

work applies regression analysis to identify the key factors influencing the level of administrative costs in the social sector.

Prospects for further research include assessing the long-term effects of digitalizing social services, analyzing its impact on social justice, and identifying mechanisms to overcome digital inequality. Another important direction is the study of the consequences of digitalization for the sustainability of public finances and the identification of optimal models for implementing electronic services in various socio-economic contexts.

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Appendices

Appendix 1. Sample of Countries and Their Key Indicators of Social Service Digitalization.

Country	Digitalization Level (%)	Share of Social Expenditures in GDP (%)	Share of Administrative Costs in Social Spending (%)	Average Application Processing Time (days)
Ukraine	70	18	4.3	3–5
Germany	95	25	2.1	1–3
France	93	24	2.3	2–4
Sweden	97	22	1.9	1–2
Estonia	98	21	1.5	1
USA	85	19	3.0	3–5
Canada	88	20	2.8	3
Japan	90	18	3.5	2–4
South Korea	92	17	2.6	2–3
China	80	16	5.2	5–7
Poland	75	17	4.8	5
Spain	85	23	3.2	3–5
India	65	12	8–10	7–10
Turkey	68	14	8–10	8–10
Mexico	60	10	8–10	10–15

Source: Author's own development.

Based on the analysis of 15 countries, Appendix 1 presents their level of digitalization, the share of social expenditures in GDP, and the average time required to process social assistance applications. Countries with a high level of digitalization (90% and above) have the lowest administrative costs (1.5–2.3%) and the fastest application processing times (1–3 days). Countries with a medium level of digitalization (70–89%) demonstrate moderate administrative costs (3.0–5.2%) and processing times ranging from 3 to 7 days. Countries with a low level of digitalization (<70%) face high administrative costs (8–10%) and significant application processing delays (7–15 days).



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Does Agricultural Productivity Drive Economic Growth? Evidence from Developed and Developing Countries within the RCEP Bloc

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Abstract: This study explores the relationship between agricultural productivity and economic growth across Regional Comprehensive Economic Partnership (RCEP) member countries from 2001 to 2024, providing a novel focus on this economic bloc. Employing advanced econometric techniques, including panel unit root tests, Autoregressive Distributed Lag (ARDL) models, panel dynamic Ordinary Least Squares (DOLS), and panel threshold models, the analysis reveals contrasting dynamics between developed and developing economies. Key findings include the dual impact of agricultural total factor productivity (AgTFP) is positive in developing countries and negative in developed ones and the role of the incremental capital-output ratio (ICOR), which fosters growth in developing economies but impedes it in developed ones. The prevalence of undernourishment consistently hinders economic growth across all models, while employment in agriculture exhibits divergent effects, positively influencing growth in developing nations but negatively in developed ones. The results underscore the critical role of improving agricultural productivity in fostering economic growth in developing countries, highlighting the need for government interventions in areas such as credit access, training programs, infrastructure development, and market expansion. Conversely, for developed nations, the diminishing contribution of agriculture to GDPPC suggests a need for technological innovation and diffusion to sustain productivity gains. This research uniquely contributes to understanding the nuanced role of agriculture in economic growth within the RCEP framework.

Keywords: agricultural productivity; economic growth; ICOR; divergent effects; government interventions; diminishing contribution.

JEL Classification: Q18; R11.

Introduction

Agricultural productivity - the process of turning inputs such as land, labor, fertilizers, and water into abundant crops, livestock, and essential products - is not merely a sectoral concern but a powerful catalyst for economic transformation. When agriculture achieves higher productivity, economies ignite growth, fostering prosperity far beyond the farm. Gollin *et al.* (2021) underlines the pivotal role of agricultural transformation in enabling countries to transition to high-income economies. This transformation is particularly vital in the context of the Regional Comprehensive Economic Partnership (RCEP), a trade bloc encompassing a diverse group of developed and

developing nations. Notably, over half the population in five RCEP developing countries resides in rural areas, with agriculture contributing a substantial share of GDP (World Bank, 2023). Agriculture also underpins food security, rural livelihoods, and export revenues, making it a critical sector for sustained growth and poverty alleviation (Etuk & Ayuk, 2021; Nhlengetfwa & Mamba, 2024).

The importance of agricultural development in RCEP countries is evident from their contributions to global food systems. In 2022, China produced one-fourth of the world's grain, feeding one-fifth of the population with under 10% of the arable land (FAO, 2024), and leads in global production of key food items, contributing significantly to the world's cereal grains, meat, and vegetables (Ghose, 2014; Qi *et al.* 2023; Wang *et al.* 2019). ASEAN dominates rice, palm oil, and various fruits and seafood exports (Mizik *et al.* 2020; Teng *et al.* 2021). Australia exports 70% of its agricultural production, including beef, wheat, and rice (Schrobbach *et al.* 2025), while is the world's largest exporter of sheep meat and an important exporter of beef (Mazzetto *et al.* 2023). Conversely, South Korea, being a major importer, underscores the strategic importance of agricultural self-sufficiency, with rice being a key focus (Cho & Yoon, 2025; Kim *et al.* 2025). Japan, with a 39% food self-sufficiency rate, is also a top agricultural importer (Feldhoff, 2014).

As urbanization accelerates and the global population grows, the proportion of non-food-producing populations is rising, intensifying the challenge of meeting food demands (de Bruin *et al.* 2021; Koch *et al.* 2018; Satterthwaite *et al.* 2010). With limited scope for expanding arable land due to urban sprawl, productivity gains are critical to meeting escalating food demands (FAO, 2009). Alarming, agricultural productivity has stagnated, with staple grain production increasing by just 1% annually, slower than population growth (Gollin, 2023; Yaqoob *et al.* 2022). Compounding these issues are external shocks such as the 2008 global food price crisis, driven by factors like biofuel demand, rising oil costs, and climate variability (Hochman *et al.* 2014; Mueller *et al.* 2011; Timilsina *et al.* 2011), and the COVID-19 pandemic, which disrupted supply chains, inflated prices, and highlighted vulnerabilities in food systems (Barman *et al.* 2021; Ben Hassen & El Bilali, 2024). These challenges underscore the urgency of advancing Sustainable Development Goal 2 (Zero Hunger) by addressing food security, malnutrition, and sustainable agriculture.

Against the above background, this study aims to investigate the relationship between agricultural productivity and economic growth in both developed and developing countries' sub-groups of RCEP, with a focus on key variables including agricultural total factor productivity (AgTFP), prevalence of undernourishment, employment in agriculture, and the incremental capital-output ratio (ICOR). It distinguishes itself from prior research by employing ICOR as a measure of capital productivity, providing a more dynamic understanding of capital efficiency in stimulating growth compared to the widely used gross capital formation (Güzel & Akin, 2021).

This study is significant as it elucidates the critical role of agricultural productivity in driving economic growth, informing policy and investment decisions, and enhancing food security. Understanding the relationship between agricultural productivity and economic growth is vital for effective economic strategies, especially in developing economies where agriculture significantly contributes to GDP. This study demonstrates how improving agricultural productivity can drive overall economic growth, providing a basis for prioritizing agricultural development in national policies. The insights help policymakers design targeted policies that enhance productivity through investments in agricultural research, infrastructure, and education, leading to growth in other sectors. By making precise policies, governments are able to allocate their financial budgets efficiently, for instance, by giving subsidies to some targeted groups or regions. At the same time, it helps policymakers make greater progress toward achieving SDG2 (Zero Hunger).

1. Literature Review

1.1 Rostow's Model of Economic Growth

Rostow's (1960) stages of economic growth provide a foundational framework for understanding the transformative role of agriculture in economic development. According to Rostow, economies transition through five stages: traditional society, preconditions for takeoff, takeoff, drive to maturity, and age of high mass consumption. Agriculture plays a critical role in the early stages by providing food security, labor, and capital for industrialization. The agricultural transformation theory posits that improvements in agricultural productivity are fundamental to economic growth (Gollin, 2023; Mellor, 2017; Peter Timmer, 1988). Higher agricultural productivity generates surplus production, which lowers food prices, boosts real incomes, and frees labor and capital to be redirected toward industrial and service sectors. Within the context of agricultural progress among RCEP countries, two distinct scenarios emerge. For developed RCEP nations, agriculture's role in GDP has significantly declined, and productivity gains frequently result in technological unemployment in rural communities rather than stimulating broader economic expansion. Conversely, for developing RCEP countries, where agriculture

continues to employ a substantial portion of the workforce, enhanced productivity remains essential for alleviating poverty and supporting structural economic transformation.

1.2 Agricultural Productivity and Economic Growth

The relationship between agricultural productivity and economic growth continues to be a central concern in development economics, especially as countries pursue inclusive and sustainable development paths. Recent studies have explored this nexus from multiple perspectives - structural transformation, financial investment, and environmental sustainability. This section critically examines three key studies that shed light on how agricultural productivity contributes to broader economic outcomes, each offering unique insights through distinct methodologies and regional contexts.

A landmark contribution by McArthur and McCord (2017) provides one of the most cited empirical validations of this relationship. Using panel regression analysis across multiple countries, the authors find that a half-ton increase in staple yields corresponds to a 14% to 19% increase in GDP per capita. This quantification highlights the powerful macroeconomic returns of even marginal improvements in agricultural productivity.

Extending this analytical tradition, Gollin (2023) adopts second-generation panel data techniques to address challenges of cross-sectional dependence - an issue often overlooked in earlier models. Employing tools such as the Durbin-Hausman cointegration test and the Common Correlated Effects Mean Group (CCEMG) estimator, on 53 middle-income countries, this study identifies strong, positive linkages between economic growth and a broad set of variables: agricultural productivity, trade openness, human capital, and gross capital formation.

