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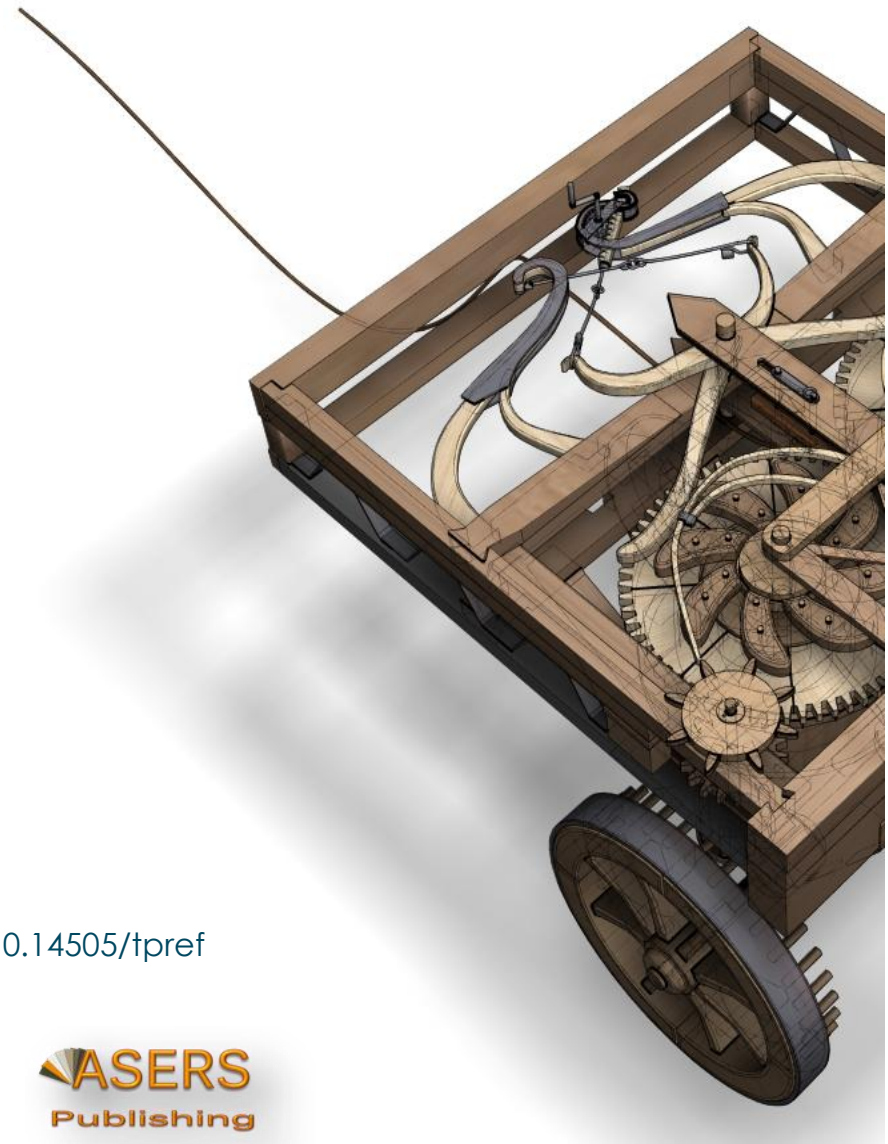

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Environmental Policy Selection Based on Linear-Times-Exponential One-Switch Utility Function and ELECTRE I Method

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Abstract: This paper examines how utility functions perform in tackling the multicriteria decision-making problem, especially one-switch utility function. Linear-times-exponential one-switch, exponential, and linear utility functions are implemented, which transforms corresponding criteria into utilities with ELECTRE I method. The detailed formulation of the decision model is presented. A numerical example about environmental policy selection is introduced to illustrate the use of the new decision model. With different wealth levels and utility functions for a policymaker, the inconsistent outranking policies illustrate the special characteristic of linear-times-exponential one-switch utility function whose initial wealth level has a significant impact on the outranking environmental policy. This study is also the first study applying one-switch utility function in address/ing multicriteria decision-making problem.

Keywords: multicriteria decision making; one-switch utility function; linear-times-exponential utility function; ELECTRE I method; environmental policy selection.

JEL Classification: D81; Q50.

Introduction

Decision-making problems involving a single criterion allow for relatively straightforward ranking or selection among a list of alternatives. This is not the case, however, in the context of facing several criteria when a decision maker (DM) evaluates alternatives according to multiple criteria. In such cases, the interference and limitation of different units of criteria, different quantitative or qualitative information, etc. can complicate direct comparisons, making it challenging for DMs to accurately and efficiently select the best alternative. So, a DM has to face multicriteria decision-making (MCDM) problems and MCDM methods which contribute to help DMs select the best alternative when they evaluate more than one criterion in a MCDM problem.

In this study, the ELECTRE I (ÉLimination Et Choix Traduisant la REalité) method (Roy, 1968) is applied to construct a new decision model. Almeida (2002, 2005, 2007) applied utility functions in ELECTRE I method but the gap is that solely the power utility function and exponential utility functions are applied. In practical situations, a utility function of wealth, the one-switch utility function (Bell, 1988), is applied in this study. The new decision model with the combination of ELECTRE I method and the one-switch utility function is introduced and a numerical problem associated with the environmental policy selection is used to prove this new model is applicable and creates a foundation for further resolving practical environmental problem.

There are four contributions of this study. First, we further explore how the utility functions perform in ELECTRE I method by using linear-times-exponential one-switch utility function instead of solely linear or exponential utility function. Second, with different initial wealth levels of a policymaker, the one-switch utility function makes the outranking alternatives different, which is illustrated by a numerical example. Third, the numerical example also proves that this new decision model which consists of linear-times-exponential one-switch utility function and ELECTRE I method is able to address the problem of selection of outranking environmental policy. Lastly, this is also the pioneered study applying linear-times-exponential one-switch utility function in ELECTRE I to resolve a MCDM problem, which extends the study of one-switch utility function in a practical direction rather than theoretical one.

1. Literature Review

MCDM methods have been applied to solve practical problems across various domains, including transportation (Liu *et al.* 2023; Maserrat *et al.* 2024; Tian *et al.* 2023), renewable energy (Wu *et al.* 2018; Akpahou *et al.* 2024; Li *et al.* 2024), supplier selection (Aal, 2024; Abdulla and Baryannis, 2024; Chakraborty *et al.* 2024), location selection (Nafi'Shehab *et al.* 2024; Topaloğlu, 2024; Karbassi *et al.* 2025), environmental studies (Akram *et al.* 2021), and personnel selection (Gottwald *et al.* 2024; Pinto-DelaCadena *et al.* 2024; Ait Bahom *et al.* 2025). In addition, the emission of greenhouse gases (GHGs) is one of the most severe environmental issues currently. There are also studies addressing MCDM problems associated with GHGs. For example, Lee *et al.* (2008) evaluated the greenhouse gas technologies based on the hybrid model in MCDM problem; Marzouk and Mohammed Abdelkader (2019) compared different MCDM methods by evaluating sustainable construction alternatives which can minimize the emissions of GHGs; Narayanamoorthy *et al.* (2021) used two MCDM methods to select the best alternative fuel based on several criteria including CO2 emission levels.

The ELECTRE (ÉLimination Et Choix Traduisant la REalité) family of methods is a notable approach in MCDM. The ELECTRE I method was first formally introduced in detail by Roy (1968). Over time, several variations including have emerged, including ELECTRE II (Roy and Bertier, 1971), ELECTRE III (Roy, 1978), ELECTRE IV (Roy and Hugonnard, 1982), ELECTRE TRI (Yu, 1992), and ELECTRE IS (Roy and Bouyssou, 1993), each differing in their specific methodologies. For instance, ELECTRE IS method which is similar to ELECTRE I method uses the pseudo-criteria rather than true criteria and ELECTRE II method introduces two outranking relations (strong and weak) instead of just one outranking relation in ELECTRE I method. Additionally, ELCTRE III method combines features of ELECTRE II and ELECTRE IS method while ELECTRE IV method is similar to ELECTRE III method without requiring a set of weights from DMs.

As the foundation of ELECTRE method, ELECTRE I (Roy, 1968) has three main concepts including the threshold value, concordance index and discordance index, which is designed for addressing selection problems instead of ranking in ELECTRE II, ELECTRE III, and ELECTRE IV or sorting in ELECTRE TRI (Almedia, 2005; Taherdoost and Madanchian, 2023). It aims to search for the outranking relations in the list of alternatives by pairwise comparisons. The values of alternatives are used directly in the procedures of ELECTRE I method but are the utility values obtained by subjecting true values of alternatives into utility functions applicable in the ELECTRE I method? Almeida (2002, 2005, 2007) applied utility functions in ELECTRE I method, which tackles the repair contract problem and outsourcing contracts selection problem in order to verify the effectiveness and validity of the new model. Brito *et al.* (2010) also applied utility function in ELECTRE TRI method to sort natural gas pipelines. However, the further exploration and extension of ELECTRE I method by using utility function remains limited. This study extends the ELECTRE I method by incorporating the linear-times-exponential utility function, a type of one-switch utility functions, and then applies it to a numerical example involving environmental policy selection to show the use of the proposed new model.

In addition, Bell (1988) introduced one-switch rule and one-switch utility functions based on expected utility theory initially developed by von Neumann and Morgenstern (vNM) in 1944. In accordance with the axioms of vNM expected utility theory, one-switch utility functions not only aim to identify the alternative with higher utility but also account for the at-most-once switch in preference dependent on the increase of wealth level. Bell (1988) noted that for a DM with one-switch utility functions, the preference to an alternative depends on the wealth level and with the increase of wealth level so the preference to one alternative will change to another one at most once. There are only four one-switch utility functions including quadratics, linear-plus-exponential, linear-times-exponential, and sumex utility functions.

There has been theoretical research about one-switch utility functions (Bell and Fishburn, 2001; Denuit *et al.* 2013; Abbas and Bell, 2015) and also about Markov decision problem (Liu and Koenig, 2005; Zeng *et al.* 2014). In addition, evaluating the measures of value of information, Bakır and Klutke (2011) discussed the conditions under which the methods of expected utility increase, the selling price method and the buying price method make an agreement in decision-making situations with linear-plus-exponential one-switch utility function, which is the only function which a decision maker keeps risk consistent as he or she gets wealthier. In addition, the demand of information before making decisions is relatively significant to the utility functions depending on the initial wealth levels. The case of quadratics one-switch utility function was considered by Abbas *et al.* (2013), who state that the value of information is monotonic to the risk aversion only in quadratic utility function. Their research applied buying price of information and also the information was also divided into perfect information and partition information. Bakır (2017) further investigated the relationship between risk aversion and the value of information with sumex and linear-times-exponential one-switch utility function. In mathematical economics, Denuit *et al.*

(2013) found that the linear-plus-exponential one-switch utility function satisfies the conditions of Ross DARA and DAP. Also, the linear-plus-exponential one-switch utility function is used to investigate a decision maker's risk-taking behaviors in response to changes in background risks in decreasing Ross risk aversion. However, the application of one-switch utility function in solving MCDM problem has not been explored before. So, this study demonstrates how one-switch utility function can be employed to resolve a MCDM problem.

2. Methodology

2.1 ELECTRE I

ELECTRE methods can be seen as outranking approaches. Specifically, ELECTRE I method contributes to help a DM choose one most preferable alternative when considering various criteria and make each criterion acceptable to the DM with satisfaction (Subramanian and Gershon, 1991). The explicit steps of ELECTRE I are explained as follows (Pohekar and Ramachandran, 2004; Milani *et al.* 2006; Alper and Başdar, 2017; Silvia *et al.* 2018; Tiwari, 2020; Ozsahin *et al.* 2021):

Step 1: Constructing the Decision Matrix (A_{mn}).

The alternatives and criteria are combined in a matrix. In the row, the alternatives are presented whereas the criterion is presented in the column. For example, with m-alternatives and n-criteria, then a decision matrix A_{mn} can be represented as follows:

$$A_{mn} = \begin{bmatrix} a_{11} & a_{12} & \cdots & a_{1n} \\ a_{21} & a_{22} & \cdots & a_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ a_{m1} & a_{m2} & \cdots & a_{mn} \end{bmatrix},$$

where a_{mn} is the evaluation score for the alternative m with the criterion n, where $m \geq 1$, and $n \geq 1$.

Step 2: Calculating the Normalized Decision Matrix

After constructing the initial matrix above, the elements in normalized decision matrix X can be created by using the formula below with the elements in the decision matrix A_{mn}. The criteria can be classified into two types: benefit criteria and cost criteria. More specifically, benefit criteria represent gains or positive criteria while cost criteria represent losses or negative criteria. The better the performance of an alternative on a benefit criterion has, the higher desire a DM has on this alternative. The lesser the performance of an alternative on a cost criterion has, the higher desire a DM has on this alternative. If there are n criteria totally and the first t criteria are benefit criteria and the rests are cost criteria. The formula used for benefit criterion is: $x_{ij} = \frac{a_{ij}}{\sqrt{\sum_{k=1}^{t} a_{kj}^2}}$, where $i = 1,2,\dots,m,\ j = 1,2,t,\dots,n$. The formula used for cost criterion is: $x_{ij} = \frac{1/a_{ij}}{\sqrt{\sum_{k=t+1}^{n}\left(\frac{1}{a_{kj}}\right)^2}}$, where $i = 1,2,\dots,m,\ j = 1,2,t,\dots,n$. So, the normalized decision matrix X is in the following form: $X_{mn} = \begin{bmatrix} x_{11} & \cdots & x_{1n} \\ \vdots & \ddots & \vdots \\ x_{m1} & \cdots & x_{mn} \end{bmatrix}$.

Step 3: Weighting the Normalized Decision Matrix

The difference in significance of the assessment factors depends on each individual DM. The DM should determine the weights of the assessment factors with $\sum_{j=1}^{n} w_j = 1$.

Then, the weighted normalized decision matrix Y can be calculated by multiplying the elements in X_{mn} with the corresponding w_j values. The weighted normalized decision matrix Y with elements is expressed as:

$$Y = \begin{bmatrix} w_1x_{11} & w_2x_{12} & \cdots & w_nx_{1n} \\ w_1x_{21} & w_2x_{22} & \cdots & w_nx_{2n} \\ \vdots & \cdots & \ddots & \vdots \\ w_1x_{m1} & w_2x_{m2} & \cdots & w_nx_{mn} \end{bmatrix} = \begin{bmatrix} y_{11} & y_{12} & \cdots & y_{1n} \\ y_{21} & y_{22} & \cdots & y_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ y_{m1} & y_{m2} & \cdots & y_{mn} \end{bmatrix},$$

where w_j is the weight of *j*th criterion and the sum of w_j is 1.

Step 4: Determination of Concordance Sets Discordance Sets

The sets of concordance and discordance can be determined by the matrix Y. Each criterion is considered to make paired comparisons for each alternative. For example, with alternative A_p and A_q, where $p, q \in (1,\dots,m)$ and $p \neq q$, if alternative A_p is preferred to or equivalent to alternative A_q, then, a concordance set is $C_{pq} = \{j | y_{pj} \geq y_{qj}\}$, where j is the criterion. If alternative A_p is worse than alternative A_q, then a discordance

set is $D_{pq} = \{j | y_{pj} \leq y_{qj}\}$, where j is the criterion. In ELECTRE method, each concordance set has a corresponding discordance set as a supplement set.

Step 5: Calculation of Concordance and Discordance Indices and Matrices

The concordance sets are used to create concordance matrix C. Matrix C is $m \times m$ in size and does not take a value where $p = q$. The elements in matrix C are calculated by $c_{pj} = \sum_j w_j$, where j is the factor (s) in the concordance set C_{pq}. Matrix C is expressed as follows:

$$C = \begin{bmatrix} - & c_{12} & c_{13} & \cdots & c_{1m} \\ c_{21} & - & c_{23} & \cdots & c_{2m} \\ \vdots & \vdots & \vdots & \ddots & \vdots \\ c_{m1} & c_{m2} & c_{m3} & \cdots & - \end{bmatrix}.$$

The discordance matrix D consists of set of discordances. It is $m \times m$ in measure and does not take a value where $p = q$. The elements in matrix D are calculated by:

$$d_{pq} = \frac{\max |y_{pj^0} - y_{qj^0}|}{\max |y_{pj} - y_{qj}|_{\forall j}},$$

where j^0 is the factor in the discordance set D_{pq} and $\forall j$ are all criteria.

Matrix D is expressed as follows:

$$D = \begin{bmatrix} - & d_{12} & d_{13} & \cdots & d_{1m} \\ d_{21} & - & d_{23} & \cdots & d_{2m} \\ \vdots & \vdots & \vdots & \ddots & \vdots \\ d_{m1} & d_{m2} & d_{m3} & \cdots & - \end{bmatrix}.$$

Step 6: Creation of Concordance Superiority (F) and Discordance Superiority (G) matrix

The concordance superiority matrix F is $m \times m$ in size. We evaluate the concordance limit ($\underline{c}$) with elements c_{pq} in concordance matrix.

$$\underline{c} = \frac{1}{m(m-1)} \sum_{p=1}^{m} \sum_{q=1}^{m} c_{pq}.$$

The elements f_{pq} compose matrix F out of 1 or 0 with no value in its diagonal.

$$f_{pq} = \begin{cases} 1, \text{if } c_{pq} \geq \underline{c} \\ 0, \text{if } c_{pq} < \underline{c} \end{cases}.$$

The discordance superiority matrix (G) is $m \times m$ in size. We evaluate the concordance limit ($\underline{d}$) with elements c_{pq} in discordance matrix.

$$\underline{d} = \frac{1}{m(m-1)} \sum_{p=1}^{m} \sum_{q=1}^{m} d_{pq}.$$

The elements g_{pq} compose matrix G out of 1 or 0 with no value in its diagonal.

$$g_{pq} = \begin{cases} 1, \text{if } d_{pq} \geq \underline{d} \\ 0, \text{if } d_{pq} < \underline{d} \end{cases}.$$

Step 7: Creation of Aggregate Dominance Matrix (E)

The aggregate dominance matrix, which is $m \times m$ in size, consists of the element-wise product of f_{pq} and g_{pq} in matrix F and G above. The component e_{pq} is 1 or 0.

$$E = \begin{bmatrix} - & e_{12} & e_{13} & \cdots & e_{1m} \\ e_{21} & - & e_{23} & \cdots & e_{2m} \\ e_{31} & e_{32} & - & \cdots & e_{3m} \\ \vdots & \vdots & \vdots & \ddots & \vdots \\ e_{m1} & e_{m2} & e_{m3} & \cdots & - \end{bmatrix}.$$

Step 8: Determination of the Orders of Policies

The matrix E above shows the decision points. The component $e_{pq} = 1$ is considered that the action p outranks the action q. Following the eight steps above, a DM can find out which alternative outranks the others with several criteria.

2.2 One-Switch Utility Function

There are four types of one-switch utility functions including quadratic, linear-plus-exponential, linear-times-exponential, and sumex utility functions (Bell, 1988). Among these four types of one-switch utility functions, a DM with the linear-plus-exponential utility function is decreasingly risk-averse and with the sumex utility function is increasingly and decreasingly risk-averse. It is seemingly natural, reasonable, and appropriate to assume that a

DM is decreasingly risk-averse in research because a DM may accept more risky alternatives when he or she becomes wealthier (Sheng, 1984) but we assume that a policymaker tends to avoid risky alternatives in policy selection in this study because with the long-lasting impact of an environmental policy, a policymaker is likely to keep hating or avoiding risks against the long-term potential negative impacts of that policy even though the policymaker has a higher wealth level. So, this implies that a DM continues to hate or try to avoid risks even though he or she becomes wealthier. The quadratic utility function has been applied in many MCDM research such as Malakooti (1993), Farahani and Asgari (2007), Wu and Tiao (2018), Alizadeh and Yousefi (2019), and so on. As Li (2022) reviewed about the applications of one-switch utility functions, however, studies associated with the linear-times-exponential utility function are still a few including only Anchugina (2017) which introduced one-switch discount utility function and Bakır (2017) which explored the relationship between the value of information and risk aversion. This study pioneers the integration of the linear-times-exponential one-switch utility function with ELECTRE I method to address a MCDM problem.

The linear-times-exponential utility function satisfies the one-switch rule for any choice of parameter b, h, s and l with w for wealth level which is the sum of a DM's initial wealth level, x, and the return of an alternative selected, r.

$$u(w) = (bw + h) \cdot e^{sw} + l.$$

3. Problem Description

Selecting the most effective or the best policy is a pivotal objective for a policymaker, especially facing with a variety of criteria. While facing environmental policies which can reduce the emission of greenhouse gases (GHGs), a policymaker needs to consider several criteria to find the outranking policy. Three relatively important criteria in this case are considered, including financial returns, costs, and the reduced amount of GHGs by the policy. More specifically, the financial returns which can be generated by applying one policy and obtained by the policy-making authorities include the tax revenues, investments, and so on, which have been used in resolving previous MCDM problems such as Ren *et al.* (2009), Džiugaitė-Tumėnienė *et al.* (2017), Ferrer-Martí *et al.* (2018), Yang *et al.* (2018), and Vasić (2018); the costs of an environmental policy include the direct costs of applying one policy such as the purchase of tools, building of infrastructures and so forth, and the indirect costs such as costs of developing new technologies or equipment, which have been applied in the MCDM research such as Yang *et al.* (2018), Babatunde *et al.* (2019), Seddiki and Bennadji (2019), and Parvaneh and Hammad (2024); Lastly, the reduced amount of GHGs of one policy is about how much amount of GHGs can be reduced by implementing one environmental policy in metric tons. This criterion has been considered as one of the environmental criteria in MCDM research such as Ekholm *et al.* (2014), Väisänen *et al.* (2016), Džiugaitė-Tumėnienė *et al.* (2017), Yang *et al.* (2018), Babatunde *et al.* (2019), and so forth. In this study, only these three criteria are considered based on utility functions and ELECTRE I method. In real cases, it is possible to have more criteria in the selection process but the main goal of this study is to consider these three criteria in a numerical example below to prove the applicability of the new model so three comparatively critical criteria in the selection of environmental policy which can reduce the GHGs including the reduced amount of GHGs, financial return of a policy, and costs of a policy, are solely considered in this study.

The action space corresponding to a set of environmental policies available to an environmental policymaker. A policy as an element in the set is represented by a_i, where $i = 1,2, \dots, m$. The discrete policies in the set with m elements are represented by $\{a_1, a_2, \dots, a_m\}$. Each element in this set is corresponding to one environmental policy faced by a policymaker. Five policies are considered in this study so $m = 5$.

There are three criteria considered in this case, including financial returns, costs, and reduced amount of GHGs so $n = 3$. Therefore, one policy p_i is associated with corresponding financial return r_j, cost c_j, and reduced amount of GHGs k_j, where $j = 1, \dots, n$. Thus, the decision matrix A_{mn} is:

$$A_{53} = \begin{bmatrix} a_{11} & a_{12} & a_{13} \\ a_{21} & a_{22} & a_{23} \\ a_{31} & a_{32} & a_{33} \\ a_{41} & a_{42} & a_{43} \\ a_{51} & a_{52} & a_{53} \end{bmatrix}.$$

The main objective of this study is to figure out which policy outranks the others by a policymaker while considering three different criteria.

4. Decision Model

Almeida (2002, 2005, 2007) introduced a new decision model, which considers utility functions and probability density functions in ELECTRE I method to address MCDM selection problems. However, Almeida's implementation was limited to linear and exponential utility functions, which Bell (1988) classified as zero-switch utility functions. The values of utility are analysed in the procedure of ELECTRE I to find the outranking relations. So, in order to innovate our decision model, not only is the ELECTRE I method integrated with utility functions which transform values in three criteria into utility but also the one-switch utility function is applied. One-switch utility functions are the utility functions of wealth, which implies that the wealth level has an impact on the preference of alternatives. So, we propose that while a policymaker is facing a list of environmental policies with three criteria above, the initial wealth level owned by a policymaker is a contributing factor in the utility function of financial returns and then impacts the preference of policy and outranking policy. The linear-times-exponential one-switch utility function is applied in the financial returns of an environmental policy to describe a policymaker's decision-making behaviour in this study, which is $u(w) = (bw + h) \cdot e^{sw} + l$, where w is the sum of a policymaker's initial wealth level x, and the return of an environmental policy, r. Almeida (2002, 2005, 2007) give values of utility functions in the numerical example in order to check if the model is feasible or not. Therefore, for the numerical example in this study below, more specifically, here is the specific settings of the parameters: $b = 5$, $h = 10$, $s = -0.01$, and $l = 10$. So, the linear-times-exponential one-switch utility function is as follows:

$$u(w) = (5w + 10) \cdot e^{-0.01w} + 10.$$

Exploring how the initial wealth level of a policymaker can impact the rankings of policies is a new research direction compared with previous research. In the numerical application section below, two initial wealth levels ($x = 0$ and $x = 100$) are considered to make a comparison to show how the outranking environmental policy differs by applying the one-switch utility function. Moreover, a linear utility function is also applied in the criterion of financial returns with two wealth levels ($x = 0$ and $x = 100$) so as to show the divergent results obtained by two different utility functions and the special characteristic of the linear-times-exponential one-switch utility function. The linear function is as follows:

$$u(w) = 0.8w.$$

In addition, while a policymaker selects an environmental policy, the cost of one policy, c, is considered with the zero-switch utility function. The exponential utility function belonging to zero-switch utility functions is as follows:

$$u(c) = e^{-0.01c}.$$

The exponential utility function shows the undesirable attitude of an environmental policy makers towards the costs because the higher the cost of implementing a policy is, the lower utility value the exponential utility function has, which implies that an environmental policy with higher cost is not preferred.

Lastly, the other zero-switch utility function, linear utility function, is subjected to the reduced amount of GHGs generated by the introduction of one policy, k. After transforming it to utility values, the reduced amount of GHGs can be compared with the other two criteria. So, the linear utility function is as follows:

$$u(k) = 0.5k.$$

Based on the settings in three different utility functions above, a numerical example is considered to check the difference between the application of one-switch utility function and zero-switch utility function, which shows the unique characteristic of one-switch utility function. In addition, if different outranking results could be obtained, it also implies that this new model is applicable in the further cases of environmental policy selection.

5. Numerical Applications of Proposed Model

To show the application of one-switch utility function with ELECTRE I method in MCDM problem, one numerical example is considered in this section. Moreover, different wealth levels are also set to show the special characteristic of one-switch utility function. The case regarding the selection of environmental policy is applied here. There are 5 elements in the set of policies, $\{a_1, a_2, a_3, a_4, a_5\}$; three criteria including financial returns of policy, costs of policy, and reduced amount of GHGs of policy are used to search for the outranking policy. The details of five policies with corresponding criteria are shown in Table 1. The decision models of a policymaker are modelled on the corresponding utility functions mentioned in Section 4. Because the one-switch utility function is the utility function of wealth, different initial wealth levels are set in this study in order to show how the ranking of a policy is affected by the initial wealth level of a DM.

Table 1. Policies with Corresponding Criteria

	Return (r)	Cost (c)	GHGs (k)
Policy 1	90	60	35
Policy 2	45	50	90
Policy 3	15	20	40
Policy 4	80	55	70
Policy 5	65	10	10

Source: compiled by the author

The values in Table 1 are subjected to the corresponding decision-making utility functions including linear-times-exponential one-switch utility function, exponential utility function, and linear utility function, respectively, mentioned in Section 4. The situations in two different wealth levels are also considered. So, the values of utilities for policies are as follows in Table 2:

Table 2. Utilities Values for Policies with Different Wealth Levels

	$x = 0$	$x = 100$		
	$u(x + r)$	$u(x + r)$	$u(c)$	$u(k)$
Policy 1	197.022	153.586	0.549	17.5
Policy 2	159.843	182.409	0.607	45
Policy 3	83.160	195.233	0.819	20
Policy 4	194.225	160.422	0.577	35
Policy 5	184.885	170.362	0.905	5

Source: calculated by the author

Then, following the Step 2 in Section 2.1, the formula for benefit criterion is used for the utility of the wealth level, $u(x + r)$, and on the utility of reduced amount of GHGs, $u(k)$ while the formula for cost criterion is used for the utility of costs of policy, $u(c)$. So, the normalized values of utilities are shown in Table 3:

Table 3. Normalized Utilities for Policies

	$x = 0$	$x = 100$		
	$u(x + r)$	$u(x + r)$	$u(c)$	$u(k)$
Policy 1	0.521	0.397	0.531	0.277
Policy 2	0.422	0.471	0.481	0.713
Policy 3	0.220	0.505	0.356	0.317
Policy 4	0.513	0.415	0.506	0.555
Policy 5	0.489	0.440	0.322	0.079

Source: calculated by the author

The weights for three criteria are 0.4, 0.25, and 0.35, respectively. Then, the weighted normalized utilities for policies are shown in Table 4 as follows:

Table 4. Weighted Normalized Utilities for Policies

	$x = 0$	$x = 100$		
	$u(x + r)$	$u(x + r)$	$u(c)$	$u(k)$
Policy 1	0.208	0.159	0.133	0.097
Policy 2	0.169	0.189	0.120	0.250
Policy 3	0.088	0.202	0.089	0.111
Policy 4	0.205	0.166	0.126	0.194
Policy 5	0.195	0.176	0.081	0.028

Source: calculated by the author

Following Step 5 and Step 6, when the initial wealth level is 0 ($x = 0$), the concordance matrix and the discordance matrix are:

$$C = \begin{bmatrix} - & 0.65 & 0.65 & 0.65 & 1 \\ 0.35 & - & 1 & 0.35 & 0.6 \\ 0.35 & 0 & - & 0 & 0.6 \\ 0.35 & 0.65 & 1 & - & 1 \\ 0 & 0.4 & 0.4 & 0 & - \end{bmatrix}, \text{ and } D = \begin{bmatrix} - & 0.6875 & 0.0625 & 0.4375 & 0 \\ 0.3265 & - & 0 & 0.302 & 0.2199 \\ 1 & 0.6735 & - & 0.9754 & 0.8934 \\ 0.124 & 0.25 & 0 & - & 0 \\ 1 & 1 & 0.375 & 0.88 & - \end{bmatrix}.$$

The concordance limit ($\underline{c}$) is 0.50 and the discordance limit ($\underline{d}$) is 0.46.