Gollin (2023) presents a compelling narrative on the foundational role of agriculture in structural transformation. This study synthesizes decades of development experience to show how improvements in agricultural productivity can release labor and capital for more dynamic sectors such as manufacturing and services. They argue that increased yields and efficiency in agriculture not only contribute directly to GDP growth but also indirectly support long-term economic diversification. However, they caution that without deliberate investments in rural infrastructure, research and development, and market integration, these gains may remain isolated and unevenly distributed. Although the study is conceptually rich and grounded in strong theoretical foundations, it lacks an empirical modeling component that could have quantified the strength of the relationships it describes.

Turning to a more empirical approach, Khafagy and Vigani (2023) explores how external finance influences agricultural productivity growth. Using dynamic panel data models, the authors demonstrate that access to external finance - such as foreign direct investment, credit, and donor funding—significantly boosts agricultural performance. The findings suggest that financial inflows can enhance capital formation in the agricultural sector, enabling technological adoption, input use, and yield improvement. These productivity gains then translate into higher economic growth, especially in lower-income countries where domestic investment is limited.

Frimpong *et al.* (2024) investigates the complex interplay between agricultural development, CO₂ emissions, food security, and economic growth in West Africa. Employing a panel ARDL model, the researchers analyze data from 14 countries over three decades to identify both short- and long-term trends. Their findings confirm that agricultural advancements have a positive effect on economic growth, but they also draw attention to the environmental costs, particularly in terms of increased carbon emissions.

There are several notable gaps that remain evident in the existing literature. Firstly, the studies reviewed often have limited geographic and temporal coverage, resulting in insufficient comprehensive comparative analyses across multiple regions (Coelli & Rao, 2005; Dzanku *et al.* 2015; Headey *et al.* 2010). Secondly, methodological inconsistencies complicate direct comparisons and synthesis of results, highlighting the necessity for standardized or multi-method comparative studies to validate and enhance robustness (Fuglie, 2012; L. Yuan *et al.* 2021). Finally, variability in the selection and measurement of key variables creates further challenges in synthesizing research outcomes, underscoring the need for standardized proxies to more accurately assess the relationships between agricultural productivity and economic outcomes (Alston *et al.* 2009; Ball *et al.* 2001; Evenson & Fuglie, 2010).

2. Materials and Methods

2.1 Data Description

Table 1 depicts variables, indicator names, unit measurements, and sources of data. A 24-year sampling period taken is 2001-2024. The acquired data is then evaluated using EViews and Stata software. A series of data panel analyses are performed on two models. Model 1 represents the developed countries group of RCEP (Republic of

Korea, Japan, Singapore, Australia, and New Zealand), whereas Model 2 represents the developing countries group of RCEP (China, Myanmar, Vietnam, Lao PDR, Thailand, Cambodia, Malaysia, Philippines, Indonesia, and Brunei Darussalam).

Table 1. Data Description

Variables	Indicator name	Unit Measurement	Source
Gross domestic product per capita	GDPPC	Current US\$	World Bank
Agricultural total factor productivity	AgTFP	-	United States Department of Agriculture (USDA)
Prevalence of undernourishment	U	Population	Our World in Data U=(% of undernourished population x total population)
Employment in agriculture	ER	% of total employment	World Bank
Incremental capital-output ratio (ICOR)	kr	-	ICOR=(Average Annual Imports of Agricultural Machinery and Tractors in GDP)/(Average Annual Growth Rate of GDP)

3. Methodology

Panel Unit Root Tests

Prior to conducting a panel cointegration test, a panel-data unit root test must first be performed so as to examine the stationarity of the dataset of the selected variables. For the purpose of examining the stationarity of the dataset for variables, the ADF-Fisher test, LLC test, and IPS test will be used in this work.

Panel Autoregressive Distributed Lag Model (ARDL)

When the outcomes obtained from the tests conducted on panel unit roots indicate that there is a combination of $I(0)$ and $I(1)$ with no $I(2)$ variable, the panel ARDL model (including Pooled Mean Group (PMG)) will be proceeded with. Sogah *et al.* (2024) highlighted that the panel ARDL model is a contemporary approach for testing cointegration among variables. It is employed to estimate the short- and long-run linkages among agricultural productivity-related variables and economic growth in this study. Pesaran *et al.* (1999) developed the models below:

Long-run relationship models of PMG:

$$\ln GDPPC_{i,t} = \mu_i + \sum_{j=1}^p \lambda_{i,j} \ln GDPPC_{i,t-j} + \sum_{j=1}^q \delta_{i,j} AgTFP_{i,t-j} + \sum_{j=1}^q \delta_{i,j} U_{i,t-j} + \sum_{j=1}^q \delta_{i,j} ER_{i,t-j} + \sum_{j=1}^q \delta_{i,j} kr_{i,t-j} + \varepsilon_{i,t} \quad (1)$$

The short-run relationship and ECM:

$$\Delta \ln GDPPC_{i,t} = \mu_i + \varphi_i (\ln GDPPC_{i,t-1} - \lambda_1 AgTFP_{i,t} - \lambda_2 U_{i,t} - \lambda_3 ER_{i,t} - \lambda_4 kr_{i,t}) + \sum_{j=1}^p \lambda_{i,j} \ln GDPPC_{i,t-j} + \sum_{j=1}^q \delta_{i,j} AgTFP_{i,t-j} + \sum_{j=1}^q \delta_{i,j} U_{i,t-j} + \sum_{j=1}^q \delta_{i,j} ER_{i,t-j} + \sum_{j=1}^q \delta_{i,j} kr_{i,t-j} + \mu_{i,t} \quad (2)$$

where j represents optimal time lag; μ_i represents a fixed effect.

Panel Dynamic Ordinary Least Square (DOLS)

DOLS is employed for a robustness check. Kao and Chiang (2001) suggested DOLS in making long-run estimations for panels that are cointegrated. DOLS is a parametric method that incorporates lags and leads to tackling the issue without concerning the integration order or the presence of cointegration. DOLS was used because it is robust in circumstances when there is a small size of the sample.

Panel Threshold Model

The study makes the assumption that agricultural productivity has a major impact on economic growth, that this impact is featured as nonlinear and possessing a threshold effect, and that the level of capital efficiency that is represented by ICOR is the key variable in the threshold effect. This study employs ICOR as the threshold variable, as it can influence how much the AgTFP impacts economic growth. The functional link between the two variables and the threshold effect can be examined via the threshold effect model (Liu *et al.* 2020). In this study,

the panel threshold model suggested by Hansen (1999) will be used. The model's fundamental structure is as outlined below:

$$\ln GDPPC_{i,t} = \mu_i + \beta_1 AgTFP_{i,t} I(ICOR_{i,t} < \gamma) + \beta_2 AgTFP_{i,t} I(ICOR_{i,t} \geq \gamma) + \varepsilon_{i,t} \quad (3)$$

where threshold variable $ICOR_{i,t}$ represents capital efficiency; γ represents the estimated threshold value; and these regimes are distinguished by having various regression slopes (β_1 and β_2).

4. Empirical Results and Discussions

Panel Unit Root Tests

Tabl 2. Results of Panel Unit Root Tests

Model 1: Developed countries						
	Level (Trend and Intercept)			First Difference (Intercept)		
	LLC	IPS	ADF-Fisher	LLC	IPS	ADF-Fisher
LGDPCC	-2.906961***	-1.365205*	15.283007	-5.378566***	-5.289641***	46.129161***
LAgtFP	1.353624	-0.993535	12.884719	-4.096529***	-5.896838***	51.22007***
LU	-3.853409***	-2.957878***	26.102686***	-7.310503***	-6.861877***	60.901557***
LER	-3.072742***	-2.265354**	25.818714***	-6.502155***	-6.330428***	55.676613***
kr	-3.788048***	-2.724613***	23.417731***	-7.960905***	-7.956537***	70.445916***
Model 2: Developing countries						
	Level (Trend and Intercept)			First Difference (Intercept)		
	LLC	IPS	ADF-Fisher	LLC	IPS	ADF-Fisher
LGDPCC	0.167015	3.168182	6.220384	-3.493892***	-3.214809***	44.106393***
LAgtFP	-0.700774	-0.285502	20.221806	-4.097337***	-5.38241***	65.745209***
LU	-0.482065	-0.543136	21.389954	-0.232119	-2.14128**	31.67354**
LER	2.229794	1.528828	11.342588	-2.214187**	-5.089794***	63.002715***
kr	-2.482542***	-4.716233***	58.388745***	-8.469802***	-13.476415***	170.257849***

Note: The asterisk (***) indicates the significance level is 1%, (**) indicates the significance level is 5%, and (*) indicates the significance level is 10%.

Table 2 depicts the results of panel unit root tests: LLC, IPS, and ADF-Fisher, at level and first difference for the LGDPCC, LAgtFP, LU, LER, and kr in two types of models: the intercept model and the intercept and trend model. For Model 1, in the LLC and IPS tests, all variables, except LAgtFP, are stationary at the level; and in the ADF-Fisher test, LU, LER, and kr are stationary at the level. However, all variables are stationary at the first difference in three tests. In brief, in the LLC and IPS tests, LGDPCC, LU, LER, and kr are integrated of order of 0, $I(0)$, whilst LAgtFP is integrated of order of 1, $I(1)$; and in the ADF-Fisher test, LU, LER, and kr are $I(0)$, whereas LGDPCC and LAgtFP are $I(1)$.