Concordance superiority matrix and discordance superiority matrix are:

$$F = \begin{bmatrix} - & 1 & 1 & 1 & 1 \\ 0 & - & 1 & 0 & 1 \\ 0 & 0 & - & 0 & 1 \\ 0 & 1 & 1 & - & 1 \\ 0 & 0 & 0 & 0 & - \end{bmatrix}, \text{ and } G = \begin{bmatrix} - & 0 & 1 & 1 & 1 \\ 1 & - & 1 & 1 & 1 \\ 0 & 0 & - & 0 & 0 \\ 1 & 1 & 1 & - & 1 \\ 0 & 0 & 1 & 0 & - \end{bmatrix}.$$

By element-wise product between these two matrices, the aggregate dominance matrix with 0 initial wealth level is:

$$E = \begin{bmatrix} - & 0 & 1 & 1 & 1 \\ 0 & - & 1 & 0 & 1 \\ 0 & 0 & - & 0 & 0 \\ 0 & 1 & 1 & - & 1 \\ 0 & 0 & 0 & 0 & - \end{bmatrix}.$$

By Step 8 in Section 2.1 shown, we can draw conclusions from the aggregate dominance matrix above: Policy 1 outranks Policy 3; Policy 1 outranks Policy 4; Policy 1 outranks Policy 5; Policy 2 outranks Policy 3; Policy 2 outranks Policy 5; Policy 4 outranks Policy 2; Policy 4 outranks Policy 3; Policy 4 outranks Policy 5. So, we can finally conclude that Policy 1 is the outranking policy with 0 initial wealth level.

On the other hand, when the initial wealth level is 100 ($x = 100$), the concordance matrix and the discordance matrix are:

$$C = \begin{bmatrix} - & 0.25 & 0.25 & 0.25 & 0.6 \\ 0.75 & - & 0.6 & 0.75 & 1 \\ 0.75 & 0.4 & - & 0.4 & 1 \\ 0.75 & 0.25 & 0.6 & - & 0.6 \\ 0.6 & 0 & 0 & 0.4 & - \end{bmatrix} \text{ and } D = \begin{bmatrix} - & 0.6921 & 1 & 0.4375 & 0.4028 \\ 0.2419 & - & 0.3079 & 0.1179 & 0 \\ 0.8379 & 0.625 & - & 0.7139 & 0 \\ 0.124 & 0.528 & 0.8359 & - & 0.75 \\ 1 & 1 & 0.5972 & 0.876 & - \end{bmatrix}.$$

The concordance limit ($\underline{c}$) is 0.51 and the discordance limit ($\underline{d}$) is 0.55.

Concordance superiority matrix and discordance superiority matrix are:

$$F = \begin{bmatrix} - & 0 & 0 & 0 & 1 \\ 1 & - & 1 & 1 & 1 \\ 1 & 0 & - & 0 & 1 \\ 1 & 0 & 1 & - & 1 \\ 1 & 0 & 0 & 0 & - \end{bmatrix}, \text{ and } G = \begin{bmatrix} - & 0 & 0 & 1 & 1 \\ 1 & - & 1 & 1 & 1 \\ 0 & 0 & - & 0 & 1 \\ 1 & 1 & 0 & - & 0 \\ 0 & 0 & 0 & 0 & - \end{bmatrix}.$$

So, the aggregate dominance matrix with 100 initial wealth level is:

$$E = \begin{bmatrix} - & 0 & 0 & 0 & 1 \\ 1 & - & 1 & 1 & 1 \\ 0 & 0 & - & 0 & 1 \\ 1 & 0 & 0 & - & 0 \\ 0 & 0 & 0 & 0 & - \end{bmatrix}.$$

Similarly, we can make conclusions based on the aggregate dominance matrix when the wealth level is 100: Policy 1 outranks Policy 5; Policy 2 outranks Policy 1; Policy 2 outranks Policy 3; Policy 2 outranks Policy 4; Policy 2 outranks Policy 5; Policy 3 outranks Policy 5; Policy 4 outranks Policy 1. So, we can finally conclude that Policy 2 is the outranking policy with 100 initial wealth level.

By applying linear-times-exponential one-switch utility function on financial return, exponential utility function on costs, and linear utility function on the reduced amount of GHGs, we can notice that the outranking results are different with initial wealth level 0 and initial wealth level 100. It is reasonable to state that the initial wealth level plays a critical role in a DM's preference on environmental policies with linear-times-exponential one-switch utility function.

In contrast, as mentioned in Section 4, the linear utility function, $u(w) = 0.8w$, is also applied on the criterion of financial returns of an environmental policy to compare with one-switch utility function. The utility functions for costs of policies and reduced amount of GHGs remain same, exponential and linear utility functions, respectively. The case with five policies under three criteria in Table 1 is still considered here. With the linear utility function on the financial return of an environmental policy, the utility values are different from Table 2. Two different initial wealth levels of a policymaker are still considered. The same procedure in Section 2.1 is applied to find the outranking policy with linear utility function on the financial return of an environmental policy with two different initial wealth levels ($x = 0$ and $x = 100$), whose aggregate dominance matrix with 0 and 100 initial wealth levels is:

$$E = \begin{bmatrix} - & 0 & 1 & 1 & 1 \\ 0 & - & 1 & 0 & 1 \\ 0 & 0 & - & 0 & 0 \\ 0 & 1 & 1 & - & 1 \\ 0 & 0 & 0 & 0 & - \end{bmatrix}.$$

So, we can draw conclusions: Policy 1 outranks Policy 3; Policy 1 outranks Policy 4; Policy 1 outranks Policy 5; Policy 2 outranks Policy 3; Policy 2 outranks Policy 5; Policy 4 outranks Policy 2; Policy 4 outranks Policy 3 Policy 4 outranks Policy 5. So, we find that Policy 1 is the outranking policy with both 0 and 100 initial wealth levels.

6. Discussions

Comparing the results of the linear-times-exponential utility function with those of the linear utility function for the financial return criterion reveals an evident difference in policy preferences. Specifically, with the linear-times-exponential one-switch utility function, the outranking policy swaps from Policy 1 to Policy 2 as the initial wealth level increases from 0 to 100. Conversely, with the linear utility function, the outranking policy keeps the same as Policy 1 regardless of the initial wealth level increase from 0 to 100. These comparisons are summarized in Table 5. The utility functions for the other two criteria- costs and reduced amount of GHGs- remain the same in comparison. Moreover, the sensitivity test varying the weights on criteria by approximately 10% yields the same results, indicating that the outranking policies with different utility functions on the criterion of financial return with different wealth levels are sufficiently robust.

Table 5. Summary of Comparison Results

Criterion	Initial Wealth Level	Utility Function	Outranking Policy
Financial Return (r)	$x = 0$	Linear-times-exponential One-switch Utility Function	Policy 1
		Linear Utility Function	Policy 1
	$x = 100$	Linear-times-exponential One-switch Utility Function	Policy 2
		Linear Utility Function	Policy 1

Source: summarized by the author

These results illustrate the significant impact of wealth levels on the preferences or the selection on outranking policies. With the linear utility function for the criterion of financial returns of a policy, the policymaker's preference remains unchanged regardless of their initial wealth, a scenario that does not align well with realistic decision-making processes. In contrast, under the linear-times-exponential one-switch utility function, the policymaker's selections toward the financial returns of a policy vary with different initial wealth levels. This variation reflects a more realistic depiction of a policymaker's decision-making behaviour. As a result, the linear-times-exponential one-switch utility function can be applied to describe a policymaker's decision-making behaviours much more practically and accurately than the linear utility function. This is also the reason why one-switch utility function is employed in this research rather than linear or exponential utility functions used in previous studies. The results also show the linear-times-exponential one-switch utility function is able to be incorporated with ELECTRE I method in resolving the MCDM problem. In addition to the linear or exponential utility function, or probability density functions in Almeida (2002, 2005, 2007), this study further provides an option of utility function to describe a DM's behaviour with the linear-times-exponential utility function.

The numerical example also implies that the utility function can also give impact on the selection of the outranking alternative. So, it is necessary to choose an appropriate utility function to describe a DM's behavior and subject it in the procedure of ELECTRE I method rather than using the original values of alternatives directly in the decision matrix. As the pioneered research integrating linear-times-exponential one-switch utility function in ELECTRE I method, this research provides a further research direction about how the outranking results can be impacted by a DM with different utility functions in ELECTRE I method while facing MCDM problems.

Conclusions

This study further extends the research about how the utility functions work with ELECTRE I method in the MCDM problem based on Almeida's research (2002, 2005, 2007). In the procedures of ELECTRE I method, the true value of each alternative is not used but the utilities obtained from utility functions are considered. The exponential utility function is applied in the criterion of costs, and the linear utility function is applied in the criterion

of reduced amount of GHGs. Compared with previous studies, the different point of this study is to apply linear-times-exponential one-switch utility function and linear utility function in the criterion of financial returns with two different initial wealth levels so as to show how the initial wealth levels of a DM with linear-times-exponential one-switch utility function can give impacts on the outranking policy than the results with linear utility function.

The numerical example shows the use of the linear-times-exponential one-switch utility function in the MCDM problem, which is the pioneered application of linear-times-exponential one-switch utility function in the MCDM research. Thus, the consideration of linear-times-exponential one-switch utility function makes a policymaker's preference on environmental policy more realistic and reasonable because it is reasonable to recognize that a DM's preference on alternatives may be influenced by the initial wealth he or she owns. Moreover, by different settings on wealth levels in the numerical example, the outranking environmental policies are different, which is Policy 1 and Policy 2, respectively. This shows the special characteristic of one-switch utility functions whose utility is dependent on the initial wealth levels rather than sole returns as applied in the linear utility function. This also implies that while an environmental policymaker considers the financial return one of the criteria in selecting a policy, the impact of initial wealth level cannot be overlooked because it indirectly impacts the outranking policies.

Finally, this study also contributes to the decision model in environmental economics about policy selection, albeit theoretical, when a policymaker tries to find the outranking policy among a list of policies with several criteria. Because the one-switch utility functions are the utility functions of wealth, the mechanism is to transform the wealth level or returns into utility function, which can be seen as one limitation of one-switch utility functions so future work may explore if one-switch utility function can be applied in other criteria instead of financial returns and check how the selection or ranking of alternative may be impacted.

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Social Stock Exchange – An Innovative Mechanism for Philanthropy through Bourse

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Abstract:

Purpose: Two decades ago, Brazil established a formal social stock exchange, followed by several other countries. This unique concept links social enterprises with philanthropic investors, but their success rate is low. This paper analyzes the mechanisms of social stock exchanges in different countries and identifies factors affecting their success.

Design: The present study is exploratory in nature whereby an attempt has been made to understand the framework of social stock exchanges established across the globe.

Findings: The failure of social stock exchanges in Brazil, South Africa, Portugal, and the UK can be attributed to lack of investor awareness, higher economic cost for registered social enterprises and limited funding options in less diversified projects. However, the model of SSE is operational in other three countries apart from India.

Originality: The concept of the social stock exchange is in the infancy stage and limited work has been done in this domain. The present paper attempts to make a significant contribution to the literature by providing a detailed analysis of such exchanges.

Research limitations: The present paper is based on secondary data and inclusion of primary data can augment the findings.

Practical implications: SSEs can be miraculous in addressing financial constraints in social enterprises but the concept still could not get momentum. The present paper aims to address challenges that hinder the success of these exchanges.

Social implications: The findings of the study could improve the functioning of these exchanges, thereby supporting the financing of enterprises aimed at socio-economic upliftment in the deprived sections.

Keywords: bourse; investment; philanthropy; social enterprises; social stock exchange; India.

JEL Classification: G11; E27; L31; P51.

Introduction

In the contemporary scenario, the role of social enterprises (enterprises primarily concerned with accomplishing social goals) has widely been acknowledged. Though the ambit of social enterprises includes non-profit organisations as well as for-profit organisation, yet all such organizations have a common agenda of social welfare. These enterprises work for eliminating poverty, undernourishment, hunger, and inequality; improving healthcare amenities; education, and employability; empowering women; and cultivating social enterprise incubators. But unfortunately, most of the social enterprises struggle to get enough funds to finance their projects. Ambrose *et al.* (2021) observed that access to debt or equity is not only a barrier to scaling up for 57% of Indian social enterprises but also a challenge in achieving sustainability goals set by global institutions. These enterprises require supportive ecosystems that could assist them to get funds. Wendt (2020) emphasized upon the need to explore the possible ways through which financial markets can help to serve societal needs in a better way. It is good to note that policymakers have recognised the need to replenish the financial crunch of social impact-driven organizations and accordingly initiated many programmes to provide social finances. An important development in social finance is the emergence of social stock exchanges, which have the ability to spur innovation, open up new financial sources, and offer long-term solutions to some of the most pressing problems facing the globe.

The idea of a social stock exchange existed in 1980s also when social entrepreneurs tried to approach the wealthy individuals to mobilise their investment flows towards socially-oriented enterprises. But the credit to introduce a formal stock exchange in the form of social stock exchange goes to Brazil which was followed by other countries also. However, it is interesting to note that such exchanges are operational only in a few countries like Canada, UK, US, and Singapore at present. The idea of introducing this unique platform was stimulated by increasing awareness of the ineffectiveness of traditional business models in creating solutions for urgent social and environmental problems (Tietz *et al.* 2018; Ahmad, 2021). Taking proactive steps, Government of India also proposed the concept of Social Stock Exchange in the Union Budget 2019. It constituted a working committee to study and suggest ways, in which, it can be operated seamlessly. Consequently, the social stock exchanges were introduced as a special segment at Bombay stock exchange and National stock exchange in late 2022 and early 2023 respectively. Although the exchanges established across the globe are not exactly similar in their structure and operational models, they have a common purpose of facilitating faster flows of capital to those organizations and initiatives that address the most critical social and environmental issues we face. The social stock exchange is a novel form of financial innovation that ostensibly fills the gap between traditional capital markets and the social sector (Lawler & Thye, 1999; Cole *et al.* 2002).

The social stock exchanges are expected to be an effective mechanism for capital allocation between social enterprises/ non-profits and impact investors who want to invest to create some social impact. These exchanges serve as a platform to facilitate linkage between socially conscious organizations and the impact investors. Here the impact/ philanthropic investors imply those investors who are willing to make some socially responsible investments. These investors have a combined focus of financial and social returns and social stock exchanges provide them a dedicated platform where they can buy securities issued by listed social enterprises which are geared toward impacting communities along with providing the financial returns (Short *et al.* 2009; Ahmad, 2021; Tietz *et al.* 2018). The social stock exchange provides information about the authentic and reliable enterprises working for the social cause. It also acts as an online fundraising platform that enables investors to acquire shares in social enterprises which are listed in stock exchange.

Despite the urgent need for an organised sector to direct public funds to social enterprises through the establishment of social stock exchanges, the global experience is not encouraging, as only three of the seven exchanges - in Canada, Singapore, and Jamaica - are currently operating in their original configuration. The success of the recently established Indian social stock exchange is vital in this situation for two reasons: first, it will help to meet the financial needs of social enterprises promoting the SDGs, and second, it will serve as a model for other nations to follow. To learn from their mistakes and take preventative action to make Indian SSE the biggest and most influential SSE in the world, it is crucial to examine the reasons behind the failures of SSEs in western nations. The study seeks to analyse the framework for SSEs worldwide on a country-to-country basis in order to evaluate their strengths and shortcomings and determine the potential causes of their success or failure.

1. Review of Literature

As the idea of a social stock exchange is still relatively new, not much research has been done in this area. A few recent studies, however, have been carried out in this area that highlights the increasing significance and

potential of social stock exchanges in fostering social impact through creative financial solutions. For example, research by Chaturvedi *et al.* (2019) and Uargade & Purohit (2021) emphasized the significance of social stock exchanges in India. Similarly, Calandra and Favareto (2020) appreciated the role of social stock exchange trading platforms in raising capital for social/environmental projects. Parekh *et al.* (2021), Wendt (2021), Sarkar and Banerjee (2022) highlighted the growing popularity of social impact investing to drive financial returns alongside addressing social/environmental welfare. The significance of readiness of investors/donors for social stock exchange has also been discussed in the studies. Mahesh *et al.* (2024) analyzed the impact of increasing funding for social and environmental concerns on the sustainable development goals.

Some studies have examined the structure of Indian social stock exchanges. For example, Kumar (2023) analyzed the guidelines of Security Exchange Board of India pertaining to the operational and regulatory mechanism of social stock exchange in India. The strengths, flaws, possibilities, and risks of the Indian social stock exchange were examined by Vig (2023). Additionally, the study emphasized the need to promote social welfare. Sadhwani *et al.* (2023) and Patel and Patel (2023) assess the Indian social stock exchange's framework and compare it to those of its international equivalents. Additionally, Mehra and Vij (2023), Challapalli and Pilla (2023), and George *et al.* (2021) looked at how social stock exchanges functioned throughout the world and contrasted India's social stock market model with that of other countries. Bhargava *et al.* (2024) examined the impact of closures of social stock exchange in United Kingdom in 2017. The study recommended the introduction of social stock exchange at wider level across the globe.

2. Research Methodology

The present study is exploratory in nature whereby an attempt has been made to understand the framework and functioning of social stock exchanges established across the globe such as Brazil, South Africa, Portugal, Canada, Singapore, United Kingdom, Jamaica and India. The study aims to provide inputs to deal with the challenges obstructing the success of these exchanges. For this purpose, secondary data has been used from published reports and documents along with the information available on concerned official websites of these countries. Further, the reports presented by working groups and technical committees on Indian social stock exchanges have also been taken into consideration.

3. Findings

As discussed in the methodology section, the present paper aims at analysing the mechanism of social stock exchange as followed in different countries. The world's first social stock exchange was established in Sao Paulo, Brazil in the year 2003. Thereafter many countries including South Africa (SASIX in the year 2006), Portugal (BVS in the year 2009), Canada (SVX in the year 2013), Singapore (in the year 2013), United Kingdom (SSE in the year 2013), and Jamaica (JSSE in the year 2019) also launched Social Stock Exchanges. After two decades of existence at the global level, it is still at an emerging stage fighting for its survival as only three social stock exchanges (belonging to Canada, Singapore and Jamaica) are working in their original form. To understand the strength and weakness of the system, all the countries that have established formal social stock exchange have been analyzed in this paper. The findings of the same can be discussed as follows:

3.1 Social Stock Exchange of Brazil

Brazil's Bolsa de Valores Socioambientais (BVSA), socio-environmental investment exchange was established in 2003 as the first formal stock exchange globally, emphasizing the social returns over financial returns on investment. The exchange assessed projects based factors like innovation, feasibility, sustainability, alignment, and thematic areas like education, health, and environment. Site visits, due diligence, and audits were part of the project monitoring system. Only non-profit organizations with strict eligibility criteria could participate in Brazilian social stock exchange. Investors were allowed to invest directly or through brokers at this platform and monitor the progress of project through published reports and updation form stock exchange platform.

The Brazilian social stock exchange raised over R$ 19 million (~$3.6 million USD) in donations from 2003 to 2018 through 188 projects. Most of these projects were focused on climate action, gender equality, and health. It also inspired similar initiatives in other countries like South Africa, Portugal, and Jamaica. But the social stock exchange stopped working in December 2018. The factors primarily responsible for the discontinuation of the Brazilian SSE include presence of limited participants (as only non-profit associations were allowed to register at SSE) and the limited investment options as one organisation was allowed to list only one project a year.

3.2 Social Stock Exchange of South Africa

In 2006, the Johannesburg Stock Exchange launched the first Social Investment Exchange in South Africa, known as SASIX. It aims to connect non-profits and social enterprises with investors to get funds for development initiatives having a measurable social impact. The exchange's methodical process involved a comprehensive due diligence procedure to evaluate proposals, risks, sustainability, and capacity to meet project objectives. The process used to take at least 12 weeks including a mandatory site visit for final approval.

SASIX was a platform used to raise funds by non-profit social enterprises with specific criteria including primary social purpose, transparency, sustainable business model and measurable social deliverables. Such businesses were allowed to raise funds from retail and institutional investors, offering them shares of listed social projects at a fixed price of R 50 per share. These sponsored projects were required to be introduced to the investors in sequential manner starting with awareness, understanding stewardship and then tracking of donations and investments. The South African SSE raised over USD 2.7 million in donations until 2009, primarily focused on healthcare, education, food, support for vulnerable people, animal/environmental protection, and enterprise development. The exchange was innovative in its leverage-market-based principles to support social impact but eventually closed its operations in 2009. Factors contributing to its discontinuation included the limited scope of financial products, with most projects focusing on debt investments via Cadiz, a joint venture for institutional investors (mainly for pension fund holders), and the limited diversification of projects, with most of the projects focusing on health-related initiatives. Additionally, the exchange had a limited range of investors.

3.3 Social Stock Exchange of Portugal

The Portuguese Social Stock Exchange (named as Bolsa de Valores Sociais-BVS) was among the initial social stock exchange in the world. Established in 2009, it aimed to connect social enterprises with non-profit organizations to mobilize funds for social impact projects in Portugal. Primarily, the social projects were assessed using SWOT analysis for their scalability, impact capacity, innovation and financial feasibility. Then, the selected social projects used to get listed for two years and monitored through audits and regular checks. Investors, including retail and institutional investors, were eligible to purchase social shares in listed projects without commission. The minimum purchase requirement was 10 shares, priced at one euro per share. The exchange raised 2 million euros from its listed projects until 2013, covering sectors like human rights, entrepreneurship, health, social inclusion, institutional strengthening, and education. However, the exchange failed to gain momentum and discontinued operations in 2015 due to Portugal's on-going economic crisis resulting into limited fundraising and failure in achieving its long-term financial target.

3.4 Social Stock Exchange of United Kingdom

The UK Social Stock Exchange (SSX) was established in 2013 to provide a platform for small and mid-cap companies that prioritize social or environmental missions to raise funds through public investment. As a certified B-corporation, the exchange is not regulated or registered under any stock exchange and has received support from organizations like Big Society Capital, Rockefeller Foundation, and the London Stock Exchange Group. To be listed, applicant company must undergo a selection process, including reviewing applications, assessing their social or environmental impact report, and evaluating their ability to achieve the same. The exchange selects only 50% of applicants and charges an annual membership fee of £10,000. Companies are required to provide annual impact reports to maintain their membership.

The SSX was open to global retail and institutional investors, trusts, foundations, and family offices. With reference to the participating social enterprises, it deals with for-profit companies with a market capitalization of under £10 million and must have earned at least two-thirds of their income through social or environmental activities. Further, the companies were required to meet at least one of the following conditions:

- The company should have publicly traded securities on a recognized stock exchange.
- The company must be interested to issue equity or debt securities through the recognized stock exchange.
- The company must aim to raise growth capital to enter publicly listed markets at a later stage.

The SSX did not provide trading services directly to investors as it was not a trading platform, and investments in impact-driven companies were processed through their listings on other exchanges. By the year 2015, the social stock exchange had raised 400 million euros.

This exchange faced challenges in market positioning due to a lack of evidence of successful impact and returns, leading to increased pressure to show progress. Stakeholders were unclear about their differences from existing investment markets, creating confusion and competition with other impact investment platforms. As a

result, the exchange stopped functioning in its original form and adopted a secondary listing platform structure, with operations and employees shifted to the Impact Investment Network in 2018.

3.5 Social Stock Exchange of Canada

Canada's first formal social stock exchange, Social Venture Connexion (SVX), was established in 2013. It is an independent non-profit organization that operates as a restricted dealer with the Ontario Securities Commission, an accredited financial broker, and a licensed crowd funding operator. The exchange aims to facilitate the linkage between impact-driven businesses and investors through crowd funding and brokerage services. It evaluates performance through Impact Reporting and Investment Standards metrics, criteria set by the social stock exchange itself.

The Canadian social stock exchange supports various non-profit, for-profit, and co-operative organizations, including community power co-operatives producing renewable energy and charitable organizations tackling mental health and addictions. The exchange offers a range of support, from educational offerings to advisory services, and capital through impact investing funds. The issuer organizations are required to demonstrate transparency, measurable social impact, and financial sustainability for trading. Investors can invest directly in projects listed on the exchange. The exchange has raised $350 million capital from over 1200 investors in over 500 enterprises till now as per the information available on their official website (https://svx.ca/).

Unlike other exchanges around the world, the main strength of the exchange is its efficient management of operating costs, running operations from funds acquired through grants, advisory services, hosting events, exchange franchise fees, and admission fees charged to issuers. However, the major challenge is the lack of awareness regarding equity investment. The same is reported by Annual Canadian Impact Survey Report , 2021(available on https://svx.ca/impact/) which states that investors have a high interest in affordable housing, food, energy, and environment sectors, and least interest in equity investments.

3.6 Social Stock Exchange of Singapore

Singapore's Impact Investment Exchange (IIX) was established in 2013 with a seed grant of $495,000 from the Rockefeller Foundation. The exchange operates under the Stock Exchange of Mauritius and is governed by the Financial Services Commission of Mauritius. It facilitates crowd funding and gender-lens investing for NGOs and social enterprises, including equity and debt mix. The IIX also functions as a digital impact assessment platform and a training centre for stakeholders. To list on IIX, projects must have a clear social/environment mission, robust business model, social impact framework, financial and environmental sustainability, and scalability with investment capital. The exchange does not charge listing fees for enterprises but covers operating expenses through technical assistance, impact assessment, and services fees. As per IIX Impact Report 2023 (published on official website of Singapore IIX: www.iixglobal.com), Singapore SSE has raised US $454 million from 1300 investors impacting 160M lives directly and indirectly till now. The two main strengths of IIX are its ability to cover operating expenses and innovative financing initiatives supporting gender-lens impact investing for gender equality solutions.

3.7 Social Stock Exchange of Jamaica

The Jamaica Social Stock Exchange (JSSE) offers two main markets for social investments: JSIM (crowd funding with social returns) and JIIM (impact investment with both social and financial returns). The JSSE follows transparent and rigorous selection process for listing starting with an application review, interviews, site visits and then final listing with official ceremony. It also operates an annual submission process for social enterprises to raise funds. The JSSE operates as a social program driven by corporate social responsibility initiatives, with collaboration from local donors, Jamaican diaspora donors, and international development partners.

The Jamaica Social Stock Exchange has been actively involved in crowd funding since 2019, raising over JMD $271 million and supporting COVID-19 relief efforts by raising JMD $1,131,950 (information available of official website of *JSSE:* www.jsse.jamstockex.com). Crowd fund donors receive social returns, while investors of profitable social enterprises receive both social returns and financial dividends. The exchange has shown steady progress in listing new projects and contributing to the growth of social impact investments in Jamaica.

Table 1 represents the comparative analysis of all social stock exchanges established across the globe till date.

Table 1. Comparative Analysis of Global Social Stock Exchanges

Name of SSE	Bolsa de Valores Socioambientais (BVSA)	South African Social Investment Exchange (SASIX)	Bolsa de Volares Sociais (BVS)	Social Venture Connexion (SVX)	UK Social Stock Exchange (SSX)	Singapore's Impact Exchange (IIX)	Jamaica Social Stock Exchange (JSSE)
Year of initiation	2003	2006	2009	2013	2013	2013	2019
Country of Origin	Brazil	South Africa	Portugal	Canada	United Kingdom	Singapore	Jamaica
Objective	To work as a transparent platform between impact-focused investors and social & environmental organisations	To encourage Corporate social development and foster accountability for social performance among beneficiary organisations	To facilitate collaborations between education entrepreneures, social investors and civil society organisations to fund and scale effective initiatives.	To strengthen organisations to tackle with poverty and build environment sustainability and scale by providing Capital access, reducing fundraising cost and a social purpose.	To create an accessible marketplace that enables social businesses and impact investors can achieve impact through efficient capital raising and allocation.	To provide a platform where social purpose organisation can raise capital and investors can enjoy liquidity.	To attain Jamaica's SDGs and promote social giving by increasing transparency in fund utilisation
Structure and sponsors	- No trading platform of its own. - Working with Brazilian stock exchange	- Working under Johannesburg Stock Exchange	- modelled after the Brazilian Social Stock Exchange -	- independent non-profit organisation - restricted dealer with the Ontario Securities Commission - accredited financial broker - licensed crowdfunding operator	- certified B-corporation - standalone private company - not regulated or housed under any stock exchange	- operated by the Stock Exchange of Mauritius (SEM) - regulated by the Financial Services Commission of Mauritius	- its a social program created by JSE's own practice of Corporate Social Responsibility (CSR), - Sponsors: Jamaica Stock Exchange (JSE) and Inter-American Development Bank (IDB)
Target Area	Marginalized communities, disability, physical health, inclusion of immigrants, livelihood and skills, environment education, Prevention of violence against women, Art and Advocacy	Rehabilitation, mental health, disability and physical Health	Environment and conservation, education, inclusion of immigrants, livelihood and skill training, disability	Food, Affordable housing, energy and environment	Physical and mental health, citizenship and community, environmental conservation, housing and local facilities, art, sports, international developments, heritage and faith	Climate, water, energy, agriculture and women empowerment	Mental Health, People with disabilities, education
Participants	Non-Profit organizations only	Non-profit organisations and social businesses	Non-profit organisations and social environmental businesses	Both Non-profit organizations and for-profit enterprises	small and mid-cap companies (main objective is social impact)	Social entreprises, micro finance institutions, development finance institutions,	NPOs registered under charity law of Jamaica

Name of SSE	Bolsa de Valores Socioambientais (BVSA)	South African Social Investment Exchange (SASIX)	Bolsa de Volares Sociais (BVS)	Social Venture Connexion (SVX)	UK Social Stock Exchange (SSX)	Singapore's Impact Exchange (IIX)	Jamaica Social Stock Exchange (JSSE)
						and NGOs	
Services	Crowdfunding platform	Social investment broking and portfolio management	Supporting financial systems, guidance in making business and investment plans	Guidance in Investment readiness programmes and investment tracking services	Provide guidance and expert advice to investors and investees	Educate organisation about impact investing and help them in raising capital	Empowering investees
Returns	Social	Social and Financial	Social	Social, environmental and Financial	Social and Financial	Social, environmental and Financial	Social and Financial
Funds Raised	R$19 milliion (2003-2018)	US $ 2.7 Million (2006-2009)	2 million euros (2009-2013)	$350 million	400 million euros (2013-2015)	US $454million (2013-2023)	More than $271 million (2019-2023)
Current Status	Closed (2018)	Closed (2009)	Closed (2015)	Active	not active in its original form	Active	Active

Source: Author's compilation

Table 1 depicts the commonalities and differences among the structure, functions, models, and objectives. It is evident that the concept of SSE was instituted across the world, but the majority were unable to sustain themselves (Brazil: 2003-2018; South Africa: 2006-2017; Portugal: 2009-2015 and UK: 2013-2017). The main reasons for the failure of SSEs in Brazil, South Africa, Portugal and the UK are lack of awareness about SSE on the part of investors and higher economic costs on the part of registered social enterprises (Mehra and Viz 2023). Further, only non-profit associations were allowed to register with SSE in many countries like Brazil, Portugal and South Africa. However, the model of social stock exchange is currently functional in three countries viz., Canada (2013), Singapore (2013) and Jamaica (2019) apart from India.