For Model 2, in the LLC test, kr is $I(0)$, whilst LGDPCC, LAgtFP, and LER, are $I(1)$; and in the IPS and ADF-Fisher tests, kr is $I(0)$, while LGDPCC, LAgtFP, LU, and LER are $I(1)$.

In LLC, IPS, and ADF-Fisher unit root tests, a mixture of $I(0)$ and $I(1)$ is found. Therefore, the ARDL test is employed.

Panel ARDL Test

The results of the panel PMG estimator for the coefficients of short- and long-run estimates are shown in Table 3. In the PMG estimator, for long-run estimates of Models 1 and 2, the rejection of the null hypotheses for all variables, which are LAgtFP, LU, LER, and kr, is revealed. This finding serves as evidence for the long-run linkage between the variables.

In Model 1, the coefficient of ECT is -0.1108, which means that in the upcoming years, about 11.08% of the disequilibrium of the earlier year is adjusted. In addition, after improving agricultural productivity-related variables, any change in the long-run relationship between agricultural productivity-related variables and GDPPC will take about 9.0245 years to be corrected. Furthermore, in Model 2, the ECT coefficient of -0.0965 is shown.

Table 3. Result of Panel ARDL

	Model 1: Developed countries	Model 2: Developing countries
PMG		
Long-run estimates:		
LAgTFP	-3.305552***	1.690775***
LU	-12.615051***	-0.795739***
LER	-0.586702***	2.608488***
kr	0.018942*	-0.264519***
Short-run estimates:		
Δ LAgTFP	-0.195183	0.217436
Δ LU	-	-0.357020
Δ LER	-	1.196083*
Δ kr	-	-4.978511
ECT-1	-0.110810**	-0.096541**

Note: The asterisk (***) indicates the significance level is 1%, (**) indicates the significance level is 5%, and (*) indicates the significance level is 10%.

DOLS Test

Table 4. Result of DOLS

	Model 1: Developed countries	Model 2: Developing countries
DOLS		
	Long-run estimates:	Long-run estimates:
	Coefficient	Coefficient
LAgTFP	-1.082997*	-0.620487**
LU	-2.993600**	-0.608929***
LER	-1.634753***	-1.099399***
kr	0.869657*	-0.379326**

Note: The asterisk (***) indicates the significance level of 1%, (**) the level of 5%, and (*) the level of 10%.

Table 4 demonstrates the DOLS test's result for long-run estimates of Models 1 and 2. In Model 1, kr is significantly and positively linked to LGDPPC, whereas LAgTFP, LU, and LER have significant and negative effects on LGDPPC. For the DOLS test of Model 2, the results show that all variables have significant and negative linkages with LGDPPC.

For Model 1, the DOLS equation derived from Table 4 is expressed as follows:

$$\ln(\text{GDPPC}) = 0.8697\text{kr} - 1.0830\ln(\text{AgTFP}) - 2.9936\ln(\text{U}) - 1.6348\ln(\text{ER}) \quad (4)$$

This indicates that in the long run, a 1-unit increase in kr will result in a 0.8697-unit increase in GDPPC. AgTFP, U, and ER increases of 1 unit will cause declines in GDPPC of 1.0830 units, 2.9936 units, and 1.6348 units, respectively, in the long run.

For Model 2, the DOLS equation derived from table 4 is expressed as follows:

$$\ln(\text{GDPPC}) = -0.6205\ln(\text{AgTFP}) - 0.6089\ln(\text{U}) - 1.0994\ln(\text{ER}) - 0.3793\text{kr} \quad (5)$$

This depicts that an increase in AgTFP, U, ER, and kr by 1 unit will result in shrinks of GDPPC by 0.6205 units, 0.6089 units, 1.0994 units, and 0.3793 units, respectively.

In Model 2, AgTFP shows a positive coefficient in the ARDL test, but a small negative coefficient in the DOLS test. In addition, ER is revealed to have a negative and significant impact on GDPPC in the DOLS test, which contradicts the result of the ARDL test that ER has a positive and significant impact on GDPPC. The reasons and decisions for the final result of these variables will be discussed in the section on the discussion of major findings.

4.1 The Relationship between Agricultural Total Factor Productivity and Economic Growth and Evidence

The expected and actual outcomes for the relationship between AgTFP and economic growth in Model 1 (developed countries) are inconsistent, but some studies validate the observed negative link (Fuglie, 2018). As depicted in the results of both ARDL and DOLS tests for Model 1, in advanced economies, AgTFP is negatively linked to GDPPC. Morkunaite (2019) explicated that the decline in AgTFP can be caused by the capital abundance of developed economies due to rapid capital accumulation over the past few decades. This situation can be explained by the law of diminishing marginal returns. Structural transformations, which have reduced agriculture's share of GDP and caused rapid withdrawal of the labor force from agriculture, also lead to diminishing returns of AgTFP (Fuglie, 2018). The slower pace of productivity-enhancing technological advancements, coupled with challenges such as climate change, extreme weather, and new pests and diseases, further limits gains (Chandio *et al.* 2024; Gornall *et al.* 2010; Yuan *et al.* 2024). Despite these challenges, economic growth continues as developed countries rely more on non-agricultural sectors for GDP growth.

For Model 2 (developing countries), the findings of the ARDL test confirm that AgTFP has a positive linkage with economic growth, supported by previous research (Ansari *et al.* 2022; Güzel & Akin, 2021). Developing countries can benefit from increased agricultural productivity, as agriculture is a key source of economic growth. Increased AgTFP raises agricultural revenues, improves living standards, and reduces food costs, benefiting low-income consumers (Mellor, 2017; Schneider & Gugerty, 2011). Additionally, higher productivity supports tax revenue and infrastructure development while stimulating industrial demand and real wage growth.

While the ARDL test shows a positive link between AgTFP and GDPPC, the DOLS test indicates a small negative coefficient, suggesting that infrastructure and market access constraints can limit productivity gains. Local markets are oversupplied, due to farmers' inability to access markets, and storage or transport infrastructure is insufficient, due to a lack of infrastructure investment, resulting in reduced incomes and slow economic growth (Hollaus *et al.* 2022; Raza *et al.* 2024). This implies that if these unfavorable conditions are improved, AgTFP will show a positive relationship with GDPPC. AgTFP is believed to be positively linked to GDPPC in the long run.

The relationship between AgTFP and GDPPC is compared between developed and developing countries. In advanced economies, capital saturation limits further productivity gains, and agricultural output contributes a smaller share to overall economic growth, whereas in developing economies, agriculture remains a primary driver of economic growth, with room for significant productivity improvements. This contrast highlights how agricultural total factor productivity (AgTFP) plays a diminishing role in driving growth in developed countries but remains a crucial lever for accelerating income convergence in developing economies.

4.2 The Relationship between Prevalence of Undernourishment and Economic Growth and Evidence

For Models 1 and 2, as analyzed by ARDL and DOLS tests, the prevalence of undernourishment is negatively linked with economic growth. Mary (2018) and Soriano and Garrido (2016) suggest that individuals suffering from undernourishment are less productive, both physically and mentally, which hampers their ability to work effectively. Furthermore, children are less likely to reap the benefits of education (due to slow cognitive development and increased school absenteeism), which can have a long-term impact on their ability to contribute to the economy.

The prevalence of undernourishment has a larger negative impact on economic growth in developed countries due to higher opportunity costs and reliance on human capital-intensive industries. Undernourishment reduces productivity in high-value sectors, leading to substantial economic losses and amplified ripple effects in interdependent industries (Lentz & Barrett, 2013). Its occurrence often signals systemic issues, such as inequality, further affecting labor markets. Additionally, strain on social safety nets and healthcare systems diverts resources from productive investments, worsening the economic impact (World Bank, 2025). In contrast, in developing countries, undernourishment limits productivity but has a smaller impact on economic growth due to lower baseline productivity and less interconnected economic structures.

In developing countries, undernourishment impacts economic growth less severely due to structural differences. Agriculture and labor-intensive industries dominate, and while undernourishment reduces individual productivity, its effect on overall output is moderated by the already low productivity baseline. Additionally, undernourishment is often normalized within existing constraints, making its impact less disruptive to growth patterns compared to developed economies. Moreover, the limited interconnectedness of sectors in developing countries reduces the ripple effects of undernourishment. However, it exacerbates challenges like poor health and education, hindering long-term human capital development and transitions to higher-value sectors (FAO,

2003; Victora *et al.* 2008). Without robust social safety nets, the burden falls directly on individuals, perpetuating cycles of poverty and limiting structural transformation. Addressing undernourishment requires targeted interventions in nutrition, infrastructure, and human capital to mitigate its impact and support economic development.

4.3 The Relationship between Employment in Agriculture and Economic Growth and Evidence

The ARDL and DOLS tests for Model 1 and the DOLS test for Model 2 demonstrate that agricultural employment negatively impacts economic growth. In developed countries, mechanization, advanced technologies, structural transformation, and urbanization reduce agricultural employment as high-tech industries attract labor (World Bank, 2019). In developing countries, low agricultural productivity persists due to limited access to modern technology, poor infrastructure, and traditional farming practices, with slower structural shifts, lower productivity, and lower educational and skill levels hindering transitions to higher-paying jobs (FAO, 2017; Raza *et al.* 2024; World Bank, 2019).

The ARDL test for Model 2 reveals a positive relationship between agricultural employment and economic growth. An increase in agricultural employment can lead to an increase in agricultural output, promote rural development, bring about an increase in food production and household income, which can help address issues of food insecurity and malnutrition, and increase demand for goods and services in other sectors of the economy (Schneider & Gugerty, 2011). Although the results differ from those of the DOLS test, the ARDL test is prioritized because its higher significance level increases the possibility of detecting the effect of independent variables on the dependent variable. Actions that improve conditions will not harm society even if the effect may not exist.

When comparing the relationship between employment in agriculture and GDPPC among these two subgroups, advanced economies benefit from mechanized agriculture, reducing the need for labor-intensive farming. In contrast, dual nature reflects the ongoing structural transformation in developing countries, where agriculture still employs a significant labor force.

4.4 The Relationship between Incremental Capital-Output Ratio and Economic Growth and Evidence

The ARDL and DOLS tests for Model 1 show that ICOR is positively linked to economic growth. The increase in ICOR suggests a decline in capital productivity. This result reflects diminishing marginal returns to capital, as rising capital per worker reduces productivity (Morkunaite, 2019). This is because workers are unable to utilize the full capacity of additional capital. In developed countries, abundant capital and a shift of labor to other sectors maintain economic growth despite declining capital productivity. Other factors, such as a rising debt burden that surpasses their annual GDP, an increasingly older population, substantial social security outlay, income inequality, corporate avarice, limited fiscal flexibility due to excessive spending, and a lack of progress in innovation processes, further limit productivity (Awan & Khan, 2015).

The ARDL and DOLS tests for Model 2 show a negative relationship between ICOR and economic growth. A decrease in ICOR reflects improved capital productivity, driven by the adoption of efficient agricultural machinery and credit programs that enhance farm output (Czubak & Pawłowski, 2024; Meng *et al.* 2024; Ojo *et al.* 2020). Emerging economies have experienced growth since the 2000s due to factors such as decreased foreign debt, local resource dependence, and the influx of multinational corporations. This has created job opportunities, fostered innovation through advanced technology, and increased per capita income and living standards. As a result, poverty rates have declined, and educational levels have shown significant improvement. This growth is attributed to the substantial market sizes and the influx of foreign direct investment (Ibarra-Olivo *et al.* 2024).

When comparing the linkage between ICOR and GDPPC among the subgroups, it can be seen that for advanced economies, high ICOR reflects inefficiencies in capital utilization due to capital saturation in the agricultural sector. However, developing economies experience significant gains from capital investments as they transition from labor-intensive to capital-intensive farming practices.

Panel Threshold Model

Table 5 exhibits the result of the panel threshold model. In the panel threshold model, ICOR, which indicates capital efficiency, is employed as the threshold variable.

For Model 1 (developed countries), when the value of kr is below the threshold ($kr < 0.01891$), $LAGTFP$ has a positive impact on $LGDPPC$ ($\beta_1 = 2.3828$). This indicates that a 1-unit increase in $LAGTFP$ will result in a 2.3828-unit increase in $LGDPPC$. When capital productivity is high (low kr), $AgTFP$ positively impacts economic growth to a lower degree. This implies that at low kr , a rise in $AgTFP$ contributes less to economic growth

compared to the situation at high kr . In high capital productivity contexts (low kr), the positive impact of AgTFP is limited by diminishing marginal returns, as additional capital investments yield lower output gains due to the saturation of capital inputs (Morkunaite, 2019). Developed countries have effectively leveraged significant investments in technologies, equipment, and infrastructure, but further productivity increases are constrained by this saturation.

Table 4. Result of Panel Threshold Model

Variable	Model 1	Variable	Model 2
LAgTFP ($KR < 0.018911$) (Low kr)	2.382774***	LAgTFP ($KR < 0.0244$) (Low kr)	2.447576***
LAgTFP ($KR \geq 0.018911$) (High kr)	2.43755***	LAgTFP ($KR \geq 0.0244$) (High kr)	2.376709***
LU	-0.375399	LU	-0.388068***
LER	-0.105527***	LER	-0.692971***
kr	-0.022364**	kr	-0.014184

Note: The asterisk (***) indicates the significance level of 1%, (**) the level of 5%, and (*) the level of 10%.

On the other hand, when the value of kr exceeds or equals the threshold ($kr \geq 0.01891$), LGDPPC is positively influenced by LAgTFP ($\beta_2 = 2.4376$), with an increment of 1 unit in LAgTFP corresponding to 2.4376 units rise in LGDPPC. When capital productivity is low (high kr), AgTFP positively impacts economic growth to a higher degree in Model 1. In low capital productivity environments (high kr), opportunities for technological diffusion and adoption are greater, leading to more transformative productivity gains. Advanced technologies improve agricultural efficiency, sustainability, and resilience, contributing to broader economic growth through higher rural incomes, labor absorption, and multiplier effects (Daum, 2023; Tan *et al.* 2022). These improvements stimulate demand for goods and services in both rural and urban economies. Further discussing the linkage, in the agricultural sector with low capital productivity, labor is a more abundant factor of production. Improvements in AgTFP can lead to increased agricultural output, which in turn can absorb surplus labor, reduce unemployment or underemployment and contribute to overall growth. Since most rural residents who engage in agricultural activities can benefit from the increase in AgTFP, it could also result in better rural incomes.

For Model 2 (developing countries), when the value of kr is below the threshold ($kr < 0.0244$), LAgTFP positively affects LGDPPC ($\beta_1 = 2.4476$), with a 1-unit rise in LAgTFP translating to a 2.4476-unit rise in LGDPPC. When capital productivity is high (low kr), AgTFP has a higher level of positive impact on economic growth. This outcome is attributable to the amplification of productivity gains due to efficient resource utilization and amplified technological adoption (FAO, 2017). In such environments, agricultural improvements boost national income and economic growth by enabling better allocation of limited resources, increasing efficiency and technological advancement, and strengthening the comparative advantage of agriculture in rural regions. Moreover, investment incentives are the reasons that bring about this result. A higher level of agricultural capital productivity can attract more investments into the agricultural sector. When AgTFP improves, it signals to investors that the sector is responsive to technological advancements and has the potential for further growth, leading to increased capital flows and expansion. Apart from these factors, export competitiveness is also considered to be a contributing factor. Arifah and Kim (2022) pointed out that improved AgTFP in the context of high agricultural capital productivity can enhance the competitiveness of agricultural exports, as a higher quantity of output can be sold to the markets at lower prices. This can contribute to foreign exchange earnings and stimulate overall economic growth through increased trade.

On the contrary, when the value of kr exceeds or equals the threshold ($kr \geq 0.0244$), LGDPPC is positively impacted by LAgTFP ($\beta_2 = 2.3767$), demonstrating that when LAgTFP increases by 1 unit, there is an accompanying increase of 2.3767 units in LGDPPC. When capital productivity is low (high kr), AgTFP has a lower level of positive impact on economic growth in Model 2. This reflects challenges like insufficient infrastructure and equipment, limited access to advanced technologies, and resource constraints. Barriers to technology adoption and financing, such as poor credit access and market imperfections, prevent farmers from fully capitalizing on productivity improvements. In reference to financial obstacles, Khan *et al.* (2024) argued that farmers require capital to initiate and expand their businesses, transforming them into prosperous ventures. Unfortunately, they frequently encounter difficulties in obtaining credit or financing, mainly due to lenders' limited comprehension of their specific requirements. In addition, as expounded by Jack (2013) and Khan *et al.* (2024), there are several market imperfections that hinder the adoption of agricultural technology: externalities and inefficiencies in input

and output markets, land markets, labor markets, credit markets, risk markets, and information. These limitations underscore the need for investments in infrastructure, financial systems, and technology to maximize AgTFP's contribution to economic growth.

Conclusion and Policy Recommendation

Panel ARDL and DOLS revealed long-term linkages between variables, and panel threshold analysis illustrated the non-linear and discontinuous effects of specific factors (variables) or policies on economic outcomes, achieving the study's objectives.

This study explores the relationship between agricultural productivity and economic growth among RCEP member countries, revealing contrasting impacts in developed and developing economies. In developed countries, agricultural productivity is limited by diminishing returns and capital saturation, necessitating policies focused on sustainability, innovation, and high-value product diversification. In developing countries, agriculture remains a key driver of growth, requiring improved market access, infrastructure, and technology adoption to unlock its potential. Variables such as the incremental capital-output ratio (ICOR), prevalence of undernourishment, and employment in agriculture reveal significant differences in how structural, cultural, and institutional factors shape these outcomes.

Trade integration under the RCEP framework presents opportunities for both groups through technology transfer, investment, and market expansion. Tailored policies are essential to address unique challenges and leverage agricultural productivity for economic growth, poverty reduction, and food security, contributing to the achievement of Sustainable Development Goals.

To address the cultural, political, and institutional dynamics in **developed RCEP countries**, policies should focus on enhancing sustainability and innovation. Governments can promote sustainable agricultural practices through incentives for low-emission techniques, regenerative farming, and precision agriculture. Strengthening public-private partnerships to advance R&D in automation, biotechnology, and digital tools can drive innovation, while diversifying into high-value and niche agricultural markets, such as organic and specialty goods, can maximize returns. Trade policies should leverage the RCEP framework to expand export opportunities by supporting farmers in meeting international standards. Additionally, workforce transition programs can help aging or displaced agricultural workers move into high-value roles in agri-tech or other sectors, fostering economic diversification.

For **developing RCEP countries**, policies must address structural barriers and enhance market access. Investments in rural infrastructure, such as roads, storage facilities, and irrigation systems, are critical to reducing post-harvest losses and improving connectivity to markets. Expanding access to credit through microfinance schemes and government-backed guarantees can enable smallholder farmers to adopt modern technologies and improve productivity. Agricultural training programs focusing on climate resilience, resource optimization, and sustainable practices should be prioritized to build farmer capacity. Policies that encourage technology adoption, such as subsidies for agricultural machinery and digital tools, can help bridge technological gaps. Strengthening land tenure systems and introducing regional trade hubs under the RCEP framework can further boost productivity and competitiveness. Attracting foreign direct investment in agriculture through tax incentives and streamlined regulations will also help developing nations integrate into global value chains and foster sustainable economic growth.