3.8. Social Stock Exchange of India

In India, the concept of social stock exchange was first introduced by Smt. Nirmala Sitharaman, Union Finance Minister during 2019-20. After getting the recommendation and broad framework from working group and technical committee on social stock exchange in 2021, the Securities Exchange Board of India gave its final approval for introduction of social stock exchange as a special segment on Bombay Stock Exchange on 27th December 2022 and subsequently to National Stock Exchange on 22nd February 2023.

The unique features of Indian social stock exchanges are as follows:

• **Eligible Enterprises.** In India, along with the not-for-profit organisations (NPOs), a for-profit organisation (FPOs) can also get listed on social stock exchanges provided their primary goal is social welfare. As on December, 2024 a total of 97 enterprises are registered on social stock exchange out of which 72 enterprises have been listed on National Stock Exchange and 25 enterprises have been listed on Bombay Stock Exchange.

• **Innovative Financial Instruments.** The social stock exchange in India aims to create a link between these social enterprises and investors aspired to generate social impact in conjunction with financial returns. The exchange introduces the following innovative instruments:

- **Zero Coupon Zero Principal bond (ZCZP).** Zero Coupon Zero Principal bond which is a financial instrument used by any non-profit organisation or social enterprise listed on the social stock exchange to raise funds. These bonds have zero coupon or interest with zero principal payment at maturity and are suited to those investors who do not want their invested funds back. These bonds are issued for the charity that promises a social return to the investor.
- **Development Impact Bonds (DIBs).** The Development Impact Bonds are used to finance development programs in those countries having less income. It involves three parties such as a private investor, a service provider and an outcome payer. The private investor is usually an investor or group of investors that provides funds for carrying out development projects that assure social outcomes. The service provider is normally a non-profit organisation that is accountable for completing the project and is responsible for its social outcomes. The outcome payer is the philanthropic organisation. The outcome

payer pays back the principal and interest amount to the investor if the service provider is able to achieve social outcomes.

- **Social Impact Bonds (SIBs).** The Social Impact Bonds are the financial instruments that provide funds to those projects that address societal needs such as access to education, better health care services, women's safety and empowerment, etc. and generate positive social outcomes.

The listed NPOs can raise funds through the issue of zero coupon zero principal instruments and also in the form of donations by way of mutual fund schemes whereas listed FPOs can raise funds through issuance of equity and debt securities. The minimum subscription required for such issuance is fixed at 75 percent of total fund raising.

- **Regulatory framework and disclosure requirements**

The Indian social stock exchanges are required to follow the regulatory provisions laid by Securities Exchange Board of India so as to ensure transparency and accountability. Listed social enterprises must give detailed information on their social impact projects that create positive change in society and environment, to the investors so that they can make investment decisions wisely.

- **Assistance in the achievement of Sustainable Development Goals:**

All the Social enterprises must reveal comprehensive information in the form of standardised report on social and environmental impact. The information should be aligned with the Sustainable Development Goals of the United Nations. It will be a highly supportive mechanism for achieving sustainable development goals also because there is a huge performance gap in this direction. Subramanian *et al.* (2023) noted that in contemporary scenario, it is very difficult to meet sustainable goals by 2030. India's philanthropy report, 2024 shows that the country is not able to spend 13% of its GDP (as estimated by NITI Aayog) to meet the 17 UN Sustainable Development Goals by 2030, including poverty eradication, quality education, healthcare, gender equality, and climate action. The number of high-net-worth individuals (HNIs) and affluent individuals in India is expected to grow to 1.7 million, with a cumulative net worth of INR 460 lakh crore over the next five years. These individuals have a high propensity to donate, accounting for over 0.7% of their net worth. Addressing barriers such as lack of awareness, transparency, and impact measurement by SSEs could unlock significant upside potential in donations from this segment. Through concentrated efforts, private philanthropic donations from wealthy these donors may reach 35% by FY 2028, up from 22% in FY 2023.

In nutshell, the ambitious targets of achieving SDGs cannot be achieved by government funding alone. It is imperative to comprehend the need to share this responsibility with high net-worth individuals and business leaders due to the changing business environment. Though corporate social responsibility efforts serve in this direction but simply on the basis of compliance-based responses, the job cannot be done. There is a need to push philanthropic investors to work in this direction who are reluctant to make such investment due to the non-availability of a transparent and reliable system. The idea of the social stock exchange is a response to enable systematic and transparent funding routes for the social sector in India.

- **Capacity building programs.** India has established a capacity development fund (CBF) with contributions from NABARD, SIDBI, NSE, and BSE, totaling Rs. 100 crores. The fund is used by SSEs with an aim to raise awareness of the social stock exchange (SSE), its processes and impact investing among social enterprises and investors through workshops.

Thus, social stock exchange in India serves as a marketplace where social enterprises and impact investors can connect in a framework that is regulated and transparent. The concept will bring change in India's impact investing ecosystem, by encouraging accountability, enabling measurement of final outcomes and ensuring enforcement of independent compliance. It is expected to allure not only the domestic investors but also the foreign investors who have desire to support healthcare, education, agriculture, or to ensure long-term environmental solutions. Thus, social stock exchange is expected to serve as a central hub for scaling impact initiatives.

Conclusion

Though SSEs, across the world, do not have a glorified history, Indian SSE has to set up a role model for the world. The success of social stock exchange is essential for social enterprises facing enormous difficulties in raising funds from the public as well as corporate under their corporate social responsibility (CSR) initiatives (Parekh *et al.* 2020). Similarly, it is imperative to secure the trust of investors worrying about the functioning of social enterprises and the proper utilization of funds (Ravi *et al.* 2019). Indian social stock exchange needs to evolve as the world's largest and most impactful social stock exchange by providing reliable and standardized information repositories to social enterprises, investors, donors, philanthropists and other stakeholders. There is

also a need to educate stakeholders on new financial instruments like zero coupon zero principal bonds, development impact bonds, and social impact bonds. The capacity building fund should be utilised for these purposes along with guiding non-profit organizations in listing and compliance requirements. Further, the availability of qualified social auditors to conduct independent audits of impact reporting of social enterprises is another challenge in front of social stock exchange which need immediate attention. It is also essential that social stock exchange creates mass understanding among the general public that investment in socially responsible companies and philanthropic organizations can also generate financial returns along with social returns. This can be done through religious preaching, government support programs, and different awareness initiatives.

The paper suggests that policymakers and regulators should consider innovative investment options, impact investing, strong and transparent regulatory mechanisms along with disclosure requirements to enhance the success of social stock exchanges.

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On behalf of all authors, the corresponding author states that there is no conflict of interest.

Credit Authorship Contribution Statement

Nishi Sharma: Conceptualization, Funding acquisition, Format analysis, Methodology, Writing –review and editing, Supervision.
Arshdeep: Conceptualization, Funding acquisition, Writing – original draft.
Kiran Jindal: Conceptualization, Funding acquisition, Writing – review and editing.
Meena Sharma (Research Associate for ICSSR Project at UIAMS, Panjab University, Chandigarh): Format analysis, Writing – original draft.

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 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 Economics Driven Entrepreneurship Nudges Among Individuals

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Abstract: This study aimed to develop and implement strategies rooted in the principles of behavioural economics to foster the growth of entrepreneurship within higher education institutions. By focusing on technology transfer offices (TTOs) as critical facilitators of innovation and entrepreneurship, the research assessed the competencies of 40 TTO employees from seven different countries. Utilizing the 180-degree feedback method, which incorporates both self-assessments and peer evaluations, the study identified significant discrepancies between how TTO employees perceived their skills and how their peers evaluated them. Notably, areas such as innovativeness, creativity, and collaboration showed marked differences, indicating a potential misalignment in self-awareness and actual competency levels. The findings emphasized the necessity for a more balanced and holistic approach to competency development, ensuring that TTO employees are equipped not only with technical skills but also with interpersonal and innovative capabilities essential for fostering an entrepreneurial mindset. In addition to the competency assessment, the study included feedback from 203 participants who attended entrepreneurship workshops facilitated by TTO employees involved in an international project. The participants overwhelmingly rated the training as useful and practical, suggesting that such initiatives significantly contribute to entrepreneurial skill development. Ultimately, this research highlights that enhancing the competencies of TTO employees is crucial for providing better support for academic entrepreneurship. As TTO employees become more adept in their roles, this leads to increased readiness among faculty and students to undertake business ventures, thereby contributing to a vibrant entrepreneurial ecosystem within higher education institutions. The study calls for ongoing professional development and training programs for TTO staff to ensure they remain effective in their support roles, ultimately fostering a culture of innovation and entrepreneurship in academia.

Keywords: entrepreneurship; business incentives; higher education institutions; competency; support specialists; technology transfer.

JEL Classification: A12; D03; D81.

Introduction

In a world where innovation and entrepreneurship are driving economic growth, it is necessary to determine how to effectively motivate people to start businesses. Traditional methods of supporting entrepreneurs, such as

financial assistance or legislative changes, are not always effective enough, as they do not address the psychological barriers and motivational factors that influence the decision to start a business.

Behavioural economics, which combines economic and psychological approaches, provides new tools for designing such measures. Research relevance is also determined by the growing interest of governments, educational institutions and international organisations in entrepreneurship development as an important element of economic development (Suh 2019). In the context of globalisation and rapid technological change, support for entrepreneurship is becoming critical to the competitiveness of national economies. Determination of how to effectively use the principles of behavioural economics to stimulate entrepreneurial activity can be a key factor in the success of these efforts.

In addition, the research relevance is determined by the need to address social issues such as unemployment and social inequality. Entrepreneurship can be an important means of creating new jobs and improving living standards (Mohammadi *et al.* 2025). Developing measures that encourage entrepreneurship can help address these challenges by providing people with new opportunities for self-fulfilment and economic growth.

One of the key problems is a lack of understanding of the psychological barriers that prevent people from starting their businesses (Novykova *et al.* 2022). Although behavioural economics offers many tools to overcome these barriers, their effective application requires a deep knowledge of the individual motivations and fears of potential entrepreneurs (Aviv *et al.* 2008).

Another relevant challenge is the difficulty of measuring and evaluating the results of behavioural interventions. The effectiveness of such interventions may vary depending on the context, culture and personal circumstances of the participants, making it difficult to develop universal strategies that would be equally effective in different settings. Integrating behavioural interventions into existing entrepreneurship support programmes is also a significant challenge. Many of these programmes focus on providing financial assistance or advisory services, while behavioural interventions require a more flexible and individualised approach, which may require additional resources and changes in the structure of support.

B. Suh (2019) is one of the founders of behavioural economics, a field that combines economics and psychology to study how people make decisions in economic situations. The study focuses on how psychological factors, such as emotions, cognitive biases and social influences, affect economic behaviour. B. Suh was one of the first to question traditional economic models based on the assumption that people act rationally and seek to maximise their benefits.

S. Kemp (2019) studied behavioural economics, focusing on how psychological factors influence economic decisions. His research focuses on the processes that guide people's choices in complex economic situations, such as financial decision-making, risk management, and responses to economic incentives. S. Kemp emphasises that human behaviour often deviates from classical economic models that assume rationality and predictability. Studies contribute to the determination of how people act in economic conditions, making behavioural economics relevant for improving economic models and developing policies that consider the real psychological mechanisms that influence decision-making.

T. Allard *et al.* (2019) contributed to the development of behavioural economics by studying how psychological and social factors influence people's economic behaviour. The research focuses on how people make decisions under uncertainty, what cognitive biases influence their choices, and how emotions can alter rational risk and benefit assessment. T. Allard *et al.* addressed economic decisions from a psychological perspective, exploring how real-world behavioural patterns deviate from standard economic theories that assume rational behaviour. The work showed that human behaviour is often more complex and unpredictable than traditional economic models suggest.

Within the framework of research on behavioural economics and entrepreneurship, the study of J.-P. Bassino *et al.* (2019) is relevant. They studied how various interventions, including reminders and nudges, can influence decision-making in various areas of life, including entrepreneurship. Their research has shown that even simple measures can significantly increase the effectiveness of entrepreneurship support programmes.

T. Studzieniecki *et al.* (2022) found that the key motivators for entrepreneurs are the desire for independence, self-realisation and financial stability. At the same time, he noted that many potential entrepreneurs face barriers such as fear of failure, lack of financial resources and the necessary knowledge.

R. Klesta *et al.* (2024) examined the factors influencing employee motivation across generations X, Y, and Z within the IT industry. Their study highlights that while traditional motivators such as salary and job security remain important, younger generations place a higher value on work-life balance, opportunities for professional development, and a sense of purpose in their work. The research emphasizes that understanding these

generational differences is crucial for organizations aiming to enhance employee engagement and retention. By fostering an environment that aligns with the unique motivations of each generation, companies can effectively drive performance and cultivate a more dynamic workforce (Kalyuzhna *et al.* 2024).

J. Jemmy (2024) conducted a systematic review of leadership styles in public administration, analyzing their effectiveness in driving organizational performance. The study reveals that different leadership styles, such as transformational, transactional, and servant leadership, have distinct impacts on organizational outcomes. J. Jemmy identifies transformational leadership as particularly effective in fostering innovation and employee engagement, while transactional leadership tends to enhance short-term performance through structured processes and clear expectations. The research underscores the importance of aligning leadership approaches with organizational goals to maximize performance. By understanding the nuances of various leadership styles, public administrators can better navigate challenges and drive positive change within their organizations (Burmistrov *et al.* 2024).

V. Vasilios and P.I. Xanthopoulou (2024) conducted a literature review on types of leadership and their impact on the effectiveness and efficiency of public organizations. Their analysis highlights various leadership styles, such as autocratic, democratic, and transformational leadership, and examines how each style affects organizational performance and employee satisfaction. The review identifies that transformational leadership is particularly effective in enhancing motivation and engagement among public sector employees, leading to improved service delivery and organizational outcomes. However, the authors note that certain areas remain underexplored, including the context-specific effectiveness of these leadership styles across different public organizations and the interplay between leadership styles and organizational culture. By addressing these gaps, the research aims to contribute to a deeper understanding of how leadership dynamics can be leveraged to enhance public sector performance.

The study aims to develop effective approaches based on the principles of behavioural economics that promote entrepreneurial activity at higher education institutions. The task was to analyse existing theoretical approaches and practical examples, as well as to develop and test new methods of influencing the motivation to engage in entrepreneurial activity. The novelty of the study lies in its application of behavioural economics principles to enhance entrepreneurship within higher education institutions by systematically assessing and developing the competencies of technology transfer office (TTO) employees, using a 180-degree feedback method and participant evaluations to bridge gaps in self-awareness and peer perception.

1. Materials and Methods

The survey of the units' employees' competencies took place from September 1 to October 30, 2023. During this period, a total of 40 employees from 8 research commercialization entities across 7 different countries participated. This comprehensive survey aimed to evaluate the competencies of these employees using a 180-degree feedback method. In this approach, each of the 40 employees was assessed one colleague (40+40), providing a well-rounded view of their skills and performance from multiple perspectives.

The 180-degree feedback method was chosen to ensure a balanced evaluation by including self-assessments as well as peer assessments. This dual approach helps to capture a more complete picture of each employee's competencies, including their technical abilities, teamwork, leadership skills, and other relevant attributes. The study, which lasted for a month, aimed to integrate specialised knowledge and project management methods, which ensured the quality and accuracy of all stages of work. Modern management approaches were used to optimise planning, monitoring and control of processes, which helped to achieve the goals set on time. Before conducting the research, joint workshops were held with the heads of TTOs, who were considered competent judges with the most experience in the processes carried out by these offices. The meetings took place weekly (on November 8, 15, and 21, 2022) and lasted between half an hour to an hour. During these meetings, discussions primarily focused on the research objectives, the role of TTOs in the knowledge transfer process between research institutions and the socio-economic environment, differences in the functioning of TTOs and universities, and common features in the form of processes that are similarly implemented across units.

Within the group of competent judges, four processes were identified for study in the institutions:

1.Administrative handling of studies, collaboration with external entities.

2.Direct and indirect commercialization.

3.Process of creation of added value for the services and products of national manufacturing companies.

4.Process of support for academic entrepreneurship.

During the workshops, participants had the opportunity to evaluate from a collective list of 36 competencies which 6-9 competencies were crucial for executing a specific process within their unit. They could also add new competencies to the list, which they did. Through joint discussion, the ideal level of competency a specialist involved in each process should possess to optimally perform their tasks was determined. As a result, four models of the main processes carried out in TTOs were developed.

The nearly year-long gap between the workshops and the research allowed TTO heads to explain the purpose of the study to their employees, apply the acquired knowledge and skills in practice, and help participants better understand the theoretical foundations of the research and deepen their knowledge on the subject. Next, using the example of the University of Silesia in Katowice, it was demonstrated how the competencies of TTO employees influence the entrepreneurship education programs they run.

2. Research Results

The barriers to the Development of Innovation and Entrepreneurship can be both financial and psychological, including fear of failure, lack of self-confidence and lack of support from society. To simplify the understanding, traditional economic models use the concept of behaviour within the framework of the Resourceful, Evaluating, Maximising Man (REMM) concept (Gentsoudi 2023). Understanding and overcoming these barriers are key to creating a favourable environment for entrepreneurship.

Research shows that people often do not make rational decisions due to their limited ability to process information, which is manifested in the phenomenon of limited rationality. For instance, a consumer may buy an expensive product without researching alternative options that could be more profitable (Kerimkhulle *et al.* 2023a). Heuristics play a key role in decision-making when people rely on mental shortcuts, such as choosing a product based on a well-known brand only, ignoring other options. The anchoring effect illustrates how initial information influences subsequent decisions: people may value a product according to the first price they see, even if there are better deals available (Kim *et al.* 2019). Overconfidence often leads to an overestimation of one's knowledge and abilities, which can be dangerous, as in the case of an investor who believes that he or she can predict the market better than others, leading to losses.

Table 1. Principles of behavioural economics

Principle	Description	Example
Limited rationality	Neglect of rationality due to limited information processing capabilities.	A person buys an expensive item without analysing the market
Heuristics	People use mental shortcuts (heuristics) to make decisions.	When choosing a product, a person focuses on the brand, ignoring other possibilities
Anchoring effect	The first piece of information received influences subsequent decisions.	People estimate the value of a product based on the first price
Excessive self-confidence	Reassess own abilities	Overconfidence leads to investment losses.
The effect of ownership	People place more value on things they already own.	A person refuses to sell an old car for the market price, believing it to be much more valuable.
Social norms	Behaviour is often determined by social norms and expectations.	A person buys a certain product because friends or colleagues use it, even if it is not the best choice.
Framing	The way information is presented influences people's decisions.	A person chooses a product that is advertised as "90% fat free" instead of "contains 10% fat", even though it is the same thing.
The status quo effect	People tend to stay with the status quo.	People do not change service providers, even if there are better and cheaper options, because they are unwilling to change.
Hyperbolic discounting	People want to benefit here and now, even if the long-term profit will be more profitable and greater.	People spend money on small things now instead of saving for a bigger purchase in the future.
Loss of the obverse	People react more strongly to losses than to equivalent gains.	The fear of loss overshadows the possible benefits.

Source: compiled by the authors based on (Barros and Ortega 2019).

The status quo effect shows the tendency of people to stay in the status quo, avoiding change, even when there are better alternatives. Hyperbolic discounting demonstrates how people prefer immediate gains to future gains, even if they are smaller: for example, spending money on small things now instead of saving for a larger

purchase. Finally, aversion loss shows that people react more strongly to possible losses than to equivalent gains, as in the case of an investor who avoids risky investments for fear of losing money, even if the potential gain could be significant (Table 1).

Studies have shown a significant increase in the number of new business registrations following the implementation of appropriate measures. The use of methods based on coercive measures, social norms and instant rewards has proven to be effective in attracting young people to entrepreneurship and stimulating the creation of new start-ups (Piiroinen and Raghavendra 2019).

An important element of support for young entrepreneurs is the existence of companies specialising in business development among young people. For example, in Cyprus, there is GrantXpert Consulting Ltd (Cyprus), a consulting company that actively promotes entrepreneurship among young people. It involves students and young entrepreneurs in international projects, which allows them to gain valuable experience at the global level. Thanks to this approach, young professionals not only gain knowledge but also expand their international contacts, which is an important factor in successful business development.

However, in addition to private companies, universities also play an important role in supporting youth entrepreneurship (Shahini 2024). They provide young people with the knowledge, skills, and access to resources needed to successfully start and grow a business. Institutions such as University of Silesia in Katowice (Poland), Vytautas the Great University (Lithuania), University of Castilla-La Mancha (Spain), Lviv University of Trade and Economics (Ukraine), Malardalen University (Sweden), Teaching Factory Competence Centre (TF CC) Greece, SPIN-US (Poland) actively cooperate with young entrepreneurs by creating special programmes and incubators that facilitate the formation of new businesses.

The University of Silesia in Katowice (Poland) is an important educational centre in Central Europe with a wealth of experience in training specialists in various fields, including economics and entrepreneurship. Through its programmes focused on the practical application of knowledge, the university helps students develop the necessary skills to start and run a business. The Teaching Factory Competence Centre, located in Greece, is noted for its innovative approach to learning, where theory is combined with practice, this centre actively involves students in real production processes, which allows them not only to acquire theoretical knowledge but also to learn how to solve actual business problems in practice. This approach significantly increases their readiness for the real business environment. Malardalen University (Sweden) is known for its research in economics and business, which often combines traditional economic models with innovative approaches. This university actively cooperates with business, involving students in research projects, which helps them better understand the current challenges and opportunities in entrepreneurship, and contributes to the development of critical thinking and the ability to adapt to a rapidly changing market.

Vytautas the Great University (Lithuania) and Castilla-La Mancha University (Spain) play a significant role in the development of entrepreneurial education in their countries. Both universities offer specialised programmes aimed at preparing students for entrepreneurship. They support students in creating business projects by providing them with the necessary knowledge, resources and mentoring support, which helps young people to confidently enter the world of entrepreneurship using the knowledge gained during their studies.

Lviv University of Trade and Economics (Ukraine) is also known for its active support of young entrepreneurs. The university has established numerous partnership programmes and business incubators to help students develop their business ideas, these initiatives are aimed at enabling young entrepreneurs to bring their ideas to life using the university's infrastructure and resources. SPIN-US Ltd (Poland) is a company that actively promotes innovation and entrepreneurship through the commercialisation of scientific research. It helps researchers and students turn their ideas into commercially successful products and services. This approach not only fosters entrepreneurship but also stimulates innovation, which is a key factor in the modern economy. The survey collected information on the competency levels of employees supporting the process of knowledge transfer from researchers to entrepreneurs, as well as employees supporting the development of academic entrepreneurship. The study of employees' competencies took place from September 1 to October 30, 2023. A total of 40 employees from 8 entities engaged in research commercialization across 7 countries participated in the survey. The competency assessment was conducted using the 180-degree method, involving 40 employees and their 40 colleagues.

The first phase of the Transfer Office Competencies study focused on laying the foundations for assessing the competencies of transfer office staff at each facility, creating a model of exemplary competencies that a knowledge transfer support employee should possess. A two-hour diagnostic workshops was held with a group of selected representatives of participating universities (competent judges), including: University of Silesia in Katowice (Poland), Vytautas the Great University (Lithuania), University of Castilla-La Mancha (Spain), Lviv

University of Trade and Economics (Ukraine), Malardalen University (Sweden), Teaching Factory Competence Center (TF CC) (Greece), SPIN-US (Polish target company) and GrantXpert (Cyprus). The main goal of the event was to define expectations, develop a profile of the ideal employee for knowledge transfer and establish criteria for hiring. It was investigated which competencies and in which TTO were self-assessed at the same level as required. Discrepancies between the lowest and highest competency scores, strengths and weaknesses of individual institutions in terms of entrepreneurship and knowledge transfer were revealed.

University of Silesia in Katowice is a major public research university located in Katowice, Poland. Established in 1968, it's one of the most prominent universities in the Silesian region (Table 2).

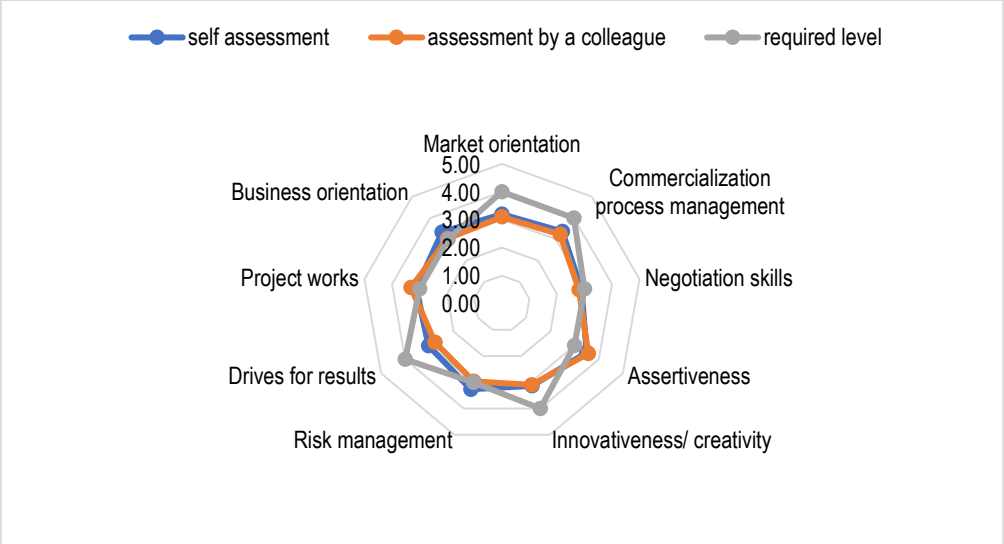
Table 2. Research results based on the example of the University of Silesia, profile 1B: The process of direct and indirect commercialization

Parameter	A	B	C	A – C	B – C	A – B
Competences	Self-assessment	Assessment by a colleague	Required level	Self-assessment vs required level	Assessment by a colleague vs required level	Self-assessment vs assessment by a colleague
Market orientation	3.20	3.10	4.00	-0.80	-0.90	0.10
Commercialization process management	3.37	3.23	4.00	-0.63	-0.77	0.13
Negotiation skills	2.89	2.81	3.00	-0.11	-0.19	0.08
Assertiveness	3.50	3.57	3.00	0.50	0.57	-0.07
Innovativeness/Creativity	3.13	3.10	4.00	-0.87	-0.90	0.03
Risk management	3.27	2.97	3.00	0.27	-0.03	0.30
Drives for results	3.03	2.77	4.00	-0.97	-1.23	0.27
Project works	3.12	3.31	3.00	0.12	0.31	-0.19
Business orientation	3.33	3.04	3.00	0.33	0.04	0.29

Source: compiled by the authors.

Overall, self-assessments reveal some areas where individuals are below the required levels, particularly in competencies like Market Orientation, Innovativeness/Creativity, and Drives for Results. Conversely, there are areas where self-assessments meet or exceed the required levels, such as Assertiveness and Business Orientation. The discrepancies between self-assessments and colleague assessments highlight differences in perception, with self-assessments often being slightly more favorable or less critical compared to colleague evaluations (Figure1).

Figure 1. Research results based on the example of the University of Silesia



Source: compiled by the authors.

Vytautas the Great University is a prominent public university located in Kaunas, Lithuania. Established in 1922, it is known for its commitment to high-quality education, research, and international cooperation (Table 3).

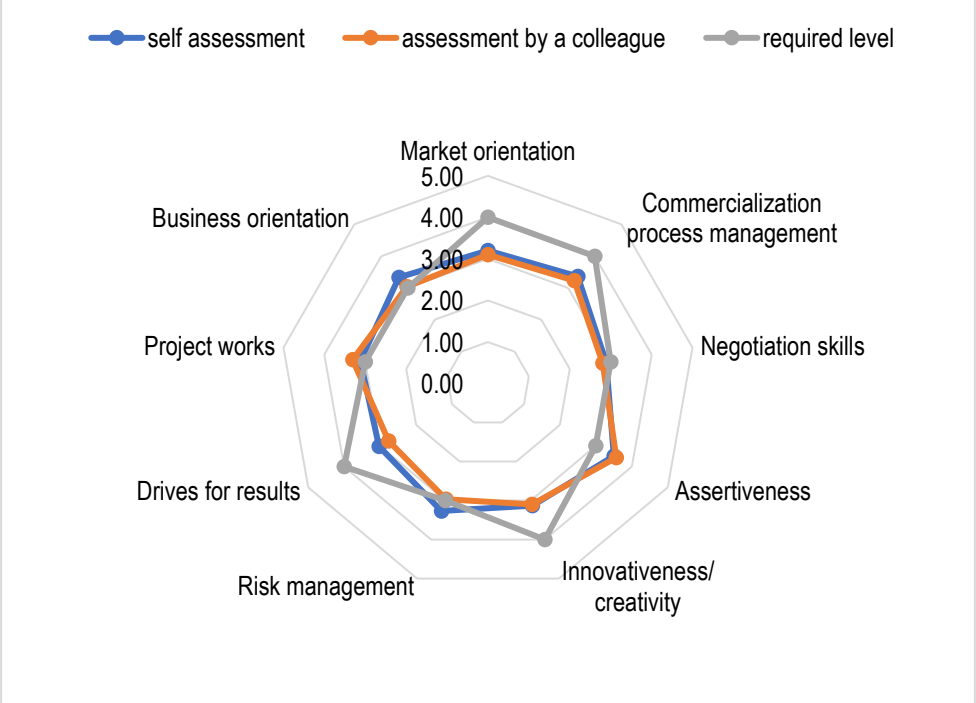
Table 3. Research results based on the example of the Vytautas the Great University (Lithuania), profile 1A: The process of direct and indirect commercialization

Parameter	A	B	C	A – C	B – C	A – B
Competences	Self-assessment	Assessment by a colleague	Required level	Self-assessment vs required level	Assessment by a colleague vs required level	Self-assessment vs assessment by a colleague
Administration	3.40	3.20	3	0.40	0.20	0.20
Negotiation skills	3.00	3.40	3	0.00	0.40	-0.40
Organizing your own work	1.60	2.60	3	-1.40	-0.40	-1.00
Problem solving	2.25	1.50	3	-0.75	-1.50	0.75
Cooperation & Team work	2.75	4.75	4	-1.25	0.75	-2.00
Relationship building	3.00	2.60	3	0.00	-0.40	0.40
Flexibility	2.20	3.20	4	-1.80	-0.80	-1.00
Communication skills	3.40	1.60	3	0.40	-1.40	1.80
Law & Regulatory knowledge	3.75	4.25	3	0.75	1.25	-0.50

Source: compiled by the authors.