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Credit Authorship Contribution Statement

Thong Ching Ling: Conceptualization, Investigation, Methodology, Software, Formal analysis, Writing – original draft, Data curation, Validation, Writing – review and editing, Visualization.

Mohammad Affendy bin Arip: Conceptualization, Software, Supervision, Writing – review and editing, Funding acquisition.

Thong Chien Ling: Conceptualization, Investigation, Methodology, Software, Formal analysis, Data curation, Validation, Writing – review and editing.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Declaration of Use of Generative AI and AI-assisted Technologies

The authors declare that they have not used generative AI and AI-assisted technologies during the preparation of this work.

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Exchange, Property Rights and Transaction Cost: An Institutional Analysis

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Abstract: The aim of this paper is to try to highlight that no social system is able to function if it is based only on networks of free contracts stipulated between legally equal contractual parties, and in which each party is supposed to be guided exclusively by its own utilitarian ends. In any developed exchange system, non-contractual components are of fundamental importance. A pure exchange system based solely on contractual relations may not work in practice.

However, even if there are non-contractual elements in a contract, these elements do not totally govern transactions. In a modern market economy, the rational calculation of profit and loss is the focus of analysis, but it is possible to criticise the claims of neoclassical economists to conceive rationality as unlimited in its scope. Thus, it is argued that in modern society the analysis of exchange should be conducted through the examination of the symbiotic relationship existing between contractual and non-contractual elements.

Keywords: transaction costs; property rights; exchange; institutional theory.

JEL Classification: B15, B52, D23, D86.

Introduction

Exchange is not only a mutual transfer of goods, services or money between individuals, but also a transfer of property rights. The concept that transactions affect property rights comes from Commons (1950, 48-49).

This concept of exchange was criticised by Von Mises (1949), who defined it as an attempt to replace a more satisfactory state of affairs with a less satisfactory one, without taking property rights into account. This concept of exchange is so broad as to also include production. The claim that production is an exchange with nature also appears in the neoclassical conception (Hirshleifer 1970). Blau (1964, 93) is also in favour of an extended concept of exchange; in fact, he states that exchange considers human intentional action but involves a theory in which a large number of social activities of a voluntary nature are referred to as acts of exchange. Blau identifies an important distinction between social and economic exchange, defining the latter as an exchange based on a formal contract by which the exact quantities to be exchanged are decided. Blau's economic exchange can be referred to what Simon (1951) describes as the sale agreement. However, Simon goes further and shows that there are other contractual arrangements in the economic scenario that do not fall into this category. Thus, Blau's definition of economic exchange corresponds to a narrow category of transactions; that of social exchange is, in contrast, too broad and without a specific meaning, as Sahlins (1972) states.

Hodgson's (1991, 210-211) orientation is different, as he states that a system of commodity exchange requires a combination of both state and customary institutions. In any developed system of mercantile exchange, there must be a system of laws that defines and protects individual and collective property rights; there must be a body of laws that can regulate contracts, establishing criteria to distinguish voluntary from involuntary transfer of goods and services.

In particular, to fully consider the criteria of consent and agreement and to assume a rational intention for all exchanges is to take an extreme position (Baily 1974). In many cases, it is not easy to detect the presence of

intention and consent. For this purpose, in social life, the use of recognised signs and signals is employed: a yes, a nod of assent with the head. Such signs are embedded in customs and rules and depend on their context. Thus, bringing products to the checkout counter of a supermarket is a signal of intention to buy at the prices displayed; in an auction a nod of assent signals the intention to buy an item, offering the last declared price increased by something. In this case, intention and consent are institutionalised in symbols and customary practices.

Thus, in any developed exchange system the non-contractual components are important, and in this paper, it is argued that no social system is able to function if it is based only on networks of free contracts stipulated between legally equal contractual parties, and in which each party is supposed to be guided exclusively by its own utilitarian ends.

1. Individual Property Rights

The property rights school takes its cue from the work of a number of economists such as, for example, Coase (1960), Demsetz (1967) and Alchian and Demsetz (1972). They argue that government intervention is not an effective way to deal with externalities. In fact, for them the solution lies in respecting a well-defined system of individual property rights. The main argument here concerns the creation of a system of individual costs and benefits. Demsetz (1967) states that an important function of property rights is to regulate incentives in order to achieve greater internalisation of externalities. This represents the application of the classical liberal postulate that the individual is the best judge of his own welfare, thus displacing one of the arguments in favour of state intervention in the economy (Randall 1978).

With the introduction of individual incentives and disincentives (in the form of property rights) in areas where they do not exist, it is thought that the scope of government intervention narrows and individuals are freer to assess costs and benefits on their own behalf and, thus, act accordingly. Naturally, a decrease in direct state intervention coincides with an increase in indirect intervention. By widening the perimeter of influence of formal possession and ownership, the state must continue to intervene, but in a different way, i.e. through the enlargement of procedural activity (Hodgson 1991, 213).

However, as Macpherson (1962) states, considering the extension of property rights as a phenomenon involving increasing state intervention in civil society does not fall within the orientation of classical liberalism or even orthodox economics. Remaining within the liberal tradition does not realise that the extension of well-defined property rights may not represent a means of diminishing state intervention; for by extending formal property relations, the state becomes even more involved in the relations of social life. For example, if there are no strict laws against pollution, every individual faces potential and actual lawsuits.

The assertion that the extension of formal property rights and the enlargement of commodity exchange relations lead to a retreat of the state from social life has been criticised by Polanyi (1944, 140-141). In fact, he brings as an example the development of market relations in Great Britain during the 18th and 19th centuries, where the free market found great help precisely from increased state interventionism. Thus, when it was thought to free the state from unnecessary obligations through its disempowerment, the state itself was entrusted with the new powers, organs and instruments that the affirmation of *laissez-faire* required.

The property rights theorists of the classical liberal tradition affirm the existence of a marked distinction between politics and economics and between the state and civil society. According to them, the state performs the function of guardian of private interests, i.e. it judges only when necessary; it controls civil society but does not confuse itself with it. Civil society is seen as separate from the state, i.e. as the sum of isolated, rational individuals who carry out exchanges and accumulate wealth (Althusser 1971).

Considering civil society as subservient to the state or, on the contrary, entirely separate is open to criticism. As Stepan (1978) has shown, the structural relationship is more complex. Indeed, according to him, the state must be regarded as more than government, since it consists of administrative, legal, bureaucratic and coercive systems, which not only seek to order the relations between civil society and public authority in the polis, but also to structure fundamental relations within civil society.

2. Williamson and the Orthodox Economic Theory

From a theoretical point of view, Williamson (1986) thinks that in order to fill the void created by the exclusion of the state from the analysis, certain guarantees are needed that can support the exchange process. A guarantee is understood to be a series of agreements whereby, for example, both parties to a contract undertake to bear specific, stranded costs. The intention is to strengthen the bond between the two parties and to minimise the possibility of default before termination of a contract. In addition, other arrangements are considered, such as the

agreed arbitration procedure, which facilitates bargaining without recourse to the formal legal apparatus. Therefore, according to Williamson (1984), a system of exchanges and contracts is possible and sustainable even in the absence of the state.

Following the liberal tradition, Williamson (1985) has in mind a 'state of nature' from which state sovereignty is eliminated; therefore, he states that social order and cohesion are conceivable through individuals who behave selfishly. Williamson's models of contractual behaviour involve a selfish version of the neoclassical homo oeconomicus, i.e. an agent who is not altruistic, but opportunistic. Opportunism is identified with the pursuit of one's own interest, which is slyly pursued.

The legitimising function that the legal apparatus performs for exchange activity and other social relations is neglected; however, the basis of agreements is not the rational calculation that individuals make of benefits and costs, it is, instead, provided by a combination of both legislation and formal legitimation and inherited customs and traditions of a less formal nature. Unlike the concept of the rational homo oeconomicus, each individual is surrounded by a series of customs and traditions that reflect the complex relationship between state and society (Morselli 2022).

Organisational arrangements and institutional forms direct action and structure social, political and economic interaction between individuals. Any economic phenomenon can be analysed as a product of the interaction between interdependent units, making it easier to overcome the traditional disciplinary boundaries between the different social sciences. (Boudon 1989, 630).

The notion of property rights and exchange, common to neoclassical economic analysis and legal doctrine, can be declined differently within institutional theory. This theory introduces an element of fundamental importance, namely the idea that every form of social interaction has costs called transaction costs (Vannucci 2004, 89).

3. Non-Contractual Features of Exchange Agreements

A contract, in essence, is the result of the intentions and agreement of two or more individuals. However, can a contract only concern the rational wishes and calculations of the parties involved? Durkheim (1984, 154-155) emphasises the need to introduce non-contractual elements into all social relations, even when markets are developed; a contractual agreement involves factors that cannot be attributed to the intentions or agreements of individuals. Durkheim's thesis (1984, 161) states that in all contracts there is a set of binding rules with respect to which there is no detailed reference by the contractual parties. Some of these rules are legal in nature, therefore, in this context, the contractual parties accept the general rules of the legal system, despite the fact that no agent can be fully aware of all the laws considered. The law binds us to honour obligations for which we have not contracted, since we have not deliberated on them or, in some cases, were not aware of them in advance.

All contracts include an element of uncertainty, since they are subject to various eventualities to which no calculable probability can be assigned. In this regard, it is possible to consider the considerations of two post-Keynesian economists, Williams and Findlay (1986), who argue that since rights and obligations can only be expressed in terms of a set of ex ante valid states of nature, no perfect contract can be written.

In a world where it is not possible to know all possible outcomes, it is undesirable to overcome, through bargaining, all or most of the uncertainty about the future. In the presence of uncertainty, we find ourselves referring to institutional rules and pre-established models of contracting; therefore, the content of a contract between two parties often indicates an explicit or implicit reference to a set of norms, customs and rules, rather than a detailed negotiation on any clause and eventuality (Durkheim 1984, 162).

According to Parsons (1937, 312), those who remain within the classical tradition pay particular attention to the reinforcement of the terms of the contractual agreement, while of an opposite orientation is Durkheim who emphasises the existence of a body of rules that have not been the subject of any agreement between the contractual parties themselves.

It is difficult to find a contract in reality for which uncertainty can be eliminated, and all future circumstances can be foreseen at the outset, so the non-contractual features of exchange agreements are important and functional for any economic system.

4. Information in a Complex Modern Economy

According to Machlup (1962), it is incorrect to regard information as a commodity like any other. For example, when information is sold, any buyer can resell it at a lower price than when it was purchased. Moreover, even if it is sold, it still remains in the possession of the producer or seller, who continues to know its content even after the

sale; therefore, the information does not correspond to the image of a 'normal' good that passes from seller to buyer.

If we consider the demand side we find other problems; as Arrow (1962) states, in the formulation of the demand for information there is a paradox of fundamental importance: for the buyer the value of the information is unknown until he possesses it, but by the time he knows it he would, in fact, have acquired it at zero cost. Consequently, pure contracts governing the exchange of information are generally not feasible. For instance, there will be a certain level of trust that must be placed in the seller as to whether the information is worth its price. The peculiarities of information develop a whole range of restrictions and imperfections; patent registration, for example, is a mechanism by which technical information is protected by legal and institutional constraints.

For Hodgson (1991, 227-228), a common phenomenon is to regard information as a gift. Many sources of information are free, such as, for example, bus timetables and trade catalogues. In the purchase of goods, there is usually a certain amount of free information, offered by the seller about the characteristics; if this information were denied, we would be suspicious about the qualities of the good. Thus, in several cases of contractual relations, elements of free exchange on the information side are emphasised.

Simon (1951) argues that most employment contracts display the characteristic of not specifying in a perfect and complete manner the nature of the tasks to be performed. This gap is filled by an extensive range of conventions and unwritten rules. These do not appear in the formal contract but are essential to facilitate working arrangements over long periods of time. In this respect Dunlop (1958) highlights the function of formal and informal customs and rules in an industrial relations system. Marsden (1986) also confirms that such institutional foundations indicate a necessary condition for the functioning of a free labour market.

In a study on industrial relations by Fox (1974), it is shown that all job descriptions include both specific instructions and certain terms over which the worker exercises discretion.

The idea that the employment contract does not represent a pure intentional exchange is also supported by Akerlof (1982). In fact, he thinks that many labour contracts partly involve a gift relationship. An example of this is the work of Homans (1962) on the widespread phenomenon of workers exceeding the company's production standards without monetary or promotion incentives. Akerlof argues that this example represents a partial gift relationship, since gifts are granted according to socially determined traditions and norms.

5. Trust in Contractual Relations

Arrow (1974) states that trust is an important lubricant in the social system, since having the right degree of trust in the actions of others allows one to avoid many problems.

In his work on the philosophy of money, Frankel (1977) states that individuals and society depend on low-value symbols, myths, beliefs and institutions that function as indicators of trustworthiness or unacceptability.

However, as Luhmann (1979) states, trust is neither demonstrable nor calculable, therefore the granting of trust is not based on any definitive foundation; trust goes beyond the available evidence; it is a compound of knowledge and ignorance.

Hodgson (1991, 231), argues that acts of trust are not only a compound of knowledge and ignorance, but also mental processes that unfold on different levels of consciousness, both conscious deliberation and unconscious customary practices and habits. The types of contexts in which we can place our trust we learn from experience, and when these become familiar, once trust is established, we begin to act out of habit. Hodgson goes on to say that such reflections on the essential function in contractual relations of trust and other components call into question the idea that exchange can be described through utilitarian calculation. The exchange of goods always contains gift components and relies heavily on trust. In part, exchange is always a leap into the void or a 'somersault', to quote an expression from Marx (1976-1979, 200). This means that for a dangerous act to become entirely commonplace, it requires the support of habitual practices and the guidance of a good measure of trust. The point to ponder is that in the context of customary acts of exchange, the rational and utilitarian calculation applies to limited and restricted contexts.

6. The Principle of Contractual Impurity

The principle of impurity consists of the idea that every system contains impurities that are not typical of the system but are nevertheless necessary for it to function (Hodgson 1984).

This statement comes from an analysis of the economic system through Ashby's (1960) law of requisite variety. He asserts that an open system must include a sufficient measure of diversity in order to cope with all potential changes in its environment.

The principle of impurity meets with the principle of dominance, i.e. the principle that socioeconomic systems have a dominant economic structure (Morselli 2021). The notion of an impure contract may fit within this scheme, where the contractual components are dominant, but the non-contractual elements represent features (or impurities) necessary for the contract as a whole. The thesis that all contracts include non-contractual elements can thus be considered an expression of the principle of impurity; whereas the existence of the principle of dominance is manifested in the supremacy, within the contract, of the utilitarian calculus (Ashby 1960).

Fox (1974) points out that the principles of impurity and dominance recommend an approach to the analysis of exchange relations that clearly differs from the separation into the two narrow groups of economic and social exchange found in the sociological literature. Durkheim's harsh criticism seems to call into question the legitimacy of this division, which is, however, met with little criticism from either economics or sociology. Sometimes all exchanges are treated as purely economic, discarding their non-contractual features from analysis, while, on the other hand, the boundaries constructed between disciplines hinder criticism.

If the social or non-contractual elements of exchange are questioned, problems of destabilisation of the system are likely to arise; with similar arguments Schumpeter (1928) argued that this process would lead to the end of capitalism and its replacement by socialism. He added that capitalism by rationalising the human mind creates a vision and lifestyle incompatible with its fundamental social conditions, motivations and institutions.

Schumpeter (1976, 139), like Marx, imagines the end of capitalism, but proposes a different analysis of this process. Whereas for Marx, it is the logic of capital that produces crises, for Schumpeter, it is capitalism's destruction of all traces of previous systems that brings out its contradictions. In destroying the pre-capitalist model of society, capitalism, therefore, demolishes not only the barriers that hinder its progress, but also the scaffolding that prevents its collapse. Consequently, according to Elliot 1980, it is the very success of capitalism in dissolving the traditions and institutions of the past that threatens its own future. This all fits in with Schumpeter's thesis that capitalism shows itself through a process of 'creative destruction'.

Schumpeter's main idea is that capitalism depends on pre-capitalist elements, and this can be made compatible with the principle of impurity examined above. This principle emphasises that there is an internal tension between the different structures of the system, and that some of the non-dominant structures are essential for the entire social formation to remain alive. Schumpeter also states that the capitalist process not only demolishes its own institutional structure but creates the basis for the rise of another. In this context, the problem of socialism arises, as a new institutional structure that derives from the functioning modalities of dynamic competition, based on the introduction of innovations increasingly predisposed to technicalize the entrepreneurial function itself. Finally, Schumpeter also focuses attention on the transformation of the accumulation regime, of the methods of regulation, that is, of the institutions that make an accumulation regime work.

According to Hirschman (1982), only through a dialectical view can the civilising and, at the same time, decaying characteristics of our modern economic system be understood.

7. Economic Property Rights and Institutions

Possession of an economic property right means controlling such a resource, being able to exercise choices concerning goods or services (Cheung 1970; Barzel 1989). For these reasons, the structure of such rights shapes the type of constraints, incentives and opportunities that guide the actions of actors and the dynamics of social interaction.

According to Coleman (1990), the existence of property rights hypothesizes a regulated social interaction, i.e. an institutional context in which the definition of such rights is represented by patterns of behaviour that regulate how resources are accessed and used.

Thus, for Ostrom (1985), institutions are translated into provisions as to what behaviour is required, prohibited, or permitted. An institution, in this respect, is a behavioural pattern supported by consistent expectations about the future actions of other individuals (Crawford, Ostrom 1995). The greater the compatibility of expectations and beliefs, the more individuals' choices fit the rules and reproduce over time the order that assigns property rights over resources.

To each right corresponds the faculty or power to dispose of actions that have as their object the ways of using resources in which individuals show interest. They are able to exercise their rights over resources by consuming them, exchanging them, donating them, destroying them (Weber 1922-1981, 51).

According to Vannucci (2004, 93), property rights have a social nature. The rules of conduct that distribute rights over actions and regulate their exercise in different circumstances are not known, recognised or respected. In fact, each individual has his own subjective image of the distribution of his rights and the rights of others to perform a certain action, based on the cognitive schemata with which he processes information from the social

and natural environment. As Aoki (2001, 12) states, an institutional equilibrium is realised when the synthetic representations that each individual has of the distribution of rights of control are coordinated with each other, resulting in a set of beliefs that generate strategic choices consistent with that structure of rights.