In summary, the evaluations indicate that there are notable differences between self-assessments and colleague assessments across various competencies. While some areas, such as Administration and Law & Regulatory Knowledge, show relatively minor discrepancies, others, such as Cooperation & Team Work and Communication Skills, reveal significant differences in perceived performance. Overall, these discrepancies highlight the variability in self-perception versus external assessment, pointing to potential areas for further development and alignment (Figure 2).

Figure 2. Research results based on the example of the Vytautas the Great University (Lithuania)



Source: compiled by the authors.

The University of Castilla-La Mancha (UCLM) is a public university located in the Castilla-La Mancha region of Spain. Established in 1985, UCLM is known for its strong focus on research, teaching, and regional development (Table 4).

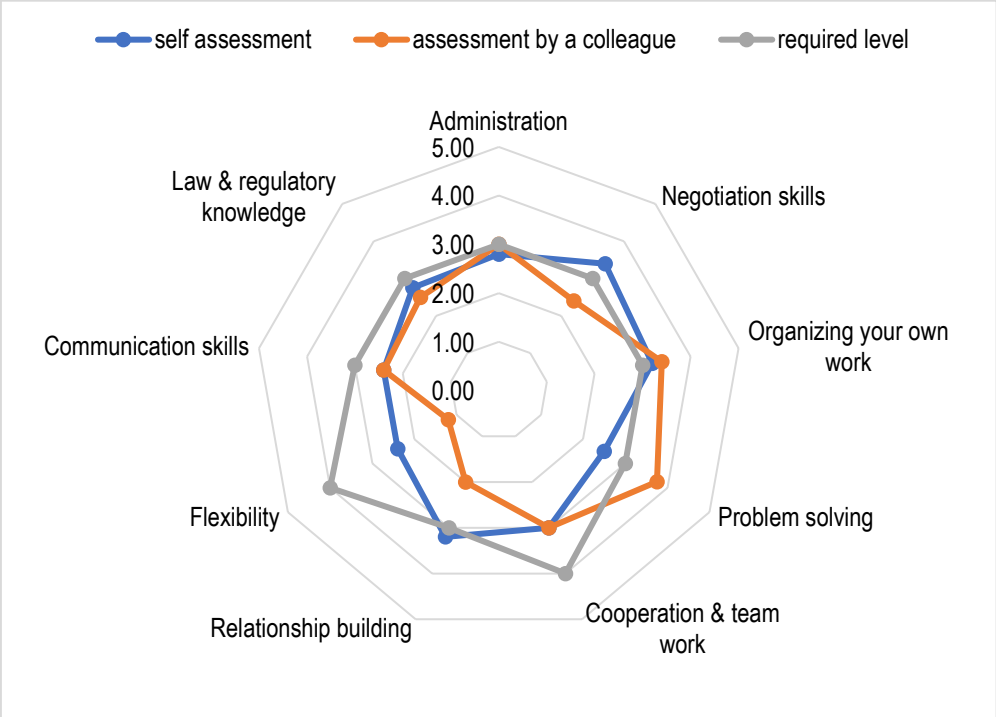
Table 4. Research results based on the example of University of Castilla-La Mancha (Spain), profile 1A: The process of direct and indirect commercialization

Parameter	A	B	C	A – C	B – C	A – B
Competences	Self-assessment	Assessment by a colleague	Required level	Self-assessment vs required level	Assessment by a colleague vs required level	Self-assessment vs assessment by a colleague
Administration	2.80	3.00	3	-0.20	0.00	-0.20
Negotiation skills	3.40	2.40	3	0.40	-0.60	1.00
Organizing your own work	3.20	3.40	3	0.20	0.40	-0.20
Problem solving	2.50	3.75	3	-0.50	0.75	-1.25
Cooperation & Team work	3.00	3.00	4	-1.00	-1.00	0.00
Relationship building	3.20	2.00	3	0.20	-1.00	1.20
Flexibility	2.40	1.20	4	-1.60	-2.80	1.20
Communication skills	2.40	2.40	3	-0.60	-0.60	0.00
Law & Regulatory knowledge	2.75	2.50	3	-0.25	-0.50	0.25

Source: compiled by the authors.

In summary, the evaluations highlight various discrepancies between self-assessments and colleague assessments. Areas such as Negotiation Skills, Problem Solving, and Relationship Building show notable differences, with self-assessments generally more favorable in these areas compared to colleague evaluations. Conversely, areas like Flexibility and Cooperation & Team Work demonstrate consistent lower evaluations, indicating a mutual recognition of the need for improvement. Overall, the data suggests that aligning self-perception with colleague perceptions and addressing areas with significant discrepancies could lead to improved performance and better outcomes (Figure 3).

Figure 3. Research results based on the example of the University of Castilla-La Mancha (Spain)



Source: compiled by the authors.

Lviv University of Trade and Economics (LUTE) is a prominent public university located in Lviv, Ukraine. Established in 1946, it specializes in economics, management, and related fields (Table 5).

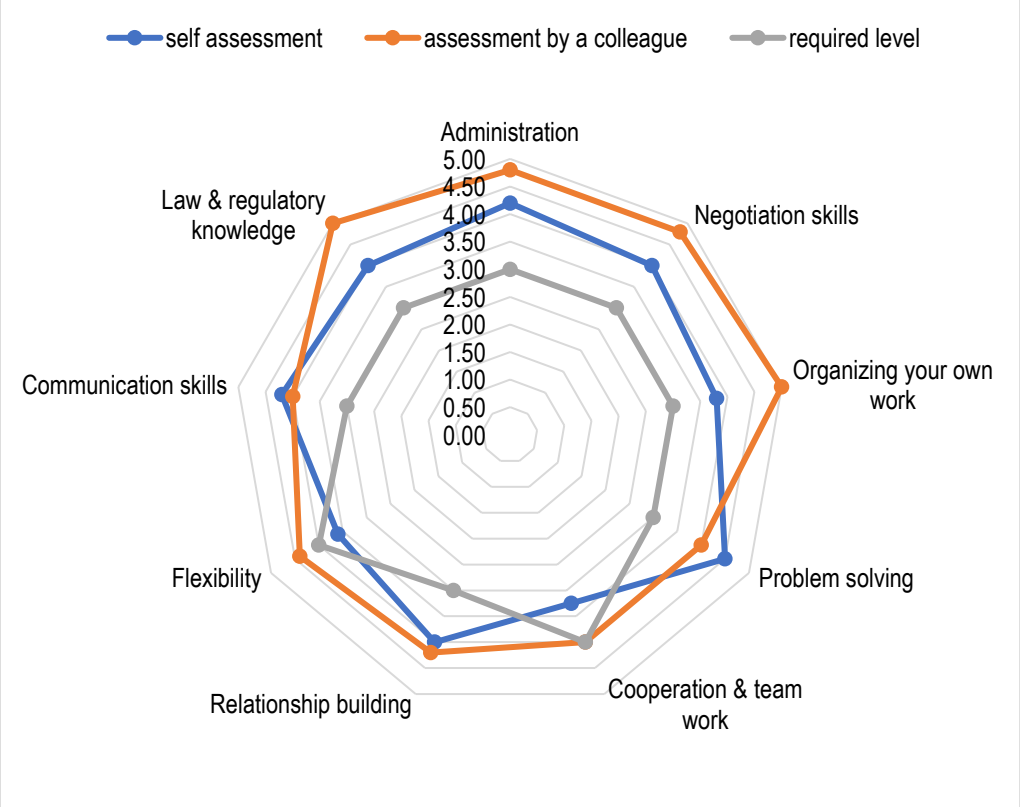
Table 5. Research results based on the example of Lviv University of Trade and Economics (Ukraine), profile 1B: The process of direct and indirect commercialization

Parameter	A	B	C	A – C	B – C	A – B
Competences	Self-assessment	Assessment by a colleague	Required level	Self-assessment vs required level	Assessment by a colleague vs required level	Self-assessment vs assessment by a colleague
Administration	4.20	4.80	3	1.20	1.80	-0.60
Negotiation skills	4.00	4.80	3	1.00	1.80	-0.80
Organizing your own work	3.80	5.00	3	0.80	2.00	-1.20
Problem solving	4.50	4.00	3	1.50	1.00	0.50
Cooperation & Team work	3.25	4.00	4	-0.75	0.00	-0.75
Relationship building	4.00	4.20	3	1.00	1.20	-0.20
Flexibility	3.60	4.40	4	-0.40	0.40	-0.80
Communication skills	4.20	4.00	3	1.20	1.00	0.20
Law & Regulatory knowledge	4.00	5.00	3	1.00	2.00	-1.00

Source: compiled by the authors.

Addressing these discrepancies and focusing on areas where both self-assessment and colleague assessments fall short of the required levels could help in aligning perceptions and improving overall performance (Figure 4).

Figure 4. Research results based on the example of the Lviv University of Trade and Economics (Ukraine)



Source: compiled by the authors.

Malardalen University (MDU) is a public university located in Västerås and Eskilstuna, Sweden. Established in 1977, MDU is known for its focus on applied research and its strong ties with industry and regional development (Table 6).

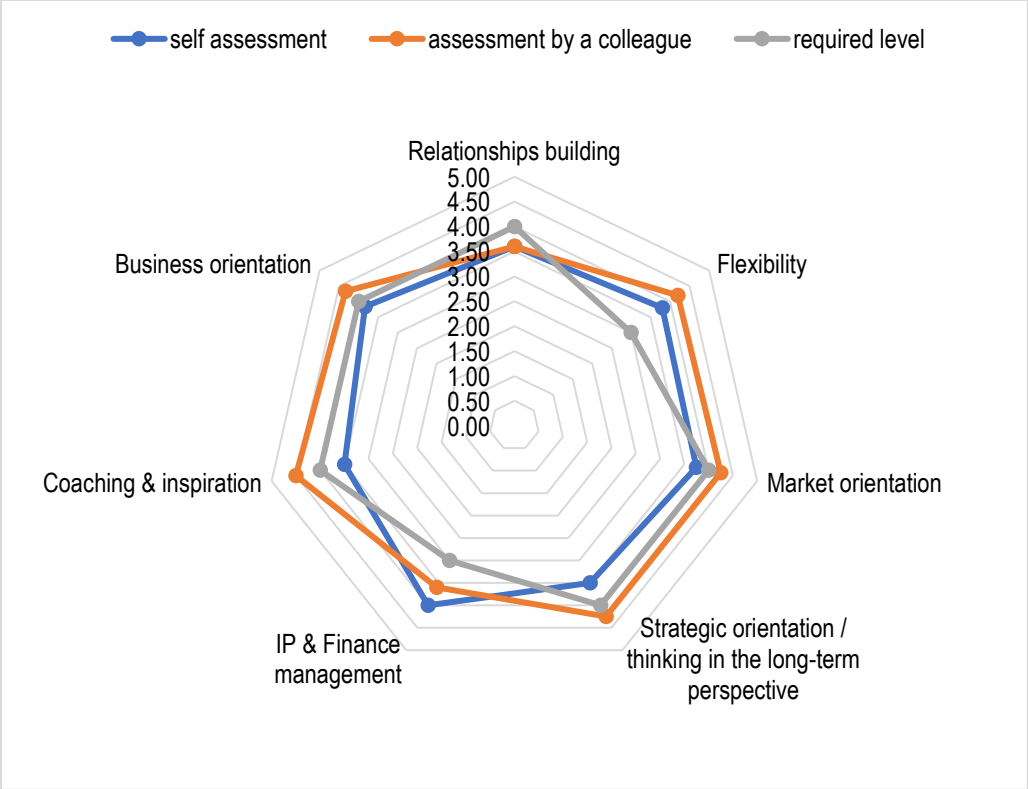
Table 6. Research results based on the example of Malardalen University (Sweden), profile 3: The process of direct and indirect commercialization

Parameter	A	B	C	A – C	B – C	A – B
Competences	Self-assessment	Assessment by a colleague	Required level	Self-assessment vs required level	Assessment by a colleague vs required level	Self-assessment vs assessment by a colleague
Relationships building	3.60	3.60	4	-0.40	-0.40	0.00
Flexibility	3.80	4.20	3	0.80	1.20	-0.40
Market orientation	3.75	4.25	4	-0.25	0.25	-0.50
Strategic orientation / Thinking in the long-term perspective	3.50	4.25	4	-0.50	0.25	-0.75
IP & Finance management	4.00	3.60	3	1.00	0.60	0.40
Coaching & Inspiration	3.50	4.50	4	-0.50	0.50	-1.00
Business orientation	3.83	4.33	4	-0.17	0.33	-0.50

Source: compiled by the authors.

Overall, the discrepancies indicate areas where self-perception differs from colleague perception, suggesting the need for targeted development and possibly further feedback to align these evaluations and enhance competency in critical areas (Figure 5).

Figure 5. Research results based on the example of the Malardalen University (Sweden)



Source: compiled by the authors.

The Teaching Factory Competence Center (TF CC) in Greece is part of a broader initiative to enhance practical, hands-on learning and industry collaboration in engineering and technology education. This center is

designed to bridge the gap between theoretical knowledge and real-world application, providing students with opportunities to work on industry-relevant projects and gain practical experience (Table 7).

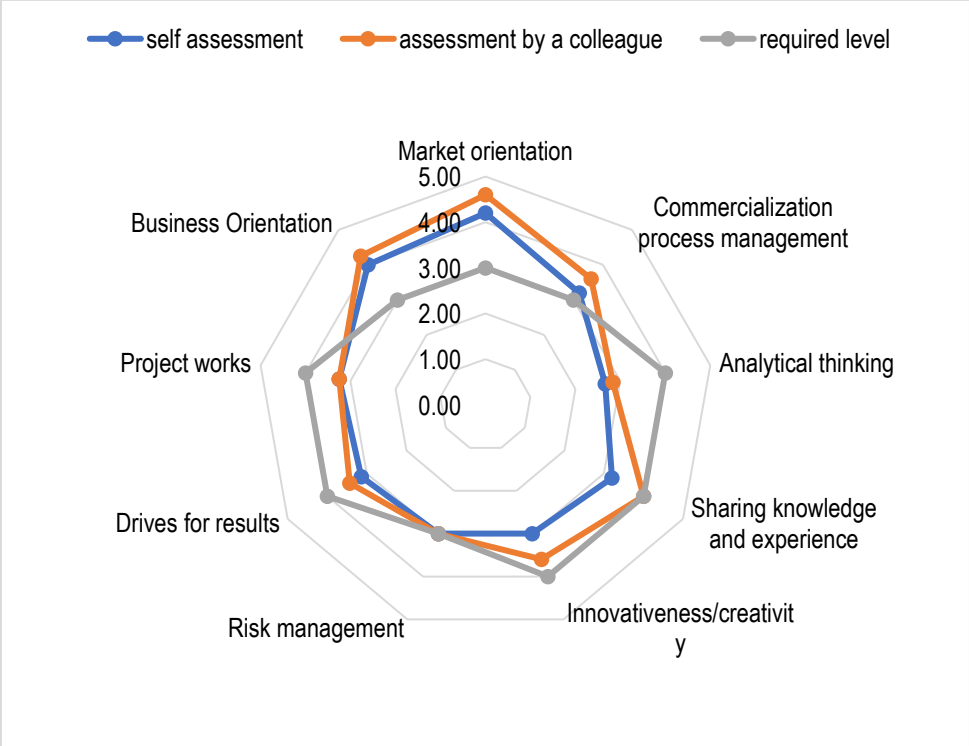
Table 7. Research results based on the example of TF CC in Greece, profile 2: The process of direct and indirect commercialization

Parameter	A	B	C	A – C	B – C	A – B
Competences	Self-assessment	Assessment by a colleague	Required level	Self-assessment vs required level	Assessment by a colleague vs required level	Self-assessment vs assessment by a colleague
Market orientation	4.20	4.60	3	1.20	1.60	-0.40
Commercialization process management	3.20	3.60	3	0.20	0.60	-0.40
Analytical thinking	2.67	2.83	4	-1.33	-1.17	-0.17
Sharing knowledge and experience	3.20	4.00	4	-0.80	0.00	-0.80
Innovativeness/Creativity	3.00	3.60	4	-1.00	-0.40	-0.60
Risk management	3.00	3.00	3	0.00	0.00	0.00
Drives for results	3.14	3.43	4	-0.86	-0.57	-0.29
Project works	3.25	3.25	4	-0.75	-0.75	0.00
Business Orientation	4.00	4.25	3	1.00	1.25	-0.25

Source: compiled by the authors.

The data suggests that while there is alignment in some areas, there are notable differences in competencies such as sharing knowledge and experience, innovativeness/creativity, and analytical thinking. Addressing these discrepancies through targeted development initiatives and seeking additional feedback could enhance overall competency alignment with required levels (Figure 6).

Figure 6. Research results based on the example of the TF CC in Greece



Source: compiled by the authors.

SPIN-US is a special purpose vehicle based in Poland, typically established to achieve specific business objectives or projects. These entities are often created for particular tasks such as research, development, or commercialization of new technologies and innovations (Table 8).

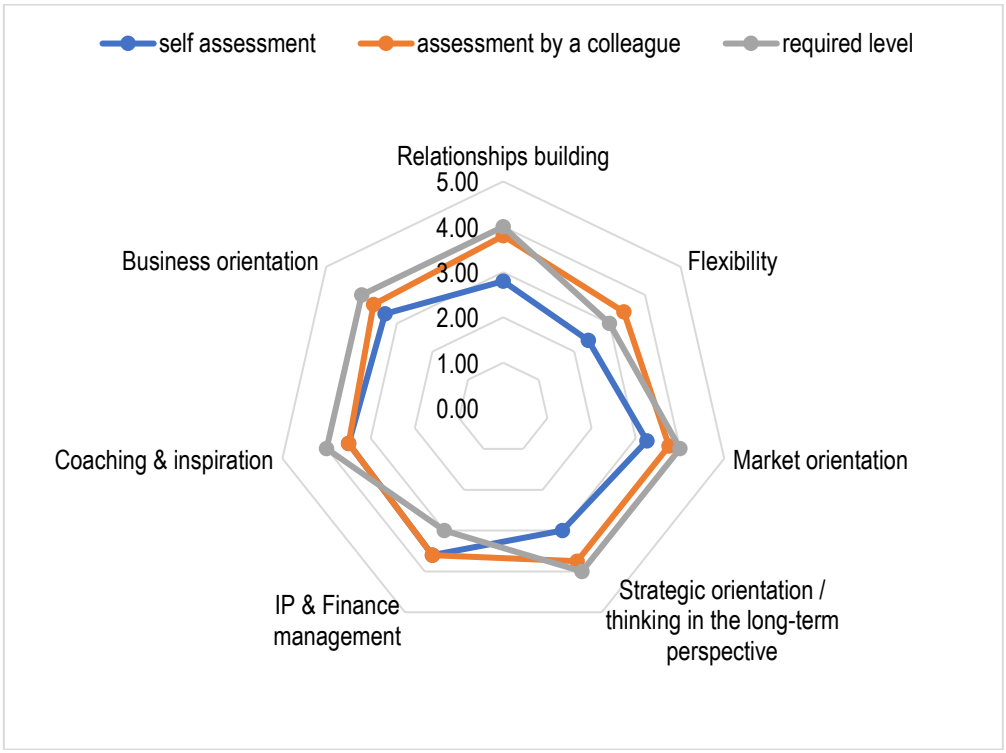
Table 8. Research results based on the example of SPIN-US (Poland), profile 3: The process of direct and indirect commercialization

Parameter	A	B	C	A – C	B – C	A – B
Competences	Self-assessment	Assessment by a colleague	Required level	Self-assessment vs required level	Assessment by a colleague vs required level	Self-assessment vs assessment by a colleague
Relationships building	2.80	3.80	4	-1.20	-0.20	-1.00
Flexibility	2.40	3.40	3	-0.60	0.40	-1.00
Market orientation	3.25	3.75	4	-0.75	-0.25	-0.50
Strategic orientation /Thinking in the long-term perspective	3.00	3.75	4	-1.00	-0.25	-0.75
IP & Finance management	3.60	3.60	3	0.60	0.60	0.00
Coaching & Inspiration	3.50	3.50	4	-0.50	-0.50	0.00
Business orientation	3.33	3.67	4	-0.67	-0.33	-0.33

Source: compiled by the authors.

Overall, the data indicates that while there are some competencies where self-perception and colleague perception align well, several key areas require further development. Addressing these gaps through targeted training and development activities could help bridge the differences and better align individual performance with required competency levels (Figure 7).

Figure 7. Research results based on the example of the SPIN-US (Poland)



Source: compiled by the authors.

GrantXpert is a consultancy firm based in Cyprus, specializing in providing support and expertise in grant management and funding opportunities. The company offers services related to identifying, applying for, and managing grants and other funding sources (Table 9).

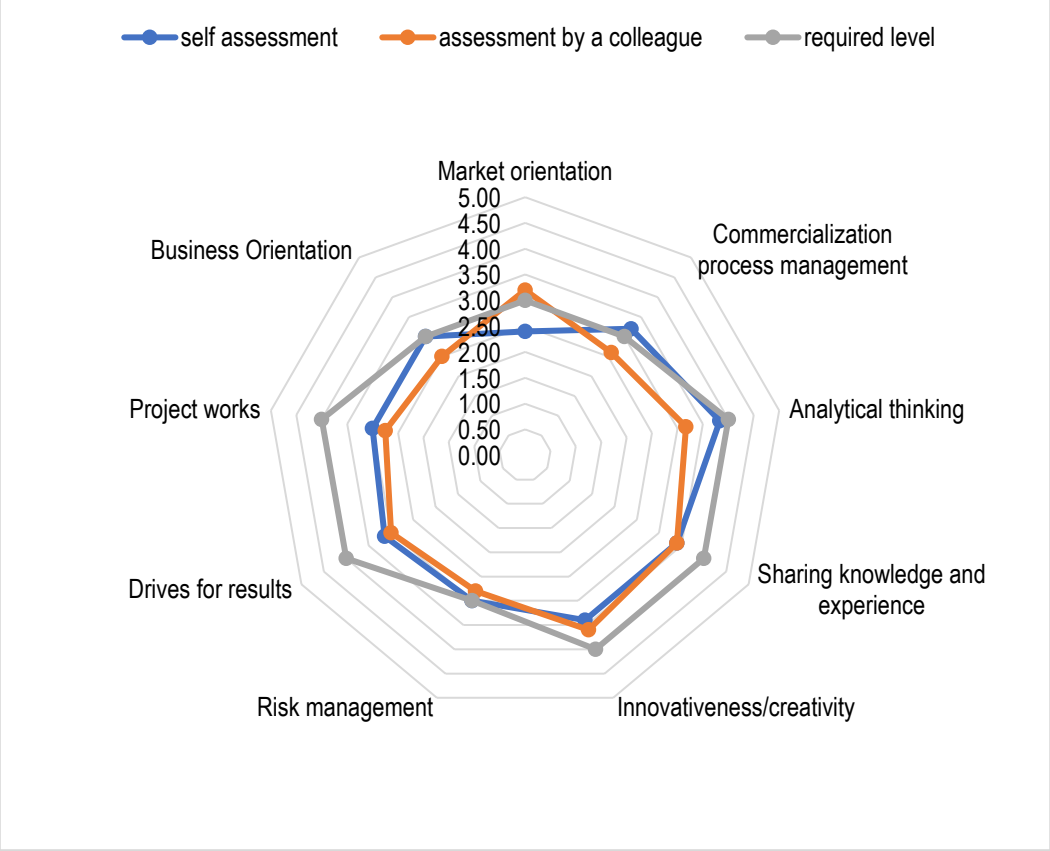
Table 9. Research results based on the example of GrantXpert Cyprus, profile 2: The process of direct and indirect commercialization

Parameter	A	B	C	A – C	B – C	A – B
Competences	Self-assessment	Assessment by a colleague	Required level	Self-assessment vs required level	Assessment by a colleague vs required level	Self-assessment vs assessment by a colleague
Market orientation	2.40	3.20	3	-0.60	0.20	-0.80
Commercialization process management	3.20	2.60	3	0.20	-0.40	0.60
Analytical thinking	3.83	3.17	4	-0.17	-0.83	0.67
Sharing knowledge and experience	3.40	3.40	4	-0.60	-0.60	0.00
Innovativeness/Creativity	3.40	3.60	4	-0.60	-0.40	-0.20
Risk management	3.00	2.80	3	0.00	-0.20	0.20
Drives for results	3.14	3.00	4	-0.86	-1.00	0.14

Source: compiled by the authors.

Overall, the assessments highlight several areas where the individual's self-perception differs from colleague evaluations and required competency levels. Addressing these gaps through focused development initiatives could enhance alignment with the required standards and improve overall competency performance (Figure 8).

Figure 8. Research results based on the example of the GrantXpert Cyprus



Source: compiled by the authors.

Unit's strength lies in the tenacity of its members, as both self- and peer-ratings exceed the required level (3.50 and 3.59, respectively). Self-evaluation and peer evaluation are consistent and similar, but the indicators are below the required level, except for Perseverance, Project Work and Business Orientation. Given the high level of Persistence, it is recommended to develop the competencies of results-oriented and innovation/creativity

to create a good foundation for the further development of other competencies. This indicates that cognitive and motivational competencies will help in full development.

The results of interviews with entrepreneurs show that the main motivators for starting their own business are the desire for independence, self-realisation and financial stability. The main barriers to entrepreneurship include lack of funding, lack of knowledge and skills, and fear of failure (Olko 2023). Many entrepreneurs have overcome these barriers by seeking additional funding, training, and mentoring, which are often provided by TTOs and higher education institutions. Some entrepreneurs are familiar with the principles of behavioural economics and have used them to motivate customers and employees, develop marketing strategies, and increase personal productivity (Weijers *et al.* 2020; Kerimkhulle *et al.* 2023b). These principles are also becoming increasingly important for universities and TTOs. The most effective principles of behavioural economics are social proof, motivational incentives, and setting up an environment to promote positive action.

Members of the departments, including those involved in commercialization or entrepreneurship development, must prioritize goals, evaluating them according to the criteria of urgency and importance. They must be clear about which goals are less important to their department and university, and which are of higher priority and require immediate attention (Mamadova *et al.* 2019; Thunström 2019). This helps optimize resources and efforts, directing them to achieve the most meaningful results. Members of the department must analyze possible options for action, considering constraints and resources, to determine the most effective approaches. This includes flexibility in planning and willingness to adapt to new conditions or change strategy when necessary (Thaler 2016; Veliev *et al.* 2018). The main focus should be on achieving the expected results. Instead of focusing on possible difficulties or limitations, department members should focus their efforts on finding solutions and ways to overcome problems. It's important to avoid a mindset that focuses on evidence that something can't be done, and instead develop a mindset for success, viewing every challenge as an opportunity for growth and development (Simon 2022). Such thinking promotes the development of initiative and a creative approach to work, helps to find non-standard solutions and contributes to increasing the overall efficiency of the department's work in achieving its goals.

A study conducted among 203 participants of entrepreneurship workshops led by TTO employees, who enhanced their competencies through an international collaborative project, showed that most students rated the workshops positively. The results indicated that 55% of participants believed that practical exercises effectively complemented the theoretical knowledge provided during the workshops, and 31% reported being able to apply the acquired knowledge in practice. Additionally, the quality of teaching was rated highly, with an average score of 3.43 on a 4-point scale. These results highlight the significant role of high-quality, practical training in entrepreneurship education and underscore the need for further competency development among TTO employees to effectively support entrepreneurial initiatives.

In addition, a structured analysis of the regulatory environment found that legislative reforms aimed at simplifying taxation and protecting the rights of entrepreneurs have the greatest potential to stimulate innovative entrepreneurship and the development of small and medium-sized enterprises (Kahneman and Tversky 2021). The results of the study confirmed the effectiveness of applying the principles of behavioural economics to develop measures aimed at supporting entrepreneurial initiatives (Peredalo *et al.* 2019). The findings are the basis for further strategies to support entrepreneurship and will contribute to the development of effective policies in this area.

Overall, this empirical study has demonstrated that the application of behavioural principles in the development of TTOs is a powerful tool for stimulating entrepreneurship and supporting future entrepreneurs. In particular, the study of bounded rationality, cognitive biases and social norms helps to develop more effective interventions that take these factors into account.

3. Discussions

The results of the study confirmed that psychological measures, such as nudges as well as the tools supporting these competencies, can significantly increase the motivation to start their businesses. These measures were found to be effective in reducing psychological barriers and stimulating a positive decision to start a business, which is consistent with the findings of E.U. Weber (2020) and N. Mažar (2019), whose research confirms that behavioural measures can help correct cognitive biases and encourage more rational decisions. Their work on prospect theory demonstrates how perceptions of losses and gains influence decision-making, which is an important aspect of entrepreneurial motivation.

The analysis of the research results confirms that organizational changes related to the more effective use of the individual competencies of TTO employees in academic practice can significantly stimulate the growth of

new companies. This is achieved through better support in their processes and more efficient utilization of resources, which is consistent with the findings of research conducted by the World Bank, which indicates that reducing administrative barriers can significantly increase the level of entrepreneurial activity in developing countries. Simplifying bureaucratic procedures within the university and among units supporting entrepreneurs as well, reduces the time and resources required to start a new business, which in turn makes Entrepreneurship education become more accessible and attractive to young people (Bayanbayeva *et al.* 2023). Additionally, legal support provided by the university through TTO employees reduces the costs of regulatory compliance and overall administrative burdens, which are significant obstacles for new businesses (Grishnova *et al.* 2019).

Similar results were also acquired in European Union studies, where simplification of bureaucratic procedures was found to have a positive impact on entrepreneurial activity and the investment climate, highlighting the importance of improving the regulatory framework to support and stimulate the development of small and medium-sized businesses. EU countries that have implemented business facilitation policies have seen an increase in the number of new businesses and an increase in overall economic activity (Dankevych *et al.* 2023; Pereguda *et al.* 2025).

Concerning the principles of behavioural economics, the results of the study show that approaches such as social norms and instant rewards have a positive impact on motivation for entrepreneurship (Dorosh 2019; Ismayil-Zada 2022). Social norms, as studies have shown, can significantly influence the behaviour of individuals, encouraging them to take certain actions or make decisions that they might not have considered without these external influences.

R.H. Thaler and C.R. Sunstein (2021) emphasise that the use of social norms and nudges can help correct cognitive biases and encourage more rational and effective decisions. Nudges, or gentle nudges, can reduce psychological barriers and make choices more obvious and easier to make (Kuznetsova 2016). In the context of entrepreneurship, this can include using positive examples of successful entrepreneurs as role models or providing small rewards to encourage certain business behaviours.

Thus, the integration of behavioural economics principles into entrepreneurship support strategies can significantly increase the effectiveness of measures aimed at stimulating business activity. The simplification of administrative procedures for supporting entrepreneurs and researchers together with the introduction of behavioural approaches applied in TTOs can create a favourable environment for the development of new enterprises and provide support for new entrepreneurs on their way to success (Trusova *et al.* 2021; Musayeva *et al.* 2024).

However, some aspects of the results differ from the findings of other studies. For example, a study conducted in Europe showed that social norms have less influence on the decision to start a business compared to other behavioural factors such as financial incentives or educational programmes (Behavioural Insights Team 2018). In this study, social norms related to the functioning of universities, TTOs, and the methods of transferring intellectual property rights during the commercialization process had a greater impact, which may stem from the cultural characteristics of our sample that could differ from the European context. The results of the study also confirm the importance of TTO employees providing mentoring, participating in training, and supporting access to financial resources. This aligns with the findings of the Global Entrepreneurship Monitor program, which highlights the significance of mentoring and educational programs for the success of entrepreneurs (Libenko and Peredalo 2019).

Given these findings, further research should include a more in-depth analysis of the impact of specific behavioural interventions by TTO employees on different population groups. For instance, a study by C. Segal in cognitive psychology has shown that young people may be more susceptible to certain cognitive biases than adult entrepreneurs. It is also worth addressing how behavioural interventions can be adapted to different cultural contexts, which is an important aspect of optimising interventions.

The study significantly contributes to understanding the use of behavioural economics principles to stimulate entrepreneurship (Studzieniecki *et al.* 2022). The findings support the effectiveness of behavioural measures and demonstrate the importance of taking into account cultural and social contexts when developing them, which is confirmed by the research of such authors as R. Thaler and C.R. Sunstein (2021) and opens up new prospects for further research aimed at optimising behavioural measures and adapting them to the needs of different population groups.

However, some aspects of the study turned out to be different from the results of other scientific studies, which are worth considering in detail (Kreshpaj *et al.* 2020). For example, a study by M. Kremer *et al.* (2019) showed that social norms have less influence on entrepreneurial decisions than financial incentives or educational programmes. The study found that the impact of social norms on the motivation to start a business

was limited. In this study, in contrast, it was found that social norms have a significant impact on participants' decisions to start a new business venture, a discrepancy that may be related to cultural or socioeconomic differences in the samples studied and points to the need for further research into cultural contexts.

F. Tramontana and L. Gardini (2021) in a study on positive psychology notes that "motivating" measures do not always have a long-term effect on entrepreneurial activity offered by TTO employees can significantly increase students' motivation to start a business. However, the issue of long-term impact still requires further research.

Similarly, a study by D. Vines and S. Wills (2020) determined that administrative simplifications do not always lead to increased entrepreneurial activity in developed countries. They emphasise that in advanced economies, other factors, such as access to high-quality mentoring programmes, may have a greater impact. In contrast, the study found that the simplification of administrative procedures could have a significant positive impact on the number of new businesses, indicating differences in contexts and levels of economic development.

The results of the study also contradict the findings of S. Storm (2021), who notes that mentoring is the main factor for supporting entrepreneurship only in the long term. In this study, the development of competencies related to coaching and inspiring students, including mentoring and participation in training, demonstrated a significant positive impact in both the short and long term. This indicates the potential for developing these competencies among TTO staff to immediately boost entrepreneurial motivation (Tepavicharova *et al.* 2020).

Differences in studies reveal that the impact of behavioural measures and organisational changes on entrepreneurial activity can vary significantly depending on cultural, socioeconomic and regional contexts, highlighting the importance of an in-depth analysis of these contexts to better understand how different factors affect the effectiveness of measures aimed at stimulating entrepreneurship (Bilik and Recep 2020). For example, the fact that in some countries administrative simplification leads to a significant increase in the number of new businesses may not be so obvious in other countries with different socio-economic conditions or cultural characteristics (Chorna 2009).

Cultural differences can affect how behavioural interventions are perceived and implemented. For example, social norms that are critical in certain cultures may have less impact in other cultural settings where other factors, such as financial incentives or educational programmes, more important (Trusova *et al.* 2020). Moreover, socio-economic conditions, such as the level of economic development and access to resources, can affect how well organisational change is implemented and what measures are most useful for stimulating entrepreneurship.

Conclusions

Research shows that competent TTO employees can offer "nudges" that significantly increase individuals' motivation to start their own businesses and the development of entrepreneurial competencies. They reduce psychological barriers, increase confidence in one's abilities, and stimulate positive entrepreneurial decisions. Psychological interventions are effective in a variety of cultural and regional contexts, which confirms their versatility and adaptability. The conclusions drawn from the empirical research on the use of behavioural economics principles to design interventions that encourage people to become entrepreneurs are multifaceted and include several key aspects.

Firstly, using the example of the University of Silesia in Katowice, it can be stated that the introduction of behavioural economic principles into curricula and training for future entrepreneurs has proven to be extremely effective. Workshop participants were given the opportunity to develop into more conscious, flexible, and innovative entrepreneurial individuals, better equipped to adapt to a dynamic and unpredictable business environment. This suggests that behavioral interventions can effectively overcome the psychological barriers and doubts that often hold back potential entrepreneurs.

Secondly, interactive training workshops and joint agreements on competencies for specific profiles enabled TTO employees to apply theoretical knowledge in practice. This not only reinforced their knowledge but also contributed to the development of practical competencies essential for supporting researchers, entrepreneurs, and students planning to start a business.

Individual consultations with coaches and experts in behavioural economics also proved to be a valuable element of the study. The personalised approach allowed participants to receive specific advice and recommendations that met their individual needs and challenges, which contributed to greater self-confidence and readiness to implement their business ideas.

Despite the positive results, the study has certain limitations. These include the limited applicability of the selected methods and the need for further adaptation to specific regional and cultural contexts. Behavioural

economic approaches, such as nudges, simplified procedures related to supporting entrepreneurs and researchers are highly effective in stimulating entrepreneurship. They help to reduce psychological barriers, increase motivation and create a favourable regulatory environment for new businesses.

Credit Authorship Contribution Statement

Maria Garus: Project administration, Writing – original draft, Supervision, Writing – review and editing.
Olaf Flak: Methodology, Writing – original draft.
Barbara Kozusznik: Formal analysis, Writing – original draft, Visualization.
Virginia Barba Sánchez: Investigation, Formal analysis, 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 generative AI or AI-assisted technologies were not used in any way to prepare, write, or complete this manuscript.

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The Economics of a VAT Cut in the Standard Keynesian Framework: A Possible Anti-Crisis Measure?

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Abstract: The standard textbook treatment of expansionary fiscal policy at intermediate macroeconomics level (and specifically implemented via a tax rate reduction), *e.g.*, Blanchard (2021), Burda and Wyplosz (2023), or even at an advanced level, *e.g.*, Romer (2018)- only considers income tax cuts affecting the economy through the consumption function, by increasing the level of disposable income. In this paper we introduce VAT in the Keynesian cross framework and study the effects of a cut in the VAT rate. Under certain conditions, such as a relatively high pre-existing level of the VAT rate, a relatively low (proportional) income tax rate, and a sufficiently high MPC (marginal propensity to consume), a cut in the VAT rate has a positive effect on output and thus can be potentially used as a short-term anti-crisis measure. Interestingly, we find that the stimulus effect dissipates once we allow for an open economy, as people spend a substantial part of their income on imported products, *i.e*, when the MPI (marginal propensity to import) is high. Our findings are novel in literature and could be of interest both to policy makers, as well as economists interested in economic education and teaching.

Keywords: Keynesian framework; expansionary fiscal policy; tax cut; stimulus effect.

JEL Classification: A23; E62; E12; C61.

Introduction and Motivation

In this paper we consider a possible stimulus effect via a cut in consumption taxation, a policy that is of interest to policy-makers in Bulgaria, in Central and Eastern European countries, as well as any developing countries with a public finance model organized around consumption (indirect) taxation. In particular, almost half of the tax revenue in Bulgaria is from value-added taxation. Also, the consumption tax rate in Bulgaria is higher than the personal income, and the corporate tax rate. Next, we ask the following questions: (i) How would a VAT cut work in a model, focused on the short to medium run, or, more specifically - into the Keynesian Framework? (ii) What is the size of the tax multiplier (*i.e*., the expression of the partial derivative of output with respect to the consumption tax rate)? There is not much treatment in either the original works of Keynes, or modern textbooks. Hence, the research in this paper is novel and will generate new insights.

After all, being a tax on demand, VAT is not as distortionary as the other taxes, such as the personal income tax (which is a tax on production factors), and is often considered a sure source of revenue. In addition, in the he US, this question is not interesting, due to the absence of a federal consumption tax. Intuitively, a VAT cut is a clear temporary reform measure: several economists have recently suggested a temporary VAT cut (*e.g*., for two years), or some scheme that has to do with reimbursement based on receipts. The issue is that by law (”de jure”) the seller is responsible for sending the money to the tax authority. However, in reality (”de facto”) the seller pushes the burden of the tax onto the consumer. From the public finance literature, and the Ramsey rule in particular, we know that the burden of tax is inversely related to elasticity. Thus, the side that is relatively more elastic, is able to pass the bigger part of the tax burden on the other counter-party. Furthermore, it is not clear who should submit the receipts for reimbursement to the tax authority - consumers, or merchants. Yet another question is whether consumers need to have a VAT registration, whether there would be a cap on reimbursement? These questions are difficult to answer. Theoretically, people can claim millions in expenditures, so there is a serious need to cross-check with their incomes and whether they match their spending; furthermore, individuals could claim they borrowed the money - so the VAT reimbursement problem is akin to problems with hiding income. Lastly, checking whether the receipts are genuine also has an administrative cost. Another reason

for caution when discussing the effects of a VAT cut, is that it might interfere with fiscal discipline, especially in countries under a currency board arrangement (Bulgaria). (Yet another camp of economists argues that cutting taxes might trigger a cut in expenditure, and actually increase efficiency of spending, and reform implementation.) In this note, we will focus on the short- to medium run and abstract away from deficits and debt considerations. For simplicity, we will also abstract away from excise taxes. Thus, in this paper we aim to fill a clear gap in the literature, and at the same time the work could be a good teaching case for students.

The paper is structured as follows: Next section evaluates the effect of a VAT cut under different scenarios and assumptions on the functional forms of the main components of aggregate demand. Finally, the paper concludes with some policy recommendations and suggestions for future research.

The Model Setup

In this section, we present a battery of models, starting from the simplest case, and then extending the setup, one element at a time. First, we begin with output determination in the closed-economy case

$$AE = AD = (1 + \tau^c)C + I + G, \quad (1)$$

where $(1 + \tau^c)C$ is the VAT-inclusive spending on private consumption C, I is investment, G is government purchases, AE is (planned) aggregate expenditure, and AD is aggregate demand. In equilibrium

$$Y = AE = AD \text{ , or} \quad (2)$$

$$Y = (1 + \tau^c)C + I + G. \quad (3)$$

Our consumption modelling follows the standard Keynesian consumption function, or

$$C = a + b(Y - T) \quad (4)$$

where a>0 is the autonomous consumption component (linked to permanent/life-cycle income), 0<b<1 is the marginal propensity to consume (MPC), and T denotes taxes. Next, we will consider several sub-cases (note that the absence of an intercept in the consumption function does not change the results):

Case I: Lump-sum (exogenous) taxes: Solve for Y to obtain

$$Y = \frac{(1+\tau^c)(a-bT)+I+G}{1-(1+\tau^c)b} \quad (5)$$

Next, rearrange terms and compute comparative-static effect of VAT on output to obtain:

$$\frac{dY}{d(\tau^c)} = \frac{a-bT}{1-(1+\tau^c)b} = \frac{C}{1-(1+\tau^c)b} < 0 \quad (6)$$

which holds as long as $(1+\tau^c)b > 1$, or when MPC and VAT are sufficiently high. This is satisfied for Bulgaria, where τ^c = 0.2, and b > 0.833, which is in the lower end for b as estimated in Vasilev (2015), who obtains a = 0.12, with st.dev (a)=0.27, so we cannot reject the null hypothesis that the true value is zero. Next, b ∈ [0.77, 0.99], where we have bounded the value from above by unity. If we ignore the economic bound, the statistical procedure yields 1.13 with error 0.15, and 0.89 with error 0.06. In addition, this high degree of hand-to-mouth consumption behaviour is not a bad approximation in the short run, and/or during periods like the SARS-CoV-2 pandemic. Next, we make the analysis more realistic by endogeneizing the taxes, and making them conditional on earning.

Case II: Proportional taxes: $T = tY, 0 < t < 1$. Solve for Y to obtain

$$Y = \frac{(1+\tau^c)(a-bT)+I+G}{1-(1+\tau^c)(1-t)b}. \quad (7)$$

Next, rearrange terms and compute comparative-static effect of VAT on output to obtain:

$$\frac{dY}{d(\tau^c)} = \frac{a-bT}{1-(1+\tau^c)(1-t)b} = \frac{C}{1-(1+\tau^c)(1-t)b} < 0, \quad (8)$$

which holds as long as $(1 + \tau^c)(1 - t)b > 1$. Relative to the earlier case, now the requirement is stronger: it requires not only MPC and VAT to be sufficiently high, but also distortionary income tax rate to be relatively low (10 percent in Bulgaria, or t=0.1.). In other case, the public finance model is organized around low income taxes, and high indirect taxes - a model that fits the fiscal situation in many Eastern European countries.

However, if we add the employee contributions as adding to the burden on labour – another 14 percent - then the result is preserved as long as MPC > 0.926, which is still plausible for Bulgaria. Lastly, the MPC

requirement is even higher depending on the size of a VAT cut considered: If we cut VAT by 1 percentage point, MPC > 0.934, while if we cut VAT by 2 percentage points, then MPC > 0.942, and we are not only approaching the upper end of the estimate for MPC (one st. dev. from the mean), but also the loss of consumption revenue might put a strain also on the budget balance (note that the tax cut may increase consumption, so consumption tax revenue might actually increase). Luckily, the debt-to-GDP ratio in Bulgaria is around 40 percent, which is quite low. Finally, yet another way to preserve our original result is to argue that the average consumer in the model is a person over the life-cycle, hence most of those contributions correspond to an income redistribution over time (a "deferred income"), and are not a tax on labour in the legal sense.

The next extension to the model setup is to open the economy and consider the effect of net exports – when taxes are lump-sum first and then consider distortionary taxes. Solve for Y to obtain

$$Y = AE = AD = (1 + \tau^c)C + I + G + NX \quad (9)$$

$$Y = (1 + \tau^c)C + I + G + X - (1 + \tau^c)m(Y - T) \quad (10)$$

$$Y = (1 + \tau^c)a + I + G + X - (1 + \tau^c)(m - b)(Y - T), \quad (11)$$

where 0 < m < 1 is the MPI (marginal propensity to import. For short we denote IGX = I + G + X. Notice also that exports are free of VAT, while the imports are levied with VAT. Notice that levying VAT on G does not affect the results in any major way, so we will not present it here. Next, rearrange terms and compute comparative-static effect of VAT on output to obtain:

$$\frac{dY}{d(\tau^c)} = \frac{a+(b-m)T}{1-(1+\tau^c)(b-m)} < 0, \quad (12)$$

which holds as long as $(1 + \tau^c)(b - m) > 1$. This, however, is possible only under extreme home bias, *e.g.* MPC > 0.9 and MPI < 0.1. For example, in the case of Bulgaria that is not plausible even when we stretch the value of the MPC, as the lower bound of the MPI over the period 1999-2023 is 0.4. However, the result is still salvageable, if we assume that the majority of the imports are investment goods (and thus freed from VAT), and not consumption goods (which are the ones levied with VAT). In general, the more open the economy is, the lower the effectiveness of this tax cut on the economy. In more complicated models, the effect would also depend on the VAT pass-through in prices, degree of competition in the product market, etc.

The implausibility scenario is reinforced once we account for proportional taxes: in that case, the comparative-static is of the right sign, *i.e.*,

$$\frac{dY}{d(\tau^c)} = \frac{a+(b-m)(1-t)Y}{1-(1+\tau^c)(b-m)(1-t)} < 0, \quad (13)$$

only when $(1 + \tau^c)(b - m)(1 - t) > 1$, which now requires the (MPC −MPI) term to be even larger than before. Such a case is not observed in any open economy.

Conclusions and Further Research

The standard textbook treatment of expansionary fiscal policy at intermediate macroeconomics level (and implemented via a tax rate reduction in particular), *e.g.*, Blanchard (2021), Burda and Wyplosz (2023), or even at an advanced level, *e.g.*, Romer (2018)- only considers tax cuts affecting the economy through the consumption function, by increasing the level of disposable income. In this paper we introduce VAT in the Keynesian cross framework and study the effects of a cut in the VAT rate. Under certain conditions, such as a relatively high pre-existing level of the VAT rate, a relatively low (proportional) income tax rate, and a sufficiently high MPC, a cut in the VAT rate has a positive effect on output and thus can be potentially used as a short-term anti-crisis measure. Interestingly, we find that the stimulus effect dissipates once we allow for an open economy, as people spend a substantial part of their income on imported products, *i.e,* when the MPI is high.

Still, we suggest the readers take the results with a grain of salt. After all, the model is ad hoc, and the calculations are back-of-an-envelope type. There is definitely a need for more detailed modelling, preferably a micro-founded one, and within a general-equilibrium framework. For example, under monopolistic competition, firms exhibit market power, and might increase prices when taxes are cut, thus decreasing consumption and aggregate demand. Finally, in the presence of tax fraud, any positive effect of a tax cut would be undermined further.

Credit Authorship Contribution Statement

Aleksandar Vasilev: Conceptualization, Investigation, Methodology, Formal analysis, Writing – original draft, review and editing.

Declaration of Competing Interest

The author is a member of the Editorial Advisory Board but was not involved in the editorial review or the decision to publish this article.

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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Macroeconomic Enablers of Sustainable Development in G20 Countries: The Role of Tourism

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Abstract: The G20 countries present a congenial macroeconomic environment in terms of per capita GDP, gross fixed capital formation, labour-force participation, inflation, cross-border trade, financial sector development, and human development for the growth of travel and tourism. These countries have a strong potential for the development of travel and tourism in terms of international tourist arrivals, international tourism expenditure and international tourism receipts. As appropriately recognised by the members of G20 in 2012 for the first time, and as identified during the India's Presidency in 2023, the potential of travel and tourism can optimally be utilized to make progress towards the SDGs by 2030. In this direction, this study is an attempt to empirically examine the impact of tourism development on sustainable development in G20 countries. The novelty of this study lies in estimating short-run and long-run effects of selected covariates on sustainable development in G20 nations in a panel framework. The results of the estimation of PMG based ARDL regression indicate a statistically significant positive contribution of the development of travel and tourism on sustainable development when macroeconomic indicators are the enablers. This finding contradicts the findings of a recent study by Destek & Aydin that tourism can be detrimental to sustainable development. Thus, the present study ushers a new direction for tourism-led sustainable development. The policy implication is that the effective and efficient implementation appropriate tourism development strategies in such a favourable macroeconomic environment can add to the progress of SDGs in G20 countries.

Keywords: economic growth; tourism development; SDGs; G20; Panel ARDL Model.

JEL Classification: C51; O18; Q01; Z32.

Introduction

The G20, being the premier intergovernmental forum for international economic and financial cooperation, plays an important role in shaping and strengthening global architecture and governance on all major international economic issues such as financial stability, climate change mitigation and sustainable development[1]. The G20 members represent around 85 per cent of the global gross domestic product, over 75 per cent of the global trade,

[1] https://www.ipsnews.net/2015/09/g20-finance-ministers-committed-to-sustainable-development/

and about 2/3 of the world population[2]. By end of December 2024, the growth of GDP in G20 economies showcased a stable pace of acceleration, albeit some countries growing while others slowed down. Indonesia (1.2%), India (1.1%), and US (0.7%) recorded stable growth whereas growth accelerated significantly in Mexico (1.1%), China (0.9%), Germany (0.1%), South Korea (0.1%), and to a lesser extent in France (0.4%) and Australia (0.3%). However, the growth of macro-economies of Brazil (0.9%), UK (0.1%), Canada (0.3%), Japan (0.3%), Italy (0.0%), Turkiye (0.2%), and South Africa -0.3%) have been slowed down by end of December 2024[3]. Despite such a mixed macroeconomic scenario, the Brazil Presidency of G20 remain focused on fighting against hunger, poverty and inequality for sustainable development through necessary reforms in global governance framework. In this summit, investment on travel and tourism sector development projects was given a priority to enhance the importance of this sector in the attainment of SDGs.

Although G20 was founded in 1999, the leaders for the first time recognised the importance of travel and tourism as a driver of jobs, growth and economic recovery in 2012 in its annual meeting at Mexico[4]. It was observed that international tourism significantly contributed to the economies of the G20 nations in 2011. In this year, 656 million international tourists visited G20 countries which were 67 per cent of total international tourist arrivals. Such a large size of inbound tourism recorded an international tourism expenditure of about 830 billion USD and created about 78 million jobs in G20 nations[5]. Thus, travel and tourism were facilitated in G20 countries for the growth of local economy, raising national income, improving the balance of payments, and boosting economic growth. In this way, tourism was envisioned in 2012 to support job creation, quality work, poverty reduction and global growth. Since then, tourism in G20 nations was targeted for development in the strategic road maps. Recently, five tourism priority areas have been identified by India's G20 Presidency, viz., green tourism, digitalization, skills, tourism MSMEs, and destination management for transforming the tourism sector to meet the objectives of the SDGs and build an inclusive and sustainable future[6]. The development of tourism can be crucial for achieving the SDGs by generating economic growth, creating jobs, reducing inequalities and promoting cultural and environmental sustainability (UNWTO, 2023).

The figures presented in Table 1, Table 2, Table 3, Table 4 and Table 5 indicate the macroeconomic situations and that of the travel & tourism industry in G20 nations including that of European Union. It is observed from Table 1 that G20 countries present a congenial macroeconomic environment for the growth of travel and tourism. The growth rate of per capita GDP in G20 countries is favourable for financial sector development, human development, and thus for the tourism sector development. The percentage of gross fixed capital formation in GDP is the indication of favour infrastructure development in G20 nations which act as a promoter of travel and tourism. The labour-force participation rate is an encouraging factor in G20 countries. Similarly, the inflation rate indicates the stability of prices. Further, trade as a percentage of GDP is a good motivator for the development of G20 nations. The pre-COVID-19 data presented in Table 3 indicates that the tourism sector in G20 nations is able to attract foreign tourist arrivals and also able to activate the economy through significant spending by the tourists. The facts and figures presented in Table 4 indicate that the pre-COVID-19 contribution of travel and tourism is quite encouraging and that of post-COVID-19 contribution has already set in the path of rapid recovery in G20 nations. The financial development index presented in Table 2 indicates the depth, access, efficiency and stability of financial markets and institutions in G20 nations. The current financial development scenario is favourable for the development of travel and tourism in these nations.

Table 1. Selected Macroeconomic Indicators of G20 (2022, 2023)

G20 Members	Per Capita GDP Growth (%)		Gross Fixed Capital Formation (% of GDP)		Labour Force Participation Rate (%)		Inflation (%)		Trade (% of GDP)	
	2022	2023	2022	2023	2022	2023	2022	2023	2022	2023
Argentina	5.04	-1.89	17.57	18.57	61.48	62.28	69.87	135.37	31.55	26.64
Australia	2.92	0.94	23.18	23.29	66.70	66.78	7.17	6.51	45.82	49.22
Brazil	2.64	2.50	17.80	16.54	63.53	62.92	8.57	4.66	38.82	33.85

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G20 Members	Per Capita GDP Growth (%)		Gross Fixed Capital Formation (% of GDP)		Labour Force Participation Rate (%)		Inflation (%)		Trade (% of GDP)	
	2022	2023	2022	2023	2022	2023	2022	2023	2022	2023
Canada	1.96	-1.67	23.29	22.83	65.25	65.36	7.65	1.53	67.55	67.19
China	2.96	5.36	41.90	41.33	65.80	65.83	1.82	-0.58	38.35	37.32
France	2.24	0.61	23.65	23.09	55.85	55.64	3.22	5.30	75.79	70.56
Germany	0.64	0.35	21.71	21.50	60.93	61.12	6.09	6.14	89.06	82.80
India	6.14	7.20	30.75	30.83	53.56	54.65	6.75	1.33	49.96	45.92
Indonesia	4.52	4.16	29.08	29.33	67.02	66.97	9.57	1.53	45.47	41.32
Italy	4.87	0.73	21.85	22.51	49.03	49.80	3.56	5.82	72.05	66.24
Japan	1.40	2.17	25.96	25.76	62.50	62.90	0.33	3.79	46.84	45.16
Mexico	2.91	2.30	22.46	24.25	60.95	61.74	6.49	4.46	88.39	73.16
Russia	-1.73	3.89	20.40	21.86	61.94	61.69	16.72	7.07	43.26	41.83
Saudi Arabia	2.84	-4.00	24.64	27.89	63.80	63.85	17.98	-2.96	63.51	62.12
South Africa	0.48	-0.63	14.06	14.93	56.94	58.53	4.99	4.80	64.778	65.18
South Korea	2.81	1.28	32.17	32.16	63.79	64.27	1.28	2.06	96.53	87.94
Turkey	4.50	4.68	29.16	31.86	53.05	53.31	96.04	68.23	81.17	66.28
United Kingdom	3.66	-0.48	17.85	17.56	61.91	61.78	5.44	7.30	68.88	63.88
United States	2.13	2.38	21.37	21.39	61.79	62.08	7.13	3.60	26.89	24.89
European Union	3.20	0.21	22.09	22.05	57.49	57.65	6.69	6.41	103.57	95.69

Source: WDI, World Bank, 2023; UK: United Kingdom; EU: European Union

Table 2. Selected Development Indices of G20 (2021)

G20 Members	Financial Development Index	Human Development Index	Tourism Development Index	Sustainable Development Index
Argentina	0.306	0.842	0.001	73.4
Australia	0.909	0.951	0.021	76.0
Brazil	0.662	0.754	0.009	73.4
Canada	0.874	0.936	0.026	78.3
China	0.634	0.768	0.147	72.0
France	0.815	0.903	0.094	82.0
Germany	0.702	0.942	0.089	83.3
India	0.534	0.633	0.027	62.8
Indonesia	0.364	0.705	0.000	70.0
Italy	0.767	0.895	0.049	78.7
Japan	0.888	0.925	0.008	79.5
Mexico	0.818	0.925	0.034	78.2
Russia	0.402	0.758	0.030	69.4
Saudi Arabia	0.530	0.822	0.018	74.1
South Africa	0.442	0.875	0.018	67.5
South Korea	0.546	0.713	0.003	63.9
Turkey	0.500	0.838	0.034	70.7
United Kingdom	0.836	0.929	0.664	81.7
United States	0.917	0.921	0.077	76.0
European Union	0.528	0.896	0.156	80.2

Source: IMF, UNDP, Authors' Own estimate, SDG-2023 Report

The levels of human development depicted in Table 2 indicate that the health, education and living standards of people in these nations also complementary to the growth of travel and tourism in G20 nations. The

current figures of sustainable development index indicate that these countries are moving towards the achievement of SDGs by 2030. Nonetheless, the composite tourism development index is relatively low in almost all countries except for UK as evidenced from Table 2. This is also implied from the travel and tourism development index of the World Economic Forum (refer to Table 3). This implies that although the travel and tourism industry have all potential to contribute to higher economic growth and sustainable development (as inferred from the selected tourism indicators and contribution to GDP for the years 2023 and 2024 in Table 4 and 5), effective implementation of appropriate strategies for tapping such potential are essential. But this needs empirical support. Thus, the crucial question is 'whether tourism development, especially international tourism, is supportive of sustainable development in G20 countries.'

Table 3. Travel and Tourism Development Index of G20 (2019, 2021 & 2024)

G20 Members	2019	2021	2024
Argentina	4.05	4.00	4.10
Australia	5.06	4.99	5.00
Brazil	4.09	4.19	4.41
Canada	4.99	4.89	4.81
China	4.80	4.92	4.94
France	5.14	5.13	5.07
Germany	5.16	5.06	5.00
India	4.23	4.12	4.25
Indonesia	4.24	4.39	4.46
Italy	4.89	4.93	4.90
Japan	5.21	5.25	5.09
Mexico	4.33	4.27	4.26
Russia	-	-	-
Saudi Arabia	4.25	4.35	4.23
South Africa	3.84	3.83	3.99
South Korea	4.74	4.83	4.74
Turkey	4.18	4.24	4.39
United Kingdom	5.20	4.97	4.96
United States	5.24	5.20	5.24
European Union	-	-	-

Source: Word Economic Forum, 2019, 2021, 2024; For Russia & EU, data not provided by WEF.

In order to address this research question, the methodological clue is taken from Destek & Aydin (2022), the only study most relevant to the present work. It suggests that the SDG index can be regressed on the indicators of travel and tourism while controlling the macroeconomic environment. Following this line of methodological application, we estimate the regression employing best suited PMG based panel ARDL framework. The results indicate a statistically significant positive contribution of tourism sector development to the sustainable development of G20 nations. This finding corroborates to the most recent agreement among the leaders of G20 during India's Presidency that travel, and tourism can be catalysed to accelerate the pace of socio-economic, cultural and environmental factors central to the achievement of SDGs by 2030.