The institutional approach highlights the effects of uncertainty on expectations regarding how property rights are exercised (Morselli 2018). This leads to the indeterminacy of economic property rights; the activities of exchange, consumption or disposition, which represent the reasons for the interest in holding rights to these resources, do not, in fact, apply to the resources as such, but rather to their attributes (North 1990a). In general, all goods and services contain an infinite number of important attributes, with respect to which the available information is incomplete and asymmetrically distributed.

For Barzel (1982), goods have many attributes, the levels of which vary from good to good. The measurement of these levels is too costly to be comprehensive. The difficulty of having complete information with respect to the variability of attributes determines the degree of complexity in delineating property rights. As a result of the high cost of measuring assets comprehensively, there is a potential appropriation of wealth in every exchange.

The lack of information available on the characteristics of resources, together with the imperfection of the cognitive schemata available to interpret it, determines measurement and protection costs, linked to the protection of rights and the guarantee of contract enforcement (Vannucci 2004, 98).

Another relevant problem concerns that of information asymmetries (Akerlof 1970), where one of the parties to a contractual relationship may have more complete information than the other regarding certain qualitative attributes of the object of exchange. Thus, one of the parties finds itself deprived of important information for determining how likely it is that the terms of the exchange are actually convenient or are respected. In fact, rent information is formed that prevents contractual arrangements in which the expected surplus does not cover the value of the transaction costs.

8. Transaction Costs and Social Interdependence

According to Allen (1991), the ability to decide on how to use an economic resource, by exercising a right of control over it, is limited by the existence of transaction costs. These costs do not only concern exchanges as mutual transfer of rights but also reflect the existence of a state of interdependence where each individual can condition the exercise of others' rights to perform actions of disposition of economic resources.

According to Schmid (1987), it is possible to distinguish different negotiating arrangements, understood as recurring ways of exercising the sets of rights available to individuals: administrative relations, which are based on a limited and unidirectional transfer of rights, founded on positions of authority deriving from private contracts; gift relations, in which the unilateral transfer of rights is rooted in custom or in the benevolence of the donor.

If an individual were able to exercise absolute control over his or her own actions in disposing of resources, without any interaction or possibility of interference by other parties, there would be no transaction costs, nor would there be any rules concerning the possible ways in which his or her rights could be exercised. Dealing with economic property rights, transaction costs, norms, and institutional constraints means analysing the following phenomenon: the effects of uncertainty arising from social interdependence (Vannucci 2004, 101).

The existence of imperfectly represented property rights is linked to the presence of transaction costs. The latter are associated with the transfer and protection of property rights; if we assume that for each resource each of these costs is increasing, it follows that property rights are incomplete, since individuals will never find it convenient to exploit the full potential of their 'rights' (Barzel 2002). Thus, transaction costs reflect the existence of frictions within any context of social interdependence, i.e. conflicting interests (North 1997). They differ from the production costs of neoclassical models in that, unlike these, they depend on the organisational or institutional arrangements used.

For Coase (1964), in general terms transaction costs are associated with the creation or change of an institution or organisation, with the use of an institution or organisation. The formation and change of institutions or organisational forms generate the first type of transition cost, whereas the latter emerges from the activities of consumption, exchange, capture and defence of existing property rights within existing organisations or institutions.

Also in authority relations, transaction costs make an implicit exchange between subordinate and hierarchical superior possible. Similarly, power relations represent asymmetrical exchange relationships between individuals possessing different bargaining powers. It is a powerful relationship from which one can benefit more than the other, but in which one is never completely defenceless against the other (Crozier, Friedberg 1977). In this case, transaction costs hinder the emergence of absolute power.

According to Williamson (1996), even in the hypothesis in which the asymmetry of power is accentuated, authority relations leave a domain of choice to the subordinate and thus a basis for negotiation. Information constraints and transaction costs, in fact, prevent the stronger individual from fully exercising his rights over the actions of the less strong. Organisations correspond to various mechanisms to govern and decrease implicit transaction costs in the changing configurations assumed by authority relations.

9. Mechanisms for Protecting Economic Property Rights

An economic property right can be built on a set of formal (laws, contracts) and informal (social norms, customs) constraints. The value of rights depends on the transaction cost structure existing in a society, i.e. on the effectiveness of the protection mechanisms of the corresponding norms of conduct, which regulate the criteria for access to and exclusion from the benefits arising from the use of resources (Alchian, Demsetz 1973; Alchian 1989).

According to North (1993), the guarantee of contractual agreements and norms of conduct can arise from moral codes and internalised constraints, which induce discipline and the formation of compatible expectations.

A contractual relationship may be subject to many forms of guaranteeing rights of control, which are ultimately based on some capacity for self-protection. A logical premise for the existence of any right is the presence of expectations, such as to induce its implicit or explicit acceptance by the social actors interested in its exercise. Recognition may come from the power of the holder to self-guarantee its use even in the presence of a conflict with the claims of others; or from the external guarantee deriving from internalised social constraints or from collective institutions that act as a bank of rights to act, to which each individual assigns a right to control his or her own action, in exchange for an equivalent waiver on the part of other subjects (Becker, Stigler 1974; Besanko, Spulber 1989).

There are different types of protection, which differ from each other in their production and application techniques, in their relative effectiveness as factors in reducing transaction costs and uncertainty in social relations, but also in their ability to elicit an involvement of the spheres of recognition of individual identity and collective belonging (Pejovich 1999).

In this context, the modern state represents an organisation that can be configured as a 'third party' in the provision of protection, thanks to the availability of violence. The use of force to order compliance with contractual agreements ensures the state economies of scale in controlling specific territorial areas, in which exchanges are more frequent Barzel (2000).

The state orders the enforcement of a particular set of claims on resources (physical, human, intellectual) by individual or collective subjects, which forms the architecture of legal property rights. The coercive force of the state does not ensure the existence of perfectly established rights to values allocated through political processes (Bachrach, Baratz 1970). Consequently, there is an increase in the likelihood that legal rights are matched by an effective capacity to deploy the resources over which they extend, which is proportional to the effectiveness and speed of state mechanisms. The state turns out to be more efficient than other protection mechanisms, especially in the context of impersonal exchanges of resources with high measurement costs (Levi 1988).

The governance mechanisms referred to are based on public and private, formal and informal modes of organisation, corresponding to the wide variety of forms of social coordination observable in human history, each marked by specific instruments of protection of individual and collective rights and different transaction cost structures. Constitutions, laws, contractual agreements, churches, governments, corporations, mafia groups, political parties, are just some of the possible examples of the interpersonal rights allocation systems prevalent in specific domains of social exchange (Aoki 2000).

The coexistence of different mechanisms of exchange regulation increases the complexity of the institutional matrix. In some domains, these structures act in a complementary manner, i.e. in economic markets, for example, the effectiveness of state enforcement of sanctions is enhanced by the pull of community constraints, reputation, internalised codes of conduct, and informal rules of trade (Nye 1997).

However, the protection of rights cannot be based solely on the threat of violence in the event of non-compliance. The effectiveness of 'third parties' lies mainly in their complementarity with other regulatory instruments. Thus, as Poggi (1998) states, the ownership of a right is based on provisions relating to the power to control and dispose of the manner in which an economic resource is used, safe from the intrusion of other parties.

The power to control the actions of other individuals may be based on political, economic, and ideological means. The likelihood of exercising one's rights does not end with the ability to endanger one's survival and physical freedom, as there are economic resources consisting of the ability to influence access to and control of material goods whose use is necessary for the satisfaction of individual needs (Klein 1987).

10. The Existence of Transaction Costs in Economics and Politics

In neoclassical economic models, goods are homogeneous and exchanged instantaneously by subjects with perfect knowledge of each of their characteristics. The perfectly competitive market abstracts from any element of rent, assuming an environment in which no individual exercises power in setting contractual terms and time does not change the conditions of interaction. In fact, each individual is able to identify a counterparty without any information cost, choosing from a multiplicity of subjects (buyers or sellers) among whom he can move freely, thanks to a coordination mechanism (price system), which processes the relevant signals in an immediate and impersonal manner. Political institutions do not appear to be important, and there is no need for enforcement mechanisms to regulate agents' choices. Since all relevant information is oriented by the price system, the informing function of the institutional system and property rights, whose allocation is negligible compared to the achievement of an efficient allocation of resources, is of no importance (Vannucci 2004, 115).

However, the elements of rent and power relations reappear as soon as we move away from this idealised context. The presence of transaction costs requires the deployment of resources in activities to measure and monitor the characteristics of goods or services. North (1990b) indicates three exchange models that describe different stages in the development process of modern market economies, imagining possible solutions to the problem of uncertainty: 1) customised exchange, marked by repeated and prolonged bargaining, capable of fostering bonds of trust based on direct acquaintance and cultural relations between the parties. Transaction costs are low, but there are also limited possibilities to benefit from the advantages of specialisation and division of labour, which require a larger scale of social coordination; 2) impersonal exchange, which allows for a broadening of the complexity of contracts and the scale of specialisation of the individuals involved. However, it has high transaction costs due to the difficulties in fulfilling agreements. In order to strengthen exchanges, various contractual and institutional arrangements can be used to make the trust between the parties more solid; 3) impersonal exchange that sanctions the enforcement of contracts. In this context, it is possible to realise a cooperative surplus of complex and large-scale exchanges, a precondition for productivity growth through specialisation.

The above can be applied to the analysis of political exchanges, which take place within two main dimensions: 1) the production of formal rules of conduct and their enforcement through political institutions. The latter help to mitigate collective action problems, in particular the problems of commitment and enforcement of guarantees, which have a negative effect on the exchange, thus enabling different individuals involved in politics to cooperate in order to achieve gains in the exchange (Moe 1990a). In this way, political authority establishes the power to sanction compliance with the rules that govern social interaction in a given territory, setting the manner in which the agents of the state allocate and enforce coercion, as Pierson (2000) states. In this context, political transaction costs are the costs of providing public goods through collective action; 2) contracts through which exchanges of resources and promises involving politically important organisations and actors take place (Furubotn, Richter 2000).