Table 4. Selected Indicators of Tourism Industry in G20 (2019 & 2021)

G20 Countries	International Tourist Arrivals (mn)		International Tourism Expenditure (USD mn)	
	2019	2021	2019	2021
Argentina	7.4	0.3	9845.0	1400.0
Australia	9.5	0.2	41345.0	1200.0
Brazil	6.4	0.7	21178.0	5200.0
Canada	32.4	4.3	33307.3	7900.0

G20 Countries	International Tourist Arrivals (mn)		International Tourism Expenditure (USD mn)	
	2019	2021	2019	2021
China	162.5	5.7	292855.4	109400.0
France	217.9	141.3	59751.0	36000.0
Germany	39.6	11.7	101231.0	51000.0
India	17.9	7.0	25922.4	14300.0
Indonesia	16.1	1.6	14449.0	500.0
Italy	95.4	40.2	37908.0	15000.0
Japan	31.9	0.2	29146.0	2800.0
Mexico	17.5	1.0	35339.0	17800.0
Russia	97.4	55.3	12300.0	5100.0
Saudi Arabia	24.4	7.1	40611.0	11400.0
South Africa	20.3	3.9	16415.0	12200.0
South Korea	14.8	2.7	5866.0	1108.6
Turkey	51.7	30.0	5354.0	1700.0
United Kingdom	40.9	6.4	68884.9	30000.0
United States	165.5	66.6	186079.0	56700.0
European Union	968.9	222.3	375550.6	305107.2

Source: WDI, World Bank, 2023

Table 5. Contribution of Travel & Tourism to GDP in G20 (2019 to 2024)

G20 Countries	Contribution of Travel & Tourism to GDP (%)					
	2019	2020	2021	2022	2023	2024
Argentina	9.4	6.5	7.0	8.0	8.8	9.6
Australia	10.7	6.0	4.7	6.9	9.8	10.2
Brazil	7,7	5.5	6.4	7.6	7.7	7.8
Canada	6.4	3.2	4.4	5.0	6.0	6.4
China	11.6	4.5	4.6	3.3	7.3	9.6
France	8.5	4.7	6.5	8.2	8.8	9.0
Germany	9.8	5.5	6.4	8.8	11.0	11.4
India	6.9	4.7	5.8	5.9	6.5	6.8
Indonesia	5.9	3.2	2.4	3.9	4.8	5.1
Italy	13.1	7.0	9.1	10.2	10.5	10.8
Japan	7.1	4.7	4.2	6.2	7.1	7.5
Mexico	15.0	8.5	13.1	14.7	14.4	14.2
Russia	4.9	2.7	3.7	3.6	4.1	4.3
Saudi Arabia	9.8	7.1	6.5	8.4	11.5	12.3
South Africa	6.9	3.7	3.2	6.3	8.2	8.8
South Korea	4.4	2.4	2.7	3.6	3.8	4.3
Turkey	11.0	5.0	7.3	11.5	12.0	12.4
United Kingdom	10.1	4.2	5.7	9.5	8.8	10.3
United States	8.6	5.3	5.5	7.9	8.6	9.0
European Union	10.1	-	-	-	9.7	10.1
G 20	9.4	-	-	-	8.1	9.0

Source: Economic Impact Report, WTTC (2021, 2022, 2023, 2024); All Figures shown for 2024 are estimates of WTTC

This research work is therefore important for planners and policy makers of G20 nations in reorienting the travel and tourism specific policies and strategies for making their economies resilient to domestic as well as

cross-border shocks and can trace a robust growth path towards sustainable development. This is the first study in the context of G20 nations in providing literature about the significance of tourism sector development for sustainable development, and hence, the study is original. The rest of the paper is organised as follows: Section 2 presents a review of relevant literature to identify the gaps of knowledge and to justify the research problem; Section 3 elaborates the data and methodology used in the study; Section 4 presents the results and discusses the findings; and Section 5 concludes.

1. Literature Review

Although the role of various sectors in the growth and development of an economy has occupied a great place in the literature since the era of classical economists, the importance of the smoke-less industry, travel and tourism, in the attainment of SGDs have discussed in the last decade only. But the origin of the concept of travel and tourism dates back to the growth of early civilization when people from one locality moved to another locality in search of living for themselves and their cattle. But the origin of the concept of modern tourism can be traced back to the 17th century when people in Europe started the 'Grand Tour'. However, the modern travel and tourism developed into an economic sector since 1850s when rail travel became cheaper and became a contributor to economic growth since 1950s when charter flights started worldwide (Chen, Zhang & Chen, 2023). Now, the global size of the tourism industry has risen to nearly 1.8 trillion USD in 2019 which after a temporary sluggishness during 2020-21 due to the unprecedented consequences of COVID-19 disease, reached over 1.6 trillion USD in 2022 (Chen, Zhang & Chen, 2023). According to report by UNWTO, the industry has been recovered 82 per cent as of July 2023.

This rapid growth in world tourism has happened due to the presence of rich cultures and traditions of different communities, colourful festivals of different places, scenic beauties, wonderful landscapes, bountiful nature, varieties of flora and fauna, the array of foods and beverages, and stunning heritage of monuments, scriptures etc. All these are catalyst in attracting large visitors worldwide every year which contributes to the development of inbound or international tourism. The extant literature acknowledges travel and tourism as a significant contributor to the economic growth and development of a nation by increasing foreign exchange reserves, creating new infrastructure and tourist attractions, enhancing the quality of human resources, creating new employment opportunities, increasing earnings, improving productivity, developing industries, reducing poverty and inequality, balancing the regional development, and in ensuring sustainable development (McKinnon, 1964; Croes, 2006; Lee & Chang, 2008; Lemmetyinen & Go, 2009; Cernat & Gourdon, 2012; Li *et al.* 2018; OECD, 2018; Khan *et al.* 2020; Mishra *et al.* 2020, 2021, 2022; Khan *et al.* 2023; Colacchio *et al.* 2023; Zhao *et al.* 2023). Therefore, tourism plays a critical role in resolving macroeconomic problems including low income and output, high unemployment, capital deficiency, shortage of foreign exchange, fiscal deficit, and balance of payments disequilibrium (Belke *et al.* 2021). Besides, travel and tourism is well known for its support to handicrafts and fine arts which not only contribute to preservation of tradition and culture of a country but also strengthens the process of national integration and universal brotherhood (Thommandru *et al.* 2023). Therefore, travel and tourism is a significant economic activity, and the most important sources of economic growth and development across the globe (Sana, 2021; Huseyn, 2023).

Thus, tourism sector development can be an important strategy for creating jobs, building capital, increasing economic growth, alleviating poverty, creating jobs, improving food security, and promote global trade (Richardson, 2021; Manzoor *et al.* 2019; Usmani *et al.* 2021). Therefore, tourism can be an important strategy to achieve some specific sustainable development goals such as no poverty (SDG-1), zero hunger (SDG-2), good health and well-being (SDG-3), quality education (SDG-4), clean water and sanitation (SDG-6), affordable and clean energy (SDG-7), decent work and economic growth (SDG-8), promoting industry, innovation and infrastructure (SDG-9), reduced inequalities (SDG-10), and sustainable cities and communities (SDG-11). In other words, tourism development can contribute to improved quality of life and country's sustainable economic growth (Sana, 2021). In this context, Destek & Aydin (2022) empirically checked the nexus between tourism and sustainable development for 10 most visited countries viz., China, France, Germany, Italy, Mexico, Spain, Thailand, Turkey, UK and USA, and the results indicate that tourism is detrimental to sustainable development in these countries primarily due to environmental degradation caused by tourists' arrivals, excessive consumption in touristic facilities, increase in the volume of transportation, etc. Although the arguments developed Destek & Aydin (2022) are justified, further investigations are also required.

It is inferred from the theoretical literature that tourism is helpful for achieving sustainable development of a country, but the empirical observation is just opposite to it and also limited. Further, studies in the context of

G20 countries as a whole in also scanty. Therefore, this study intends to fill this gap by examining the impact of tourism on sustainable development in the context of G20 members.

2. Materials and Methods

The key research question in this paper is 'does tourism sector development contribute to sustainable development in G20 countries?' and, to address this research question, all the G20 members have been included in the study. These members are: Argentina, Australia, Brazil, Canada, China, France, Germany, India, Indonesia, Italy, Japan, Korea Republic, Mexico, Russian Federation, Saudi Arabia, South Africa, Turkey, United Kingdom, United States and European Union. This study has been conducted in a panel data framework consisting of 20 countries, 09 variables and 20 years (from 2002 to 2021).

The variables included in the study are: Sustainable Development measured by SDG Index (*sdgi*), economic growth measured by GDP Per Capita growth (*gdpc*), capital measured by Gross Fixed Capital Formation as percentage of GDP (*gfcf*), labour as measured by Labour force participation rate as a percentage of total population ages 15+ (*lfpr*), human development as measured by Human Development Index (*hdi*), trade as a channel of tourism sector development across nations as measured by Trade as percentage of GDP (*trade*), depth, access, efficiency and stability of financial markets and institutions as measured by Financial Development Index (*fndi*), inflation as measured by Annual Rate of GDP deflator-based Inflation (*inf*), and tourism sector development (*tdi*) measured by a composite index computed based on three key indicators of tourism development, viz., international tourist arrivals, international tourism expenditure, and international tourism receipts. The data on these variables have been compiled from the World Development Indicator, World Bank, International Monetary Fund, UN Sustainable Development Report-2023, and UNDP Human Development Reports. Wherever data were missing, the same either have been taken from CEIC database or have been interpolated or extrapolated.

Construction of Composite Tourism Sector Development Index (tdi): The rationale behind the construction of a composite tourism sector development index is that individual indicators of tourism development such as international tourist arrivals, international tourism expenditure, and international tourism receipts reflect only a partial linkage with the economic growth of a nation. Secondly, these indicators portray a strong linear correlation among themselves as the larger arrival of international tourists means greater volume of expenditure and bigger size of national receipts thereby leading to the problems of multicollinearity (Shahzad *et al.* 2017). Besides, extant literature also supports the construction of a composite index of tourism sector development for its better representation and interpretation in empirical studies (Shahzad *et al.* 2017; Shahbaz *et al.* 2018; Al-Mulali *et al.* 2020; Mishra *et al.* 2023). Thus, it is justified to construct a composite tourism sector development index which is detailed below:

If the set of values of the 3-selected tourism indicators for the i^{th} G20 member are T_{i1}, T_{i2}, T_{i3}, then the composite indices obtained for each of the G20 country by using the first principal component is given by the linear combination of the variables: $ctsd_i = w_{11}T_{i1} + w_{12}T_{i2} + w_{13}T_{i3}$, where w_{11}, w_{12}, w_{13} are weights of each indicator such that their sum of squares is one, and *ctsd* is the composite tourism sector development index. The first principal component is calculated such that it accounts for the greatest possible variance in the dataset (Mishra *et al.* 2023). Finally, the obtained composite index is normalized by the max-min method to obtain the tourism sector development index for G20 as given by:

$$tdi = \frac{ctsd_i - \min\{ctsd_i\}}{\max\{ctsd_i\} - \min\{ctsd_i\}}.$$

Theoretically, it is argued that tourism sector development contributes to sustainable development in G20 countries through its contribution to GDP, capital formation, employment, human development, trade, financial sector development, and inflation. Tourism sector development raises arrivals of tourists, increases their spending, and makes revenue contributions. All these directly and indirectly contribute to national income thereby favourably influencing sustainable development of a country. *Second*, tourism sector development is both a pre-condition for and a post-realization of capital formation in an economy which in turn positively influences sustainable development of a nation. *Third*, tourism sector development makes direct and indirect contributions to the creation of employment opportunities in a country thereby positively adding to sustainable development of a country. *Fourth*, tourism sector development via its income and employment contributions raises the level of human development and thus, positively impacts the sustainable development of a nation. *Fifth*, tourism sector development via increased number of tourists' arrivals and their spending, positively contribute to exports and imports which in turn favourably add to the sustainable development of a nation. *Sixth*, tourism sector

development via increased number of tourists' arrivals and their spending, maintains a balance between demand and supply of money thereby contributing to the sustainable development of an economy by stabilizing prices. *Seventh*, tourism sector development adds to financial sector development by favourably influencing depth, access, efficiency and stability of financial markets and institutions which in turn positively contributes to sustainable development of a country.

Based on the above stated theoretical underpinning, it is assumed that sustainable development in G20 countries is a function of tourism sector development through its contribution to increased volume of income, employment, and capital formation, improved human development, increased volume of trade, greater financial development, and lower inflation. Symbolically, $sdgi = f\left(gdpc, gfcf, lfpr, hdi, trade, fndi, inf, tdi\right)$ (1)

The estimated form of this theoretical model (1) is:

$$sdgi_{it} = \gamma_{i0} + \gamma_{i1} gdpc_{it} + \gamma_{i2} gfcf_{it} + \gamma_{i3} lfpr_{it} + \gamma_{i4} hdi_{it} + \gamma_{i5} trade_{it} + \gamma_{i6} fndi_{it} + \gamma_{i7} inf_{it} + \gamma_{i8} tdi_{it} + \varepsilon_{it} \quad (2)$$

Here, γ_{i0} is the intercept term, γ_{ij} is the coefficient measuring the extent and direction of each of the explanatory variables, and ε_{it} is the random error. The anticipated sign of γ_{ij} depends on the direction of relationship of the relevant regressor with the dependent variable. Specifically, the coefficients of *gdpc*, *gfcf*, *lfpr, hdi, trade, fndi,* and *tdi* are expected to be positive as these factors have positive impacts on sustainable development. But the coefficient of *inf* is expected to be negative as it is having an inverse relationship with the degree of sustainable development.

Prior to the estimation of this empirical equation (2), descriptive statistics have been observed in terms of mean and standard deviation, cross-section dependency has been tested by using CD test of Pesaran (2004), and stationarity of variables checked by using Cross-sectional Augmented Dickey-Fuller (CADF) unit root test of Pesaran (2007).

In the literature, it is argued that the panel datasets may be subject to cross-sectional dependency due to the present of spatial or spillover effect or may be due to unobserved common errors (Baltagi & Pesaran, 2007). Therefore, it is important to check the cross-section dependence of the panel dataset used in the study by using CD test statistic as proposed by Pesaran (2004). Moscone & Tosetti (2009) found the strength of CD test over other tests in the literature. Therefore, the CD test is used in this study. The CD test statistic is stated as follows:

$CD = \sqrt{\frac{2t}{n(n-1)} \sum_{i=1}^{n-1} \sum_{j=i+1}^{n} \hat{\theta}_{ij}}$ where $\hat{\theta}_{ij}$ is the mean value of the pair-wise association of coefficients of Ordinary Least Square (OLS) residuals in fixed effect or random effect regressions. This test checks the likely validity of the null hypothesis that 'panel dataset has cross-sectional independence' against the alternative hypothesis that 'panel dataset has cross-sectional dependence'.

It will be seen in the next section that the null is rejected for the panel dataset used in this study, and thus, infer that there is cross-sectional dependence which warrants use of use of CADF unit root test for observing the stationary properties of variables under the study. This test is based on the regression equation that:

$$\Delta Y_{it} = \psi_i + \vartheta_i Y_{i,t-1} + \xi_i \bar{Y}_{t-1} + \phi_i \Delta \bar{Y}_t + \upsilon_{it} \quad (3)$$

This CADF unit root test is based on the OLS results of regression equation (3), and the test statistic is stated as: $CADF = \frac{\Delta Y_i \bar{M}_w Y_{i-1}}{\hat{\eta}\sqrt{\left(Y_{i-1}^{'} \bar{M}_w Y_{i-1}\right)}}$. In this test, the null hypothesis is 'the variable is not stationary'. It would be seen in the next section that variables of this study are either level stationary or first difference stationary.

Thus, the Autoregressive Distributive Lag (ARDL) framework based on the Pooled Mean Group (PMG) estimators (Pesaran *et al.* 1999) has been used to estimate the equation (2). The selection of this estimation technique has been made based on the outcome of the Hausman (1978) test in which the chi-square test statistic at 5 degrees of freedom having a p-value of 0.9995 > 0.05 fails to reject the null hypothesis that 'PMG based panel ARDL estimation is appropriate over MG based panel ARDL estimation'.

This panel ARDL model based on PMG estimators is preferred when the variables of interest are a mix of I(0) and (1), and in no case any variable is I(2) (Pesaran & Shin, 1999). Using this estimation technique, both long-run and short-run relationships can be studied (Pesaran *et al.* 1997, 1999) in which the lags both for

dependent and independent variables are chosen based on Akaike Information Criterion, and the following estimated form of regression equation is used:

$$\Delta sdgi_{i.t} = \zeta_i ect_{i,t} + \sum_{j=1}^{p-1} \tau_{i,j^*} \Delta sdgi_{i,t-j} + \sum_{j=0}^{q-1} \zeta_{1i,j} \Delta gdpc_{i,t-j'} + \sum_{j=0}^{r-1} \zeta_{2i,j} \Delta gfcf_{i,t-j'} + \sum_{j=0}^{s-1} \zeta_{3i,j} \Delta lfpr_{i,t-j''} + \sum_{j=0}^{u-1} \zeta_{4i,j} \Delta hdi_{i,t-j^{iv}} + \sum_{j=0}^{v-1} \zeta_{5i,j} \Delta trade_{i,t-j^{v}} + \sum_{j=0}^{x-1} \zeta_{6i,j} \Delta inf_{i,t-j^{vi}} + \sum_{j=0}^{y-1} \zeta_{7i,j} \Delta fndi_{i,t-j^{vii}} + \sum_{j=0}^{z-1} \zeta_{8i,j} \Delta tdi_{i,t-j^{viii}} + \omega_{i,t} \quad (4)$$

In this panel ARDL equation (4), the term *ect* stands for error correction indicating thereby the deviation from long-run equilibrium relationship in the short-run, and if it has a statistically significant negative coefficient, then a periodic adjustment towards the long-run equilibrium relationship is indicated implying the stability of the long-run equilibrium relationship. The results of this panel ARDL estimation are presented and discussed in the next section.

3. Research Results

Table 6 summarizes the descriptive statistics of variables of the study. The annual average sustainable development index across cross-sections of G20 is 71.03 which is less than one. It means, on average, there is yet many miles to go to achieve the targets of SDGs in G20 countries. The annual average growth rate of the economy is 1.95 per cent which indicates a low level of growth of per capita income across the cross-sections of G20 countries.

Table 6. Descriptive Statistics of Covariates

Statistics	*sdgi*	*gdpc*	*gfcf*	*lfpr*	*hdi*	*trade*	*fndi*	*tdi*	*inf*
Mean	71.03	1.95	23.43	59.99	0.81	53.74	0.62	0.11	5.45
Median	72.22	1.79	21.98	60.65	0.85	53.47	0.60	0.05	3.10
Maximum	83.28	13.63	44.51	75.71	0.95	105.56	0.97	1.00	54.15
Minimum	51.69	-11.84	11.96	45.52	0.50	20.44	0.26	0.00	-16.58
Std. Dev.	7.07	3.66	6.23	5.77	0.10	18.26	0.20	0.17	7.65
Observations	400	400	400	400	400	400	400	400	400

Source: Authors' Estimation

The annual growth of gross fixed capital is 23.43 per cent which indicates low level of capital accumulation across the cross-sections of G20 countries. The average labour force participation rate is 59.99 per cent which indicates a moderate level of total labour force participation across the cross-sections of G20 countries. The average level of human development is 0.81 across the cross-sections of G20 countries. The average total trade as a proportion of GDP is 53.74 per cent which indicates a moderate volume of total trade (exports + imports) across the cross-sections of G20 countries. The average inflation rate is 5.45 per cent which indicates a bit high rate of prices across the cross-sections of G20 countries. The average value of financial development index is 0.62 which indicates a moderate level of depth, access, efficiency and stability of financial markets and institutions across the cross-sections of G20 countries. The average level of tourism sector development is 0.11 which is considerably low across the cross-sections of G20 countries. This observation is crucial when the extant literature recognizes the contribution of travel and tourism to income and employment for growth and development of nations. Therefore, in this study, an attempt has been made to investigate whether tourism sector development can really be catalyzed for sustainable development of G20 nations as envisaged in G20 summits since 2012.

Table 7. Results of Cross-sectional Dependence Test

Panel Data Model	CD test stat.	p-value
Fixed Effect	18.085	0.000*
Random Effect	18.807	0.000*

Source: Authors' Estimation; *H_0: No Cross-Sectional Dependence; * sig. at 0.01 level*

Next, the cross-sectional dependence on the panel dataset has been tested by the CD test and its results are presented in Table 7. It is observed that the null hypothesis of 'no cross-sectional dependence' is rejected at the 0.01 level of significance. This means cross-sectional dependency is present in the panel dataset considered in this study. So, the cross-sectional ADF unit root test is appropriate to observe the stationary properties of the variables under study. The findings are presented in Table 8. It is observed that variables of the study are a mix of I(0) and I(1). And it is ensured that none of the variables is integrated in order two.

Table 8. Results of Cross-Sectional ADF Unit Root Test

Variables	CADF at Level		CADF at 1st diff.		Decision
	With Intercept only				
	t-bar	p-value	t-bar	p-value	
sdgi	-2.201	0.019**	-	-	I(0)
gdpc	-1.648	0.640	-2.935	0.000*	I(1)
gfcf	-2.234	0.014**	-	-	I(0)
lfpr	-1.117	0.996	-2.375	0.002*	I(1)
hdi	-2.523	0.000*	-	-	I(0)
trade	-1.114	0.997	-2.448	0.001*	I(1)
fndi	-1.817	0.351	-3.512	0.000*	I(1)
inf	-2.093	0.056***	-	-	I(0)
tdi	-2.523	0.000*	-	-	I(0)

Source: Authors' Estimation; *Note: *sig. at 0.01 level; **sig. at 0.05 level; ***sig. at 0.10 level*

Therefore, the impact of tourism sector development on sustainable development in G20 countries can appropriately be estimated in the panel ARDL framework. Before the estimation is performed, the correlation between the regressors is checked by employing Person's correlation test and the results are presented in Table-9. It is observed that no pair-wise correlation coefficient of explanatory variables is more than 0.80. This means there is no problems of exact linear correlation or multi-collinearity in the model specification in this study.

Now, the panel ARDL estimation is performed by including one lag of the dependent variable, and one lag of each dynamic regressor as suggested by Akaike info criterion (AIC). The estimation outcomes are presented in Table 10. It is observed that the tourism sector's development has a statistically significant positive impact on the sustainable development in G20 countries in the long-run. In addition, the contributions of per capita GDP growth, gross fixed capital formation, labour-force participation, human development, and trade on sustainable development in G20 countries in the long-run are positive and statistically significant. As expected, inflation is inversely related to sustainable development in G20 countries in the long-run. But the finding that financial development has a statistically significant negative impact on the sustainable development in G20 countries in the long-run was not expected.

Table 9. Results of Pearson's Correlation Test

Variables	*gdpc*	*gfcf*	*lfpr*	*hdi*	*trade*	*fndi*	*inf*
gfcf	0.446	-	-	-	-	-	-
lfpr	0.169	0.269	-	-	-	-	-
hdi	-0.352	-0.295	0.047	-	-	-	-
trade	0.011	0.010	-0.172	0.207	-	-	-
fndi	-0.207	-0.033	0.162	0.727	-0.012	-	-
inf	0.097	-0.218	-0.078	-0.260	-0.196	-0.527	-
tdi	-0.037	-0.013	-0.030	0.284	0.251	0.164	-0.224

Source: Authors' Estimation

Furthermore, understanding that the long-run relationship can be disturbed in the short-run, it is found that the short-run deviations are primarily due to labour-force participation and inflation which are statistically significant. However, such short-run deviation has a convergence tendency towards long-run equilibrium as indicated by the negative and statistically significant coefficient of the error correction term (ϕ) and thus, the long-run equilibrium relationship can subsequently be restored. It is noticed that the short-run deviation is corrected

towards long-run equilibrium at a speed of 55.62 per cent per annum. This means G20 countries would benefit from the tourism sector development in the long-run.

4. Discussions

Based on the results of PMG based panel regression estimation as shown in table-10 above, the following are the points of discussions:

Per Capita GDP Growth: It is observed from Table 10 that the per capita GDP growth has a positive and statistically significant impact on sustainable development of G20 countries in the long-run. The estimated coefficient of *gdpc* indicates that 1 per cent increase in it can increase the sustainable development index by 0.0226 points G20 countries in the long-run, assuming all other factors remaining unchanged. This finding implies the importance of higher economic growth as an enabler for a positive contribution of tourism sector to sustainable development in G20 countries.

Table 10. Results of Panel ARDL Model (PMG Estimates of Short-Run Long-Run Relationships)

Dependent Variable: $\Delta sdgi$:	Dependent Lag: 1	Dynamic Regressors Lag: 1		
Regressors	**Coefficient**	**Std. Error**	**t-statistic**	**p-value**
LONG-RUN RELATIONSHIP				
gdpc	0.0226***	0.013	1.668	0.097
gfcf	0.0179***	0.010	1.757	0.081
lfpr	0.1048*	0.013	7.734	0.000
hdi	14.1833*	1.446	9.808	0.000
trade	0.0131*	0.003	5.087	0.000
inf	-0.0239***	0.013	-1.779	0.077
fndi	-6.4816*	0.527	-12.297	0.000
tdi	0.8571*	0.320	2.678	0.008
ERROR CORRECTION TERM				
ϕ	-0.5562*	0.119	-4.650	0.000
SHORT-RUN RELATIONSHIP				
Δ(*gdpc*)	0.0032	0.007	0.455	0.649
Δ (*gfcf*)	-0.0341	0.044	-0.774	0.439
Δ (*lfpr*)	-0.0970***	0.049	-1.960	0.051
Δ (*hdi*)	-7.1270	10.643	-0.669	0.504
Δ (*trade*)	-0.0159	0.011	-1.494	0.136
Δ (*inf*)	0.0395**	0.019	2.053	0.041
Δ (*fndi*)	-0.1001	0.831	-0.120	0.904
Δ (*tdi*)	2.7186	3.764	0.722	0.471
C	30.1593*	6.092	4.950	0.000
@trend	0.1628*	0.032	5.116	0.000

*Note: *, ** , *** sig. at 0.01, 0.05 and 0.10 levels respectively; Lag order selection by AIC value of 0.199*
Source: Authors' Estimation

Gross Fixed Capital Formation: It is observed from Table 10 that the gross fixed capital formation has a positive and statistically significant impact on sustainable development of G20 countries in the long-run. The estimated coefficient of *gfcf* indicates that 1 per cent increase in it can increase the sustainable development index by 0.0179 points G20 countries in the long-run, assuming all other factors remain unchanged. This finding implies the importance of higher capital availability as an enabler for a positive contribution of tourism sector to sustainable development in G20 countries.

Labour-Force Participation Rate: It is observed from Table 10 that the labour-force participation rate has a positive and statistically significant impact on sustainable development of G20 countries in the long-run. The estimated coefficient of *lfpr* indicates that 1 per cent increase in it can increase the sustainable development index by 0.1048 points G20 countries in the long-run, assuming all other factors remain unchanged. This finding

implies the importance of higher labour-force participation as an enabler for a positive contribution of tourism sector to the sustainable development in G20 countries.

Human Development: It is observed from Table 10 that the human development index has a positive and statistically significant impact on sustainable development of G20 countries in the long-run. The estimated coefficient of *hdi* indicates that 1 per cent increase in it can increase the sustainable development index by 14.18 points G20 countries in the long-run, assuming all other factors remain unchanged. This finding implies the importance of higher level of human development as an enabler for a positive contribution of tourism sector to the sustainable development in G20 countries.

International Trade: It is observed from Table 10 that international trade (exports + imports) has a positive and statistically significant impact on sustainable development of G20 countries in the long-run. The estimated coefficient of *trade* indicates that a 1 per cent increase in it can increase the sustainable development index by 0.0131 points G20 countries in the long-run, assuming all other factors remain unchanged. This finding implies the importance of a higher volume of trade as an enabler for a positive contribution of the tourism sector to the sustainable development in G20 countries.

Inflation: It is observed from Table 10 that inflation has a negative and statistically significant impact on sustainable development of G20 countries in the long-run. The estimated coefficient of *inf* indicates that 1 per cent decrease in it can increase the sustainable development index by 0.0239 points G20 countries in the long-run, assuming all other factors remain unchanged. This finding implies the importance of lower level of inflation as an enabler for a positive contribution of tourism sector to sustainable development in G20 countries.

Tourism Sector Development: It is observed from the Table 10 that the tourism sector development has a positive and statistically significant impact on sustainable development of G20 countries in the long-run. The estimated coefficient of *tdi* indicates that 1 per cent increase in it can increase the sustainable development index by 0.8571 points G20 countries in the long-run, assuming all other factors remain unchanged. This finding implies the role of travel and tourism towards achieving sustainable development goals in G20 countries. This finding contradicts the findings of a recent study by Destek & Aydin in 2022 that tourism can be detrimental to sustainable development and establishes a new direction for further research that travel, and tourism can have significant contributions towards attainment of SDGs.

Conclusions and Scope for Further Research

This study empirically examined the impact of the development of travel and tourism on sustainable development in the G20 nations. In this study, important macroeconomic variables have been used as control variables. The results lend support to the G20 members' consideration that travel, and tourism can drive the economies to achieve SDGs by 2030. Making travel and tourism one of the critical economic sectors for accelerating the pace of sustainable development necessitates the implementation of appropriate strategies for effective and efficient growth and development of this industry. The recently identified priorities include greening the tourism sector, harnessing the power of digitization, skilling the youth, nurturing tourism MSMEs and strategic management of destinations during the India's Presidency in 2023, can certainly accelerate the progress on SDGs in G20 countries. Despite the simplicity of this study, the limitations include non-incorporation of domestic tourism development and ignoring the importance of institutional factors that are likely to play a crucial role in the development process. Furthermore, country-specific factors need to be identified may be through time-series analyses for designing relevant tourism development policies for accelerating the advancements on SDGs. In all these directions, future works can be planned.