In political relations, the equivalent of property rights, which underlie economic exchanges, is the right to exercise powers derived from public authority, making choices with collectively binding effects. But several factors increase political uncertainty about the extent, stability and binding force of this authority to a greater extent than in market exchanges (Eggertsson 1990).

Dixit (1996) points out that while political processes are affected by transaction costs to a greater extent than in economic relations, the outcomes of these processes contribute to the definition and distribution of transaction costs in society. Thus, the rules of the political game, represented in written or customary norms, play a central role, allowing public individuals to govern their contractual relations, reducing their uncertainty. The institutional mechanisms and governance structures of specific sets of contractual relations can mitigate these costs.

11. Economic Market and Political Market

The different characteristics of the competitive process in the economic and political market reflect the properties of the exchanges conducted in the two spheres. The market process tends to expand the availability of information and knowledge about available alternatives to a greater extent than in political and electoral choices. The direct causal correspondence between decisions in the market and its consequences means that over time the economic agent can anticipate what he will do as a result of his actions. The incomplete information about the basket of rights acquired in the contractual relationship weakens this link between decision and consequence, but does not abolish it altogether, as the same process often ensures a quick correction of erroneous expectations and the adjustment of the cognitive schemata used (Vannucci 2004, 129).

According to Downs (1957), on the other hand, politicians operate in a structure of greater uncertainty, as there is little information available on the options at stake, due to their good public characteristics; decisions are less frequent; interpretative models are imperfect and conditioned by ideologies. For Mueller (1989), even if one assumes the availability of complete information on all possible outcomes of each policy, one cannot predict which of the alternatives will be selected, since this does not depend on an individual decision, but on the outcome of complex procedures involving many individuals. Thus, the causal link between choices and effects is broken, to the detriment of the transparency of the decision-making process and the completeness of the definition of the political property rights at stake.

In modern market systems, the fulfilment and safeguarding of rights can rely on a wide range of instruments of an informal nature (reputation, internalised norms, customs) and institutionalised mechanisms based on the intervention of third parties who settle disputes and apply sanctions, exercising an arbitration function. In contrast, in the political market there are no third parties with the power to coercively guarantee the fulfilment of political contracts and the enforcement of precarious rights over the resources at stake (Moe 1990b). In the political context, the weakness of rights, due to the absence of external, impartial and coercively binding protection, increases transaction costs and hinders cooperative agreements.

Contractual relationships are usually characterised by information asymmetries that lead to principal-agent type relationships. For example, we can recall the relationship between shareholders and directors of a company, or between buyer and seller of a used car (Akerlof 1970). Thus, the agent can profit to his own advantage from the information rent to the detriment of the principal's interests. However, different contractual arrangements are possible to limit these disadvantages. Agency theory studies incentive-compatible contracts between principal and agent, and the contractual arrangements that emerge depend not only on technological conditions, but also on the institutional context.

This model also applies to the political marketplace: voters and groups are the principal who can exercise partial control over the actions of public agents. Indeed, the institution of representation is linked to the fact that representatives act as agents of the representatives. They are bearers of the interests of the represented, but at the same time they are responsible for the manner and effectiveness with which they pursue them, thanks to the presence of mechanisms that ensure a certain degree of control over their activities. The termination of the relationship of delegation of powers to elected representatives finds expression in the non-confirmation of the electoral mandate (Leoni 1961). Whereas in economic relations, the delegation of powers to the agent derives from a decision whose contents and limits are expressed in contractual terms.

Conclusions

From the analysis carried out it emerges that the concepts of exchange and property, fundamental to any study of institutions, are still treated in an unsatisfactory manner. One of the questions concerns the extent to which the concepts of exchange and property must be defined in relation to the law and the State. The question of exchange raises doubts about the validity of the utilitarian perspective, revealing the existence of limits also to its application in acts of exchange regulated by the price mechanism.

According to Arrow and Hahn (1971) in any developed exchange system the non-contractual components are of fundamental importance. A pure exchange system based solely on contractual relations may not work in practice.

However, even if there are always non-contractual elements in a contract, they do not totally dominate transactions in a developed capitalist system. Indeed, in a modern market economy, the rational calculation of profit and loss is taken into strong consideration; but the claims of neoclassical economists to conceive rationality as unlimited in its scope; to suggest that all actions come from rational calculation; to ignore the learning processes that underlie the act of reasoning; and to assume that all non-contractual components can be disregarded are open to criticism.

In contrast, in modern society the analysis of exchange should be conducted through the examination of the symbiotic relationship existing between contractual and non-contractual elements.

Considering only the criteria of consent and agreement, and assuming a rational intention for all exchanges, may give rise to problems. In many cases, it is not easy to detect the presence of intention and consent. Therefore, in social life, the use of recognised signs and signals is employed. Such signs are embedded in customs and rules and depend on their context. Therefore, concepts such as intention and consent are not easily managed, but in society we can resort to a complex system of signs and institutionalised rules to ascertain their presence. In this case, intention and consent are institutionalised in symbols and customary practices.

Making a decision is a complex activity influenced by the context in which it occurs; therefore, although the intentional character of exchanges is present, it is also necessary to consider the scenario in which these exchanges take place.

In an institutionalist perspective, economic and political markets can become competitive with the gradual emergence of an institutional matrix that lowers transaction costs, encourages coordination, and rewards compliance with contractual arrangements.

Declaration of Competing Interest

The author declares that he has no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Declaration of Use of Generative AI and AI-assisted Technologies

The authors declare that they have used/not used generative AI and AI-assisted technologies during the preparation of this work.

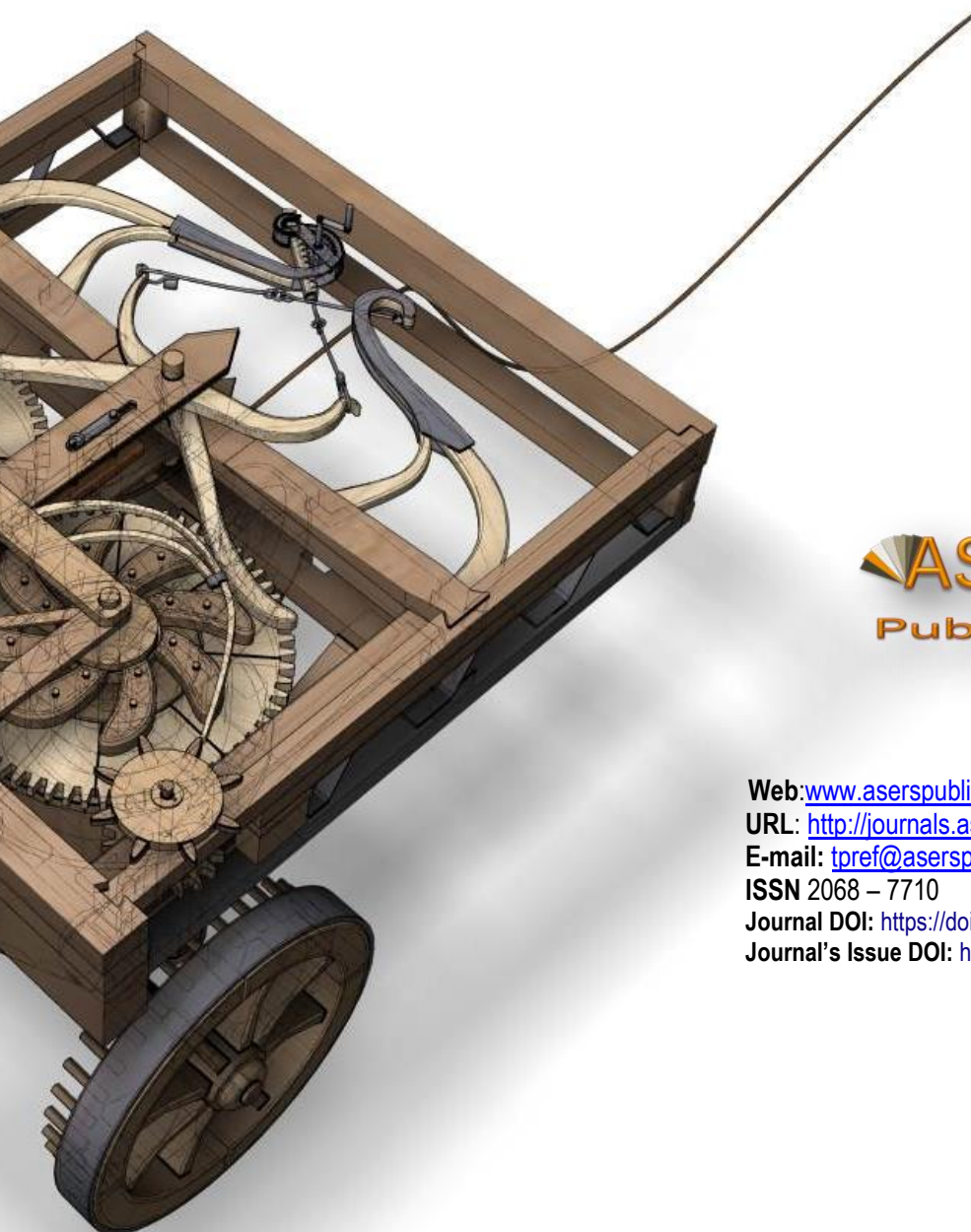
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