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Credit Authorship Contribution Statement

P. K. Mishra: Conceptualization, Investigation, Methodology, Software use, Formal analysis, Supervision, Data curation, Validation, Writing – review and editing, Visualization.
Himanshu B. Rout: Investigation, Formal analysis, Writing – original draft, Writing – review.
Pradip Kumar: Investigation, Data curation, Validation, review and editing, Visualization.
Sanjeev Kumar Saxena: Investigation, Validation, Writing – review.

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 Role of International Energy Agreements in Price Band Formation

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Abstract: The price of energy is one of the key determinants of the well-being of numerous countries, therefore, analysis of the factors of influence on such price formation is of great importance. This work aims at the determination of the main vectors of influence of international energy agreements on the formation of the price bands on the example of the Organization of the Petroleum Exporting Countries. Statistical analysis method, descriptive method, and correlation analysis method were used in the study. As a result of the study, the significant role of international energy agreements in the formation of the price bands was proved. Using the characteristic of the mechanism of influence of oil exporters on the prices of oil, the control major oil exporters can have over price formation. The analysis of price fluctuations in time enabled combining these fluctuations with key geopolitics and economic events of the relevant period, as well as explaining the influence of oil exporters on the price change. The offer of the members of the Organization of the Petroleum Exporting Countries significantly affects the prices of crude oil, spot prices, and prices of products, which was confirmed using correlation analysis. The influence of exporters is larger than that of the states outside the organization. Gasoline, Diesel, and Jet/Kero are the most sensitive to fluctuations in the offer of the Organization of the Petroleum Exporting Countries. Not only official energy agreements but also informal practices significantly influence the formation of price bands, which was demonstrated through the analysis of the revenue from Russian oil exports. Governments and energy companies may use these results for optimisation of strategies for managing risks associated with the actions of international organizations.

Keywords: international energy agreements; price bands; prices of energy; oil exporters; energy security; price control.
JEL Classification: F10; F16; F38; G13.

Introduction

The energy sphere plays a key role in the world economy as it directly affects the well-being of states through the development of production and infrastructure (Khan *et al.* 2021b; Li & Leung, 2021). Changes in prices of energy cause inflation rate fluctuations and increase or decrease in the income of the state and private sector and influence the level of competitiveness of economies (Kilian & Zhou, 2022; Abdallah & Kpodar, 2023). In turn, a whole series of geopolitical and economic factors, including conflict escalation, global uncertainty, financial crises, etc. influence the prices of energy (Wen *et al.* 2021; Nerlinger & Utz, 2022).

Various energy agreements can contribute to the mitigation of the negative effects of the factors mentioned above for the states entering into them (Mišík, 2022). Moreover, they enable an influence on the price of energy, providing advantages to the state-members (Kisswani *et al.* 2022). Different agreements between the Organization of the Petroleum Exporting Countries (OPEC) may be outlined among the most influential energy agreements in recent decades (Derbali *et al.* 2020; Pirani, 2022). Oil is one of the key energy sources and plays a strategic role in geopolitical space (Yang *et al.* 2022). Expansion of the organization within the OPEC+ agreement enables strengthening control of this organization on the world oil market (Ulatowski, 2020; Na & Hongmei, 2022).

OPEC+ has significant control over oil production and can establish quotas for member states. Production reduction means a reduction of oil supply, which leads to a price increase. This affects both members of the cartel and other states, exporting oil, which is reflected in their incomes. An increase in the price of oil causes additional expenses and strengthens the economic pressure on import-dependent states, especially in case of insufficient import diversification (Mazaraki *et al.* 2021; Kudyrko *et al.* 2024).

This study aims to determine the main vectors of influence of international energy agreements on the formation of the price bands in the example of OPEC+. The tasks of the study are:

- to analyse the dynamics of the price of oil as one of the strategically important resources, to determine the causes of fluctuations and the role of OPEC and OPEC in it;
- to characterise the mechanism of influence of OPEC and OPEC+ on the prices of energy;
- to conduct correlation analysis between the prices of crude oil and products on the one side and parameters of demand and supply of different organizations on the other side;
- to study the influence of sanctions on Russia as a part of international energy policy.

1. Literature Review

The price of energy is affected by numerous factors, which are noted in numerous works of scientists. Researchers aim to detect and analyse different macroeconomic factors of influence to confirm or refute their influence on the prices of energy. Su et al. (2020) analysed the dependence of the price of oil on the factors of guerrilla conflicts (in the example of the USA), the dollar index, and oil production in the USA. Khan et al. (2021a) conducted an analysis directed at detecting the influence of different bubbles on crude oil prices. Beckmann et al. (2020) selected the narrow direction, studying the relationship between the prices of oil and exchange rates. Lin & Bai (2021) noted the significant influence of uncertainty on oil prices. Uncertainty can be caused by various financial crises and other economic and political phenomena and events. Wang et al. (2022) studied the relationship between inflation rate and economic growth on the one side, and oil price fluctuations on the other side.

The mentioned works significantly contribute to the studied theme, explaining numerous cause-effect relationships between oil prices and various geopolitical and economic factors. However, it is important to analyse the influence of international energy agreements in the formation of prices of energy as well, as such agreements can have a significant influence on prices depending on the influence of macroeconomic factors. For example, agreements between large oil suppliers, as in the case of the OPEC+, can make significant changes to the price policy in the absence of a direct relationship with economic growth, currency rate, etc (Çemrek & Bayraç, 2021). Ji et al. (2019) noted that the OPEC members are the most important players among oil exporters. These states produced approximately 40% of oil and had over 81% of the world's oil at their disposal. Quint & Venditti (2023) studied changes in oil prices due to a reduction in production by the members of OPEC+, as well as further shock due to COVID-19 and the price war between organization members.

In light of aggravating climate issues, the other important area of research is the influence of various "green" agreements on the energy market (Litvak & Litvak, 2020; Prokopenko *et al.* 2023). Lee *et al.* (2021) analysed the relationship between the US green bond index, geopolitical risks and the oil price. Referring to the Kyoto Protocol and the Paris Agreement, Rasheed *et al.* (2022) studied the relationship between the prices of oil and the use of fossil and renewable fuels.

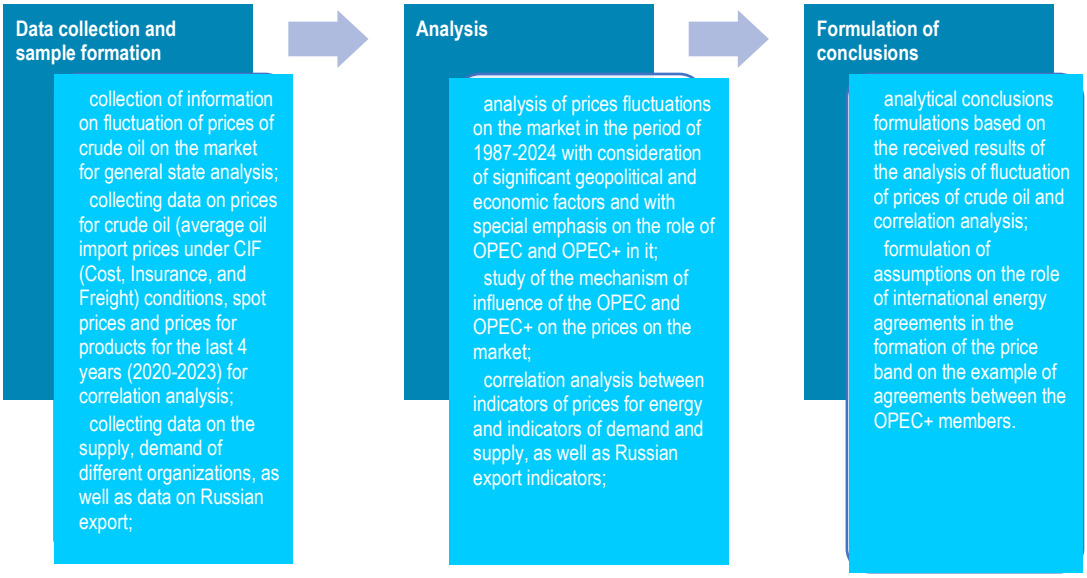
Considering the influence of numerous factors on the price of energy, this work focuses on the analysis of the modern state of the energy market and the OPEC+ influence on it. This is related to the significant influence members of OPEC+ can have on the energy market through the control of over 40% of oil production and the major share in the export of this energy source. Hence, as oil is the main energy source, its price affects the price of other energy resources. The necessity for extending studies in the mentioned theme is stipulated by the lack of works, containing profound analysis of the influence of international energy agreements on prices of energy. In turn, such agreements can have decisive meaning along with other geopolitical and economic factors.

2. Research Methodology

2.1. Study Procedure

The study procedure provides for the realisation of standard stages: data collection, analysis, and formulation of analytical conclusions. The analysis stage contains the analysis of price fluctuations, the study of the mechanism of influence of OPEC and OPEC+ on the price, and the correlation analysis between price indicators and indicators of demand and supply. The stages of the study are interrelated and consistently present the content of the received results (Fig. 1).

Figure 1. Study procedure



Source: construed by the authors

2.2. Sample

The sample of indicators for the study is presented in Tables 1 and 2. The period covered by data in these tables is limited to the latest available data for 2020-2023. Table 1 contains data on prices of crude oil, spot prices and prices of oil products.

Table 2 contains the main indicators, which can influence oil prices - supply, and demand - divided by regions, in price, OPEC. This enables analysis of the influence of the agreements between the members of this organization on price formation. Table 2 also contains data on Russian exports and revenues from oil. These indicators were included in the analysis for evaluation of the latest changes in the market, related to the Russian invasion of Ukraine and the influence of these events on the prices of energy. In particular, it is important to analyse the influence of sanctions on the revenues of Russia from energy exports. Although sanctions are not full-fledged international agreements, they also play an important role in international energy policy and, thus, have a direct relation to the theme of the work.

Table 1. Prices of crude oil and products

	2020	2021	2022	4Q22	1Q23	2Q23	3Q23
CRUDE PRICES IEA CIF Average Import							
IEA Europe	42.91	70.67	100.22	89.42	82.16	79.75	87.94
IEA Americas	37.31	64.78	90.77	77.18	67.91	70.63	78.24
IEA Asia Oceania	46.28	70.41	102.56	96.43	86.14	83.19	84.91
IEA Total	42.19	68.87	98.2	87.96	79.25	78.03	84.49
SPOT PRICES							
North Sea Dated	41.76	70.82	101.1	88.36	81.11	78.02	86.74
North Sea Dated M1	42.9	71.51	101.17	89.54	82.37	78.02	86.69
WTI (Cushing) M1	39.25	68.1	94.58	82.82	75.96	73.54	82.51
WTI (Houston) M1	40.71	69.01	96.19	84.33	77.74	74.69	84.01
Urals	41.21	69	76.58	62.46	46.77	54.63	72.79
Dubai M1	42.36	69.35	96.27	84.68	80.2	77.56	86.54
PRODUCT PRICES Northwest Europe							
Gasoline	44.64	80.07	117.01	99.41	96.17	99.44	112.44
Diesel	49.34	78.41	142.36	139.55	113.71	96.12	119.87
Jet/Kero	45.8	77.31	139.91	130.9	114.74	95.43	120.67
Naphtha	40.18	71.58	86.51	72.63	77.95	67.47	71.72
HSFO	33.99	61.18	76.58	59.55	60.51	67.96	82.63
0,5% Fuel Oil	48.5	76.78	107.05	87.19	83.99	79.21	88.17
Mediterranean Europe							
Gasoline	45.57	80.5	119.73	103.89	100.36	98.77	112.74
Diesel	48.82	77.93	136.11	130.46	112.08	94.97	118.1
Jet/Kero	45.57	77.19	140.02	131.28	114.89	95.43	120.6
Naphtha	39.04	70.65	84.62	70.36	75.83	65.93	69.99
HSFO	34.17	60.05	73.4	56.73	56.97	65.19	81
US Gulf Coast							
Gasoline	47.3	86.49	123	103.04	105.58	103.93	117.09
Diesel	50.26	84.73	145.74	141.65	120.39	100.11	124.92
Jet/Kero	46.3	77.95	140.05	134.73	125	94.79	120.4
Naphtha	40.12	72.24	91.24	76.09	80.92	74.87	72.92
HSFO	34.71	59.9	76.96	55.48	57.1	64.07	78.65
0,5% Fuel Oil	49.88	79.69	112.92	92.69	90.54	82.18	93.2
Singapore							
Gasoline	45.28	78.49	110.86	89.89	95.15	89.57	99.68
Diesel	49.6	77.8	135.47	126.25	108.44	93.09	115.23
Jet/Kero	45.06	75.29	126.9	118.3	106.38	91.57	112.47
Naphtha	40.94	71.02	83.79	70.92	74.21	63.26	80.28
HSFO	38.33	63.2	77.65	58.6	62.36	68.53	80.28
0,5% Fuel Oil	52.85	80.81	116.78	97.77	90.95	86.97	94.06

Source: generalised by the author based on the data of IEA (2024)

Table 2. Parameters, having an influence on oil prices

	2020	2021	2022	4Q22	1Q23	2Q23	3Q23
DEMAND							
OECD Demand	42.1	44.8	45.7	45.7	45.4	45.7	46
NON-OECD Demand	49.8	52.7	53.8	54.6	54.9	56.1	56.8
Total Demand	91.9	97.5	99.5	100.2	100.2	101.8	102.9
SUPPLY							
OECD Supply	28	28.2	29.3	30	30.4	30.5	31.2
NON-OECD Supply	31.7	31.6	32.2	32.5	32.7	32.4	32.4
Total Non-OPEC Supply	64.4	64.9	66.8	67.7	68.1	68.6	69.6
OPEC Supply	29.7	30.6	33.3	33.7	33.8	33.2	32.4
Total Supply	94.1	95.5	100.1	101.4	101.8	101.8	101.9
Russian Oil Exports							
Total (Crude and Products)		7.2	7.5	7.3	7.9	7.1	7.4
Export Revenue		15.7	19.5	14	14.2	13	18.8

Source: generalised by the author based on the data of IEA (2024)

2.3. Methods

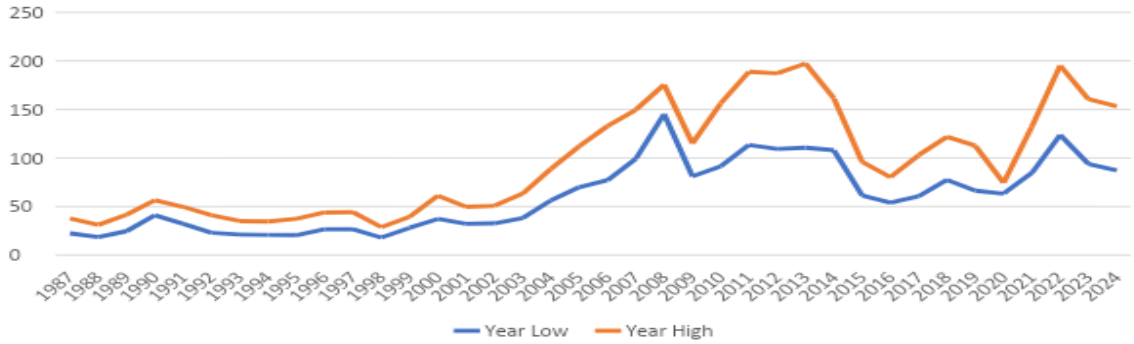
Statistical analysis method was used in the process of this study for the study of fluctuation of prices of crude oil in time. Using this method, the most important changes in prices of oil during the studied period. The enabled comparison of the detected 'jumps' in prices with certain geopolitical and economic events. Moreover, the possible relationship between the activity of OPEC and OPEC+ with detected fluctuations was analysed. The descriptive method was used to characterise the influence of OPEC and OPEC+ on the prices of oil. The use of this method enables the description of the mechanism of such influence and an explanation of cause-effect relations and whole organizations. Correlation analysis was used to detect changes between the studied indicators of prices of energy and indicators of demand and supply from different organizations. Correlation analysis enabled the detection of the relation between price dynamics and supply and demand dynamics, the determination of the most significant correlations and relation area.

3. Results

3.1. General Tendencies on the Market

The last two decades were marked by significant fluctuations in oil prices on the global scale (Figure 2). The gradual price increase after 2001 ended with a sharp drop in 2008-2009 due to the economic crisis, which affected global demand and the financial market. After a short-term recovery, prices sharply decreased again in 2010-2013, which could be related to a complex of different factors. In particular, such a situation was caused by the extension of shale oil production in the USA along with the refusal of OPEC to shorten production for price stabilisation, which caused an increase in resource supply. Further, in 2016 Saudi Arabia and Russia agreed to maintain the prices of oil. Finally, OPEC+ was created, which involved members of OPEC as well as other states. Production reduction by OPEC members, in particular Saudi Arabia, contributed to the gradual increase in the prices of oil. Further price decreases may be explained by the consequences of the COVID-19 pandemic, which among others influenced demand reduction. The new price recovery occurred alongside the recovery of economic activity after the pandemic. Prices of oil achieved their peak in 2022 - the year of the Russian full-scale invasion of Ukraine. This was provoked by the fear of price increases due to supply disruptions related to sanctions imposition against Russia. The situation with prices of oil somewhat improved after 2022, which could be related to the production increase in other countries. Herewith, the opening of the US Strategic Petroleum Reserve and other geopolitical factors could contribute to this situation.

Figure 2. World prices of crude oil



Source: developed by the author according to data of Macrotrends (2024)

Referring to the data from the report of the International Energy Agency (IEA, 2024), it is worth noting the slowdown in the increase in global oil demand among other tendencies at the beginning of 2024. The slowdown is related to macroeconomic fluctuations, strengthening efficiency standards, slowdown of the growth in China, increase in electric vehicle fleet. Herewith, the supply of energy by the increase in production in such countries as the USA, Canada, Brazil, and Guyana. Herewith, production increase will be more noticeable for countries outside OPEC+. Production of the last remains stable. The other tendencies are an increase in the production of Russia and the reduction of global oil reserves. Generally, the forecast of the World Bank provides for the reduction in prices of oil from 84 USD per barrel in 2024 to 79 USD in 2025. The main risks in the prognosis may be noted as conflict escalation, lower than expected energy supply in Northern America, as well as the increase of the global GDP lower than expected (Agnolucci & Temaj, 2024).

3.2. Influence of OPEC+ on Oil Prices

From the previous paragraph, it can be summarised that OPEC+ has a significant impact on the energy market. 80% of the confirmed world reserve of oil and a significant share of exports are under the control of the organization (Bromberg, 2024). The organization regulates oil supply to control prices on the world energy market. Other goals of this association may be named as counteracting other countries in their ability to produce oil, limiting supply control and prices of OPEC+ itself. In 2022, OPEC+ used production reduction to increase prices of oil, which failed due to the possibility of recession.

The essence of OPEC+ activity is supply reduction by its members to stimulate an increase in prices in case of dissatisfaction with oil prices. Herewith, supply reduction leads to income decrease, which may be unprofitable for separate states of the organization. Being the main exporters, Russia and Saudi Arabia aim for a supply increase, as they have possibilities to expand production. On the other side, other countries of the organization may not have such possibilities, therefore, they can object to supply increase, which leads to internal differences. It is possible to assume that the influence of OPEC+ is mostly short-term, as the correlation of oil production in the future can change under the influence of its increase in other countries. The long-term influence of international “green” agreements stimulating the transition to renewable energy sources, and thus affecting the structure of fossil fuels demand, is not excluded.

3.3. Correlation Analysis

Correlation analysis on the basis of the data was conducted to confirm previous conclusions (Table 1 and Table 2). The results of correlation analysis are presented in Table 3. Correlation analysis between the prices of crude oil and products on the one side and parameters of demand and supply of different organizations on the other side was conducted. The correlation value obtained as a result of the calculations is shown at the intersection of the two indicators.

The following conclusions can be made on the results of the conducted correlation analysis. High correlations are observed between indicators of OPEC supply and prices of crude oil. Hence, the price of crude oil is significantly less correlated with the supply of states, which are not OPEC members. Gasoline, Diesel, and Jet/Kero have the tightest relation to the supply of OPEC, which is characteristic of all studied regions. This means that the level of supply of OPEC has a significant influence on the prices of crude oil. Herewith, Gasoline, Diesel, and Jet/Kero are the most sensitive to such changes.

Table 3. Correlation analysis results

	OECD Demand	NON-OECD Demand	Total Demand	OECD Supply	NON-OECD Supply	Total Non-OPEC Supply	OPEC Supply	Total Supply	Total Russian Export (Crude and Products)	Russian Export Revenue
CRUDE PRICES IEA CIF Average Import	0.708	0.171	0.294	0.283	0.423	0.322	0.615	0.505	0.290	0.577
IEA Europe	0.632	0.077	0.210	0.126	0.173	0.181	0.395	0.311	0.088	0.704
IEA Americas	0.640	0.098	0.210	0.243	0.519	0.274	0.762	0.546	0.294	0.318
IEA Asia Oceania	0.685	0.130	0.255	0.238	0.398	0.280	0.616	0.479	0.246	0.545
IEA Total	0.708	0.171	0.294	0.283	0.423	0.322	0.615	0.505	0.290	0.577
SPOT PRICES										
North Sea Dated	0.648	0.092	0.218	0.202	0.352	0.242	0.563	0.428	0.291	0.618
North Sea Dated M1	0.631	0.070	0.195	0.193	0.369	0.229	0.583	0.429	0.321	0.594
WTI (Cushing) M1	0.645	0.089	0.217	0.190	0.310	0.231	0.514	0.398	0.266	0.662
WTI (Houston) M1	0.649	0.097	0.224	0.203	0.330	0.243	0.529	0.412	0.288	0.655
Urals	0.129	-0.224	-0.125	-0.316	-0.557	-0.261	-0.447	-0.379	-0.335	0,842*
Dubai M1	0.728	0.219	0.340	0.323	0.421	0.362	0.584	0.514	0.321	0.637
PRODUCT PRICES Northwest Europe										
Gasoline	0,870*	0.499	0.605	0.543	0.476	0.589	0.544	0.639	0.216	0.629
Diesel	0.679	0.160	0.270	0.326	0.550	0.346	0.709	0.564	0.360	0.390
Jet/Kero	0.710	0.214	0.323	0.381	0.581	0.400	0.716	0.600	0.432	0.449
Naphtha	0.064	-0.397	-0.309	-0.242	0.068	-0.235	0.309	-0.004	0.612	0.596
HSFO	0.646	0.500	0.576	0.412	0.038	0.464	-0.029	0.281	-0.049	0.800
0,5% Fuel Oil	0.473	-0.084	0.042	0.012	0.163	0.053	0.404	0.230	0.320	0.725
Mediterranean Europe										
Gasoline	0,850*	0.439	0.547	0.524	0.538	0.562	0.625	0.660	0.317	0.595
Diesel	0.708	0.207	0.315	0.373	0.578	0.392	0.717	0.596	0.404	0.424
Jet/Kero	0.709	0.213	0.321	0.380	0.583	0.399	0.718	0.601	0.432	0.444
Naphtha	0.020	-0.431	-0.345	-0.289	0.006	-0.280	0.250	-0.062	0.586	0.615
HSFO	0.599	0.478	0.550	0.374	-0.033	0.426	-0.116	0.215	-0.102	0.805
US Gulf Coast										
Gasoline	0,819*	0.464	0.564	0.532	0.503	0.569	0.564	0.635	0.352	0.642
Diesel	0.670	0.159	0.267	0.333	0.560	0.349	0.708	0.565	0.408	0.407
Jet/Kero	0.648	0.190	0.284	0.390	0.651	0.395	0.767	0.620	0.556	0.360
Naphtha	0.191	-0.275	-0.186	-0.142	0.197	-0.122	0.495	0.161	0.500	0.434
HSFO	0.546	0.344	0.429	0.258	-0.074	0.313	-0.085	0.158	-0.035	0,868*
0,5% Fuel Oil	0.484	-0.065	0.057	0.055	0.234	0.088	0.458	0.278	0.403	0.701

	OECD Demand	NON-OECD Demand	Total Demand	OECD Supply	NON-OECD Supply	Total Non-OPEC Supply	OPEC Supply	Total Supply	Total Russian Export (Crude and Products)	Russian Export Revenue
Singapore										
Gasoline	0.677	0.273	0.376	0.368	0.432	0.401	0.549	0.519	0.460	0.673
Diesel	0.692	0.172	0.285	0.331	0.531	0.353	0.688	0.558	0.387	0.467
Jet/Kero	0.736	0.252	0.360	0.413	0.593	0.432	0.718	0.622	0.432	0.464
Naphtha	0.292	-0.078	0.015	0.019	0.009	0.031	0.048	0.036	0.502	0,917*
HSFO	0.555	0.411	0.484	0.320	-0.028	0.372	-0.066	0.204	-0.009	0,822*
0,5% Fuel Oil	0.521	-0.057	0.070	0.052	0.247	0.092	0.509	0.307	0.293	0.620

Source: calculated by the author based on the data of IEA (2024)
* Statistically significant correlations are marked

Statistically significant correlations are characteristic of indicators of OECD Demand and prices of Gasoline in Northwest Europe, Mediterranean Europe, US Gulf Coast. The increase in demand for gasoline occurred in association with quarantine restrictions removal and stimulated price increases. The other significant factors were limitations of OPEC+ production, pressure due to the war in Ukraine, and reduction of oil reserves in Europe and the USA.

It is also worth noting high and statistically significant correlations between the revenue of Russia from export and a number of price indicators for energy and products. Thus, Russian export revenue is tightly correlated with the spot price of the Urals, prices of HSFO in the US Gulf Coast and Singapore, as well as prices of Naphtha in Singapore. Thus, regardless of sanctions, the revenues of Russia from oil export increase, which can be connected to shadow fleet expansion. This enables the state to exceed the price cap for oil and receive high revenue. China and India are the largest importers of Russian crude oil, and importers of oil products are Turkey, China, Brazil, the UAE, Malaysia, Singapore, India, and Saudi Arabia.

4. Discussions

The analysis conducted in this work proved the significant role of international energy agreements in the formation of the price band. In particular, the example of OPEC+ was used to show the impact of agreements between member states on prices by setting production limits. Correlation analysis proved the significant role of OPEC+ in the formation of prices of crude oil and products. The analysis of indicators of the revenue from Russian oil export enabled us to assume that not only official energy agreements, but also informal practices, significantly influence the formation of price bands.

It is important to consider the issue of price band formation in the energy market within the context of different geopolitical and economic factors of influence. The author's work conclusions on the relation between oil prices and geopolitical and economic events of the relevant period correspond to the results of other researchers. In such a way, based on the data of the USA, Su *et al.* (2020) proved that guerrilla conflicts influence the prices of oil, but such influence is lower compared to the effect of the dollar rate. Oil production volume in the USA was found to have less influence. Khan *et al.* (2021a) found that prices of oil are affected by different "bubbles". The "bubble" factors include world economic growth, decline in the dollar, excessive supply of OPEC, US production levels, and insufficient demand for energy in developing countries. Beckmann *et al.* (2020) concluded that prices of oil undergo significant influence from exchange rates from a long-term perspective. This may be useful for forecasting, although scientists noted that such influence significantly changes with time. Lin & Bai (2021) found that oil prices negatively react to uncertainty. Herewith, price shocks significantly influence oil exporters. Wang *et al.* (2022) proved that prices of oil, in their turn, have a significant influence on economic growth and financial development. This influence is experienced by both states-importers and states-exporters of energy. The influence of various factors on price band formation is considered, but special attention is given to international energy agreements. This is the advantage of the study for understanding price fluctuations, which may not be directly related to geopolitical situations.

The significant influence of OPEC on price bands is noted both in the work of the author and in other works. Çemrek & Bayraç (2021) expressed their confidence in the significant dependence on the global industry and export of oil in OPEC states. Ji *et al.* (2019) noted the significant influence of OPEC on the oil security of China, Japan, and Southern Korea as key oil importers. The scientists concluded that political uncertainty in

OPEC countries can have a significant influence on countries and influence these prices. The conclusions of the mentioned researchers correspond to the results of the author of this article. However, unlike this study, Quint & Venditti (2023) have not found a significant influence of OPEC+ on the price of oil. The scientists explained this as a result of oil producers' deviations from the assigned quotas. In general, scientists found that the price of oil was lower by 6% than actual ones without reductions, caused by OPEC+.

Scientists touched on the theme of the issue of the "green" policy for the prices of energy in some works. Lee *et al.* (2021) found a dependence between the prices of oil and the index of green bonds in the USA. Rasheed *et al.* (2022) found that an increase in oil prices can stimulate a more rapid transition from renewable energy sources, which changes the demand structure. These issues were not covered in depth in the author's work, although their potential influence on prices from a long-term perspective. The received results may be used by governments to improve the efficiency of policymaking in the energy sector. The relationship found can be used for better forecasting the consequences of the actions of international partners and their consideration during the development of risk management strategies.

Conclusion

The study of factors of influence on prices of energy is important from the position of significant influence of price fluctuation on the well-being and competitiveness of national economies. Such factors can include global uncertainty, crises, conflicts, etc. International energy agreements can mitigate the destructive influence of negative events. In turn, such agreements also influence price formation, which may be beneficial or, on the contrary, it is unprofitable for different countries.

The results of the conducted study prove the significant role of international energy agreements in the formation of price bands. The significant influence of agreements between large oil exporters, controlling a significant share of the market on price formation, was proved by the example of the activity of OPEC and OPEC+. This is above all realised by establishing quotas for oil production.

The influence of OPEC and OPEC+ on the energy market is clearly observed in the course of the analysis of fluctuations in the price of crude oil. Periods of oil price increase are often accompanied by decisions of the organization on production reduction. The offer of the members of the OPEC was proved to significantly affect the prices of crude oil, spot prices, and prices of products, using correlation analysis. Herewith, the influence is more significant compared to the influence of the states outside the organization. Products such as Gasoline, Diesel, and Jet/Kero are the most vulnerable to changes in OPEC supply. Additionally, it is worth noting that not only official energy agreements, but also informal practices and arrangements significantly influence the formation of price bands. This was proved by the example of analysis of revenues of Russia from oil export, received regardless of current sanctions. Long-term consequences of the influence of international energy agreements on price bands shall be considered in further studies. Herewith, it is worth analysing whether OPEC+ will save its controlling positions with time. It will be also useful to study the influence of international "green" agreements, which can change fossil fuels demand structure, with long-term consequences.

The novelty of the work lies in the elimination of the existing scientific gap by conducting a thorough analysis of the impact of international energy agreements on pricing in the energy sector. In particular, the study considers these agreements as one of the determinants along with other geopolitical and economic factors, which allows for a more comprehensive understanding of the mechanisms of energy price formation, which emphasizes the importance of the study.

Credit Authorship Contribution Statement

Oksana Okhrimenko: Methodology, Providing Survey, Formal Analysis.
Ihor Samsin: Methodology, Providing the Survey, Data Curation.
Tetiana Zubko: Validation, Formal Analysis, Writing.
Elena Lytvynenko: Writing and Editing, Visualization.
Ihor Kiiakh: Conceptualization, Project administration, Writing and Supervision.

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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Investigation of Islamic Financing Institutions in Middle Eastern Banking

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Abstract: Islamic finance institution is becoming increasingly important for MENA countries to finance their growth economically. Businesses respect people's social and religious beliefs while meeting their economic necessities. Even little is known about the factors influencing Islamic banking's expansion. It offers a preliminary study of the relative significance of the major elements contributing to the expansion of Islamic banking in the area. By examining these banks' historical performance, we may use the financial crisis as an opportunity to analyze how Islamic banks contribute to the financial sector's resilience and inclusivity. The paper begins *(Nizam, Kamarudin, Ali, & Hussain, 2024)* with a brief background Islamic banking's development in the Sultanate of Oman, including how it connects to regional and foreign assets, liabilities, finance, and funding structures on the global Islamic financial markets, before examining Oman's current environment, examining the trends in the traditional financial sector and the rationale for adopting an Islamic financial system, as well as the long-term strategies the Sultanate of Oman has taken. Include how it might the layout achieve the objective, create jobs for local people

Keywords: islamic banking; operations; funding; management.

JEL Classification: G21; C01; G28; P43; Z12.

Introduction

Oman is a country in the Sultanate of Oman actively creating a legislative and governing framework ineluctable to Islamic "windows" for conventional banks with operating licenses within the nation. The Islamic finance sector has experienced significant growth since its commercialization in the 1970s. For many Muslim-majority countries that gained independence from colonial rule, developing a financial industry aligned with their faith and value systems provided a sense of identity. Various Islamic banks and tellers are currently being constructed and prepared for the public offerings (IPO). Imminent, Introducing the publish Client Alert a series of articles to introduce the fundamental ideas of Islamic banking and will continue to cover other Islamic finance topics of importance to companies in Oman. An overview of the basic assumptions and organizational principles that govern Islamic banking globally has been noted. Different products are available from each Islamic bank or teller that is targeted to that institution and its clients. The specifics of these issues change as the banks and windows build. Each Islamic bank or window has its own Shariah board, which guides the design and implementation of products and the conduct of banking operations. While relevant policies and regulations are underway, it has been projected that in Oman bank that follows Islamic principles and window will let you be free establish to assemblage of its

parts as Shariah council, to some minimum expected restrictions. For example, such restrictions comprise requirements on the number of academics in Shariah institutions (three or more are currently being debated), restrictions on the number of institutions in which one academic can sit (two or fewer) may be included. Both Omani Shariah scholars and internationally recognized scholars should be included in the committee. At present, it does not seem necessary for scholars to be from any Madahib (school of Islamic jurisprudence). Individual banks and windows are free to configure Sharia his body as you see fit. I also understand that there is no government-level central Shariah institution (such as the Central Bank of Oman's Shariah institution). They afford (a) Transactions involved in asset conversion, (b) payment system (c) Brokerage services, and (d) The risk conversion process. Matching supply and demand for financial assets and liabilities is necessary for wealth transformation (deposits, stocks, credit, loans, insurance, etc.). Changes in product and asset size, maturity, and location are considered transformational actions. Cheque remittance activities, electronic funds transfers, clearing operations, and clearing activities are the major components of payment management. Brokerage is the process of bringing together buyers and sellers of musical instruments. Driving demand and supply for intangibles and contingent with the scope of liability including goal to provide assurances of collateral free, expert analyst of financial knowledge, and safeguarding from the risk transformation. In hypothetical point of view, it has been observed that there are three widely used Islamic banking models known at the time (a) the two-tier Mudaraba model, (b) the two-window model, and (c) the Wakala model. It is crucial to mentally understand that the Islamic banking model contains accounts that can be deposited in two different ways before examining the other two models. For Islamic banks and tellers, these accounts provide as a source of funding. A depositor's funds are moved from their bank account to either a demand deposit account or an investment account. Savings deposits and time deposits are the two primary categories of sight deposits. Savings accounts allow depositors to make any number of deposits and withdrawals, while some institutions have a minimum balance requirement. In addition to these structures, there are other ways to save money through accounts that is qardhass an (interest free loan), wadi'ayadhamanah (guaranteed custody) and, less commonly, mudaraba. The Middle East has long been regarded as the birthplace of Islamic finance, where the principles of Sharia law govern financial transactions and institutions. Islamic finance, characterized by its prohibition of interest (Riba), speculative activities (Gharar), and unethical investments, has evolved significantly over the past few decades, transforming from a niche sector to a vital force in the global financial system. Islamic financial institutions (IFIs) in the Middle East not only serve the local economies but also play a pivotal role in shaping international Islamic financial markets. As these institutions grow in both size and influence, their importance in the broader banking sector becomes increasingly evident. The Middle East, with its rich cultural and religious heritage, has witnessed the establishment of some of the world’s largest and most prominent Islamic banks. Countries such as Saudi Arabia, the United Arab Emirates, Qatar, and Kuwait lead the region in Islamic finance, implementing innovative financial products and services designed to comply with Islamic principles while addressing the needs of modern economies. The growth of Islamic finance in the region is further fueled by governmental support, favourable regulatory frameworks, and a rising demand for Sharia-compliant financial services, both domestically and internationally. This shift towards Islamic banking is not only an economic trend but also a reflection of the region's desire to integrate traditional values with contemporary financial practices. Islamic financial institutions play a crucial role in fostering financial inclusion, supporting infrastructure development, and promoting ethical investments in areas such as real estate, healthcare, and energy. Additionally, they offer an alternative to the conventional financial systems, often attracting both Muslim and non-Muslim investors seeking ethical, stable, and risk-sharing investment opportunities. However, the landscape of Islamic banking in the Middle East is not without its challenges. Issues such as regulatory harmonization, liquidity management, and the adaptation of Islamic finance to global financial standards require ongoing attention and innovation. Understanding the operational models of Islamic financial institutions, the regulatory environments they navigate, and the socio-economic impact they create is essential to appreciating their significance in the regional banking sector. This investigation seeks to provide a comprehensive analysis of Islamic financing institutions within the Middle Eastern banking sector. By examining their structure, governance, regulatory frameworks, and contributions to economic development, this study aims to uncover the evolving dynamics of Islamic finance in the region. The research also explores how Islamic finance can respond to both regional and global financial challenges, offering valuable insights into its role in the future of Middle Eastern and global banking.

Islamic Bench Model 1: Two Tiered Mudaraba

The core model of Islamic banking is two-tier Mudarava model and investment deposits. Mudarava contracts are used on two very different sides of a financial institution’s balance sheetto consolidate assets and debts;

therefore, a deep understanding of them is essential as background. The investor or funder (depositor) and the bank are the parties to the first stage of his Mudaraba contract. The arrangement made by Mudaraba calls for banks and depositors to split profits made on the investments made with these monies. The Mudarava Secondary Agreement is tied to the two-stage mudarava model, where the raising of funds (first mudarava) and using of funds (second mudarava) are both based on share of profits and losses is agreed upon. A mudarava agreement is a partnership according to which (i) It may involve one or more individuals ("Rabbul-mal") provide capital and (ii) another working people ("mudarib") provides engage in services. Configure and define contract types. Yield like investment of money offered by rabbistimes. The Mudarib has entrusted these funds as just for the ascendancy and care of the depositor, rabbul-mal, thus the Islamic financial institutions requisite to do the best of its ability comply with the terms of the Mudarabha contract.

Models of Islamic Bench2: Two Windows

The two-window model uses both site and investment deposits. This model divides the liability side of a bank's balance sheet into (a) a demand deposit window and (b) a non-current account window. Demand deposits have no income as they are returned at face value when required. For the custodial services we offer in connection with your Demand Deposits, we can be paid a fee. In contrast to the Mudaraba model, reserve applied to demand deposits is hundred percent for regulatory reasons. Amanah Custodial Deposits do not give to use funds for further gains on a partial reserve basis. Such amounts are cumulative and subject to possible losses. Deposits held in investment accounts do not require a reserve requirement, since they do not have must affirmed.

Islamic Banking Model 3: Wakala (Agency)

The Islamic Financial Institutions Audit Authority ("AAIOFI") ("Standard 23"), § 2/1, defines Wakala as "an action that can be delegated". Banks participate in the Wakala model or agency model is a fixed fee and acts as an agent or wekel for the investor's payers and depositors. A typical Wakala-based deposit and investment model bank generally have wide discretion in investing their deposited funds (so long as the investment is Shariah compliant) and will notify depositors of profits and losses. Banks often keep profits above a certain yield as incentive fees. The depositor is liable for all transactional risks since they are the transaction's principle (muwakkeel). In general, deposit insurance is not permitted. There are a wide range of investment opportunities such as Mudaraba, Ijara (leasing), Istisna` (construction or mortgage lending), Murabaha (expenses and sales), Salam the agency models where the institution acts as a Waker. Investor's investment deposits on behalf of depositors. Bank generally have wide discretion in investing deposited funds (as long as the investment is Sharia law compliant) and will notify the bank. As an incentive, banks frequently keep profits that are higher than a specific rate of return. Except for risks related to fraud, harm, default, or agent carelessness, all transaction-related hazards fall under the purview of the depositor as principal (muwak keel).

Demand Deposits: Card Hassan and Wadia

The principal of the loan is guaranteed, and the bank is required to return it. There are no dividends or returns associated with deposits. However, banks are allowed, at their discretion, to offer depositors the return of deposits as a gift (hibih). A Wadia-based deposit structure is also used for savings and checking accounts. A storage bail is known as a Wadia (or ida-bale). The property being deposited must be owned, deliverable, and in a form of physicalpossession.

Necessitate Repository: Map Hassan and Wadia

The formation of saving by Qard-Hassan and checking accounts is AAIOFI Shari`a Standard no- 19, Loan, Qard, Default-19. According to the standard, a card is a transfer of ownership of fungible property to a recipient who is obligated to give it back. The Card-Hassan structure's purposes are to secure depositors' custody of their funds to give permission to use those funds for banking and entrepreneurship purposes. The deposit sum of money will be considering bona fide loan. Without the depositor's permission, banks are allowed to use money that has been left in their custody. The loan amount is guaranteed and the bank is committed to reimburse it. Deposits do not have any dividends or returns attached to them. However, the bank is free to provide the depositor a gift (hibih) in exchange for the return of their money. A Wadia-based deposit structure is used to savings and checking accounts. Escrowed property must be owned, transferable, and in the form of physical possession.

1. Review of Literature

In Oman, Islamic Bank was established in 2012. The final GCC nation to adopt Islamic banking is Oman. This is due to a lack of knowledge about the actual state and functioning of Islamic banks. This is due to a lack of knowledge regarding the management environment and operations of Islamic banks. The survey revealed

Salalah residents' knowledge and comprehension of Islamic banking practices. They were mostly Islamic bank customers. Client's religious obligations, Islamic baking understands. Product is the evaluated variable. Results: The results explain that although the perceived value of Islamic banking is high, the awareness of Islamic banking among Omanis is very low. Tough problems with Oman's banking system were also noted in the research, such as non-Muslims' resistance to embracing Islamic banking, pressure from traditional banking competitors, and a lack of understanding of Islamic banking. They people are mostly Islamic bank customers. Client's Religious Obligations is Islamic Banking's Understanding. Almost all customers accept that any interest in Islam is forbidden, but most Islamic banks believe they are not Shariah compliant. According to this finding, religious devotion and public perception of Islamic banking are the key driving forces behind Islamic banking. Islamic law is founded on Shariah, and Islamic banking is a form of Islamic finance. They offer financial services in accordance with Islamic Shariah guidelines. Islamic banking's primary characteristic is its interest-free nature. The predominantly Muslim community prefers to use Islamic banking services and products. Islamic banking is not particularly advanced now, but it is anticipated that due to its effectiveness, it would soon appeal to a huge number of people. This study analyzes the contribution of Islamic finance to economic growth across 15 countries with significant Islamic banking sectors, highlighting its positive impact and inherent stability (Hanif *et al.* 2024). This introduction makes no inference or claim that any Oman-based licensed Islamic bank or teller will accept or use any specific arrangement or item mentioned in the Client Alert (Nizam, Kamarudin, Ali, & Hussain, 2024). The Institutional Development of Islamic Finance in the Middle East: A Post-Colonial Comparative Perspective." Business History. This research traces the evolution of Islamic finance governance models in Bahrain, Kuwait, and the UAE, emphasizing the shift from decentralized to centralized systems post-independence. (G. Rammal *et al.* 2023). This paper discusses how asset-backed Islamic finance structures can mobilize financial resources to boost investment in the Middle East, aligning with sustainable development goals. A., Salhaoui, S., Argabi, A., & Khater, T. (2024). Another study by Moustapha and Nadir (2023) examined the impact of Islamic financing products on the profitability of Islamic banks, focusing on Al Rayan Bank in Qatar. The research analyzed various Islamic financing products and their contributions to the bank's profitability, providing insights into the operational dynamics of Islamic banks in the Middle East (Moustapha & Nadir, 2023). Rabbani and Khan (2020) explored the use of Islamic fintech in the banking sector, focusing on challenges and regulations in compliance with Sharia. After studying 133 articles, it is believed that fintech can enhance efficiency, transparency, and customer satisfaction in Islamic finance and also global cumulative fintech market is expected to reach 1.5 billion in the next three to five years. Hassan, Sanchez and Yu (2011) examined the challenges faced by Islamic finance and banking in the post-Covid era, focusing on Fintech's role. Islamic financing dominates microfinance, small and medium enterprises, and retail banking. The global financial crisis posts Covid 19 differed from 2008, with measures like lockdowns causing a decline in output, supply chain disruptions, income loss, and credit flow disruptions. Herliansyah, Nugroho, Ardilla and Putra (2020) examined the impact of religion on decision-making and the presence of Islamic banks, which are crucial for the national economy, as they facilitate payment processing and provide dependable savings. Sonko (2020) used descriptive statistics and logistic regression to assess customers' perceptions of Islamic banks in The Gambia. Surveying 150 customers at four standard banks and one Islamic bank, the study assessed their religious observance, understanding of Islam, and familiarity with Islamic banking. Results showed that Islamic banking customers had a better understanding of Islamic banking than traditional banking customers. Akguc and Rahahleh (2018) examined risk management in Islamic banking and finance literature, focusing on the association between risk and Islamic and conventional banks. It highlights that sharia-based products in Islamic banks lack risk mitigation, as both serve as intermediaries between borrowers and lenders, offering investment opportunities. Comparative analysis is necessary to understand the impact of risk types. Khattak *et al.* (2010) stated that The Islamic banking sector comprises two fully fledged Islamic banks and Islamic windows at six traditional domestic banks, resulting in a significant increase in bank lending in the Sultanate. Abdul-Wahab*et al.* (2019) explored Islamic banking practices in Ghana, their adoption, challenges, and perceived importance. It uses a targeted survey with eight respondents and semi-structured interviews to gather data. The research also explores the understanding and perceived importance of Islamic banking in the region. Salman and Nawaz (2018) examined the efficiency of banks in their operations in South East Asia, specifically Malaysia, Indonesia, and Brunei. The authors analyzed 29 Islamic banks to identify any deviations or variations in their performance. The majority of the countries chosen had a predominantly Muslim population, and the study aimed to identify any deviations or variations in the efficiency levels of these banks. Komijani and Taghizadeh- Hesary (2018) gave their comment on the reflection of Islamic bank functioning. It is opinioned that over two decades' Islamic finance industry has grown substantially due to increase in the rapid growth of Muslim population and improvement in their standard of living which is an alternative to the

conventional financing mechanism. It is also observed that the investors in Middle East countries seek to invest in those financial products which are in accordance with their religious beliefs. The funding is substantial because of huge liquidity from oil and oil products. In Islamic countries most of the conscious investors exclude their investment in alcohol and gambling. Nadarajan, Selvanathan and Zamri (2018) explained the factors influencing customers' decisions regarding Islamic banking using questionnaires in Selangor. It reveals that choosing an Islamic bank balances reliability and cost benefits, with convenience being less important, and religion negatively impacting the decision. Khan and Khan (2015) report a rapid growth in Islamic banking in Malaysia and Pakistan, both Muslim nations adhering to Islamic law. The study compares these two countries, highlighting the flourishing of Islamic banking in Malaysia, compared to Pakistan, and the performance of Islamic banks in fulfilling their duties. Miah and Suzuki (2020) stated that the Islamic Economic Bank is committed to promoting economic growth, job creation, wealth accumulation, cultural justice, equitable income distribution, long-term capital gains, investment mobilization, competitive returns, and top-notch customer service. However, their efforts may be hindered by ignorance of Islamic banking policies and practices, which contribute to the overall economic growth. Bahrini (2017) evaluated the E-banking efficiency of Islamic banks in the Middle East and South Africa between 2007 and 2012 using the DEA approach. The results showed stable efficiency during the 2007-08 global financial crisis and a post-crisis period, prompting Islamic bank managers to conduct post-crisis analysis. Obeid and Kaabachi (2016) attempted to explain the main antecedents that will bring acceptance of Islamic banking by traditional users of banking in Tunisia. This was a research questionnaire completed by 239 Tunisians. The findings of this study suggest the determinants that aegis to adopt Islamic banking include religious preferences, customer perceptions of it, its relative accessibility, and its compatibility with market ideals, way of life, and financial sector customs is the findings also reveal that Tunisian customers lack understanding and familiarity with the financial system. Rahman *et al.* (2023) surveyed consumers about Islamic banking, finding that most believe interest is forbidden and it's distinct from conventional banking. 69% of respondents were moderate Muslims. Despite Omani Banks' financial services being enjoyable, consumers believe they only barely comply with Shariah, leading them to desire better performance than current offerings. These studies collectively provide a comprehensive understanding of the development, operational dynamics, and impact of Islamic financing institutions in Middle Eastern banking, highlighting the sector's evolution, profitability factors, and resilience in the face of economic challenges.

1.1. Research Methodology

The study is based on the financial units in the Sultanate of Oman. The financial bodies are divided in to two broad categories – (1) Conventional Banking and (2) Islamic Banking. The period of study is 5 years from 2017 to 2021.The main focus of the research is contribution of the banking system not only in the economic development of the country but also focuses on the operational efficiencies of the banking industry. The total population of banks available in Oman is taken as a sample size and three main variables are taken in to consideration to measure three important aspects of the banking industry (Kashi, Laallam, Nomran, Abumughli, & Al-Binali, 2024). They are: (1) Profitability, (2) Efficiency (Yin, 2021) and (3) Liquidity. The following equation serves as the foundation for the statistical model that forecasts the variations in financial performance (Nizam, Ng, Dewandaru, Nagayev, & Nkoba, 2019) between conventional and Islamic banks with relation to cash deposits. The following variables are selected as independent variables for this study:

1) ROAib = Return on Assets of Islamic banks
2) ROE ib = Return on Equity of Islamic banks
3) RODib = Return on Deposits of Islamic banks
4) OPMib = Operational Profit Margin of Islamic banks
5) OIAib = Operating Income to Assets of Islamic banks
6) ATOib = Asset Turnover of Islamic banks
7) CTAib = Cash To Assets of Islamic banks
8) ROAcb = Return on Assets of Conventional banks
9) ROEcb = Return on Equity of Conventional banks
10) RODcb = Return on Deposits of Conventional banks
11) OPMcb = Operational Profit Margin of Conventional banks
12) OIAcb = Operating Income to Assets of Conventional banks
13) ATOcb = Asset Turnover of Conventional banks
14) CTAcb = Cash To Assets of Conventional banks

Dependent variables

CTDib = Cash to Deposits of Islamic banks
CTDcb = Cash to Deposits of Conventional banks

Problem statement

There have been a number of studies and articles published by researchers indicating Islamic banks (Ibrahim & Rizvi, 2017) seem to be more efficient and profitable than traditional banks in the Sultanate of Oman. So, the present study will focus on an empirical study to find out the conventional philosophy of thinking in the debate and to judge it through variable testing and data analysis about the ground reality.

Hypothesis

Ho = There is a cogent influence on the opiate banks in terms of customer trust.
H1 = There is no cogent influence on outcome of both the banks in terms of customer trust.
Financial Ratios
Liquidity ratios and Profitability, Efficiency of two types of banks is calculated and then compared.
ROA = Net profit after tax plus interest expenses / Average TA
ROE = NI / Average common equity of stockholders'
ROD = NI / Total customer deposits
OPA = Operating income / Total assets
ATO = Asset Turnover = Revenue / TA
CTA = Cash to Assets = Cash / TA
CTD = Cash to Deposits = Cash / Total customer deposits

Population and Sample

The total population of banking industry available in Sultanate of Oman during the study period is taken as the population of the study including both the categories of banks. The data collected is the secondary source and information obtains from published annual reports in the website of Muscat Securities Market (MSM).

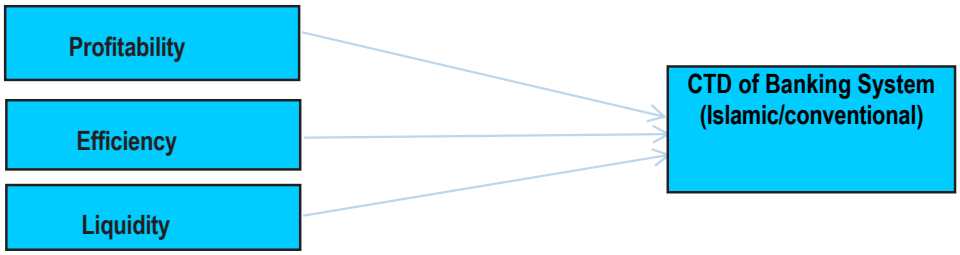
Tools and Technologies

R software is used, and panel data analysis to find out the results.

1.2. Data Analysis

The study to the sample banks includes the characteristics of the respondents as a key component (Fig.1). Panel data analysis was done to confirm typical sample observations of Islamic banks and conventional banks. The outcomes present that all the variables have shown positive performance of growth and if there is any decline it is marginal to its performance.

Figure 1. Financial Ratio of Conventional Banks and Islamic Banks



Source: compiled by the authors.

As the data is panel data, panel regression is adoptable to know which variables significantly contribute on capital term deposit account (CTD). Initially, Random Effects model and Fixed Effects model are used to find the best fit model for the data. Analysis has used PLM package.

Table: 1

Year	Banks	ROA	ROE	ROD	OPA	ATO	CTA	CTD
2017	Ahli Bank	3.36	10.71	1.84	2.87	4.61	0.36	0.49
2018	Ahli Bank	3.50	11.29	1.73	2.89	5.02	0.41	0.53
2019	Ahli Bank	3.82	11.92	1.81	2.9	5.18	0.63	0.88
2020	Ahli Bank	3.36	9.05	1.25	2.74	5.03	0.56	0.76
2021	Ahli Bank	3.24	9.73	1.27	2.86	4.91	0.63	0.83
2017	Alizz Islamic Bank	5.19	15.53	3.43	0.5	4.45	0.93	1.23
2018	Alizz Islamic Bank	5.66	24.32	4.2	5.37	4.93	0.87	1.2
2019	Alizz Islamic Bank	5.48	25.68	3.4	0.54	4.89	0.87	1.28
2020	Alizz Islamic Bank	5.34	24.11	7.87	2.36	4.72	1.1	1.62
2021	Alizz Islamic Bank	5.63	24.34	9.2	2.77	4.83	0.74	1.27
2017	Bank Dhofar	3.04	8.5	1.55	3.1	4.4	0.73	0.98
2018	Bank Dhofar	3.21	7.82	1.72	3.17	4.64	0.74	1.07
2019	Bank Dhofar	2.71	4.37	1.03	3.04	4.88	0.73	1.06
2020	Bank Dhofar	2.64	4.43	1.07	3.03	4.78	0.68	1.02
2021	Bank Dhofar	2.66	3.6	0.84	2.91	4.75	0.69	1.01
2017	Bank Muscat	2.72	10.51	2.38	3.97	3.86	1.67	2.47
2018	Bank Muscat	2.76	9.59	2.12	3.81	4.09	1.33	1.85
2019	Bank Muscat	1.07	9.44	2.6	4.01	4.59	1.41	2.33
2020	Bank Muscat	2.48	8.07	1.95	3.69	4.1	1.33	1.96
2021	Bank Muscat	2.61	9.04	2.16	3.73	4.09	1.3	2.14
2017	Bank Nizwa (islamic)	0.62	2.52	1.27	3.69	6.32	0.87	1.77
2018	Bank Nizwa (islamic)	0.96	5.01	1.93	2.82	6.63	0.66	1.32
2019	Bank Nizwa (islamic)	1.07	6.79	2.09	3.46	6.5	0.5	0.97
2020	Bank Nizwa (islamic)	0.99	7.38	1.98	3.5	6.25	0.49	0.97
2021	Bank Nizwa (islamic)	0.96	6.77	5.87	3.4	6.17	0.55	3.35
2017	NBO	2.81	10.22	1.79	3.77	5.43	1.47	2.09
2018	NBO	3.23	12.02	2.06	3.66	5.55	1.62	2.33
2019	NBO	3.45	11.78	2.03	3.56	5.7	1.22	1.73
2020	NBO	2.6	4.38	0.72	3.22	5.45	1.07	1.54
2021	NBO	2.82	6.88	1.04	3.2	5.37	1.06	1.4
2017	Oman Arab Bank	2.81	9.63	1.52	3.7	5.24	1.87	2.25
2018	Oman Arab Bank	2.87	10.6	1.61	3.92	5.45	1.8	2.15
2019	Oman Arab Bank	3.07	10.99	1.63	3.85	5.58	1.76	2.13
2020	Oman Arab Bank	2.14	3.95	0.51	3.52	5.18	1.38	1.45
2021	Oman Arab Bank	1.72	1.2	0.25	3.61	5.12	0.99	1.16
2017	Sohar Intl. Bank	3.24	8.63	1.54	2.85	5.15	0.63	1.03
2018	Sohar Intl. Bank	3.5	10.29	1.61	3.21	5.71	1.33	1.29

Year	Banks	ROA	ROE	ROD	OPA	ATO	CTA	CTD
2019	**Sohar Intl. Bank**	3.39	10.24	1.64	3.19	5.53	0.82	1.29
2020	**Sohar Intl. Bank**	2.67	6.03	0.9	2.59	4.69	0.82	1.31
2021	**Sohar Intl. Bank**	2.55	7.15	1.18	2.86	4.68	0.89	1.44

PLM (CTD~ROA+ROE+ROD+OPA+ATO+CTA, data=dt, model='within', index=c('Banks','Year'))

Model- 1 PLM

One-way (individual) effect Within Model

Call: plm (formula = CTD ~ ROA + ROE + ROD + OPA + ATO + CTA, data = dt,
model = "within", index = c("Banks", "Year"))

Balanced Panel: n = 8, T = 5, N = 40

Table: 2

Residuals:				
Min.	1st. Qu	Median	3rd Qu	Max.
-0.544389	-0.1127344	0.0046344	0.0988804	1.165599
	Coefficients:	Estimated Std. Error	t-value	Pr(>|t|)
ROA	0.1653154	0.1860105	-0.8887	0.3822904
ROE	0.0027873	0.0332219	0.0839	0.9337793
ROD	0.1893268	0.0529538	3.5753	0.0014001
OPA	-0.0306164	0.0829727	-0.369	0.7151202
ATO	-0.2897063	0.2512715	-1.153	0.2594165
CTA	1.1575	0.3096853	3.7377	0.0009231
Significance codes	0.001	0.01	0.05	0.1

Total Sum of Squares: 6.0905, Residual Sum of Squares: 2.6492, R-Squared: 0.56503

Adj. R-Squared: 0.34755F-statistic: 5.62905 on 6 and 26 DF, p-value: 0.00074612

Model- 2PLM (CTD~ROA+ROE+ROD+OPA+ATO+CTA, Data=dt, model='random', index=c('Banks','Year'))> summary(model2)

Onaway (individual) effect Random Effect Model
(Swamy-Arora's transformation)

Call: PLM(formula = CTD ~ ROA + ROE + ROD + OPA + ATO + CTA, data = dt,
model = "random", index = c ("Banks", "Year"))

Balanced Panel: n = 8, T = 5, N = 40

Effects: varstd.dev share

Table: 3

Idio Syncratic	0.10189	0.31921	0.715
Individual	0.04071	0.20177	0.285

Theta: 0.4224

Residuals: In. 1st Qu. Median 3rd Qu. Max.
-0.5443890 -0.11273440.0046344 0.0988804 1.1655986

Table: 4

	Coefficients:	Estimated Std. Error	t-value	Pr(>|t|)
ROA	**-0.2570004**	**0.1159497**	**-2.2165**	**0.02666**
ROE	-0.0032821	0.0262482	-0.125	0.90049
ROD	**0.1932321**	**0.0467996**	4.1289	**3.645e**
OPA	-0.0279169	0.0710261	-0.3931	0.69428
ATO	-0.0625343	0.1240044	-0.5043	0.61406
CTA	**1.113845**	**0.180057**	**6.1861**	**6.168e**
Significance codes	0	0.001	0.01	0.05

Coefficients: Estimate Std. Error z-value Pr (>|z|)
(Intercept) 1.1543015 0.7938526 1.4541 0.14593
Total Sum of Squares: 8.7709
Residual Sum of Squares: 2.91
R-Squared: 0.66823
Adj. R-Squared: 0.6079
Chisq: 66.4657 on 6 DF, **p-value: 2.1647e-12**
PH Test (Model- 1, Model- 2)
Hausman Test
Data: CTD ~ ROA + ROE + ROD + OPA + ATO + CTA
Chi Sq = 1.4883, df = 6, p-value = 0.9603

A model that is inconsistent is an alternative hypothesis considering the above analysis; it is evident that the random effects model better fits the data as R2 and Adjusted R2 are 60.79% and 66.823% respectively. Considering Adjusted R2 being Panel Regression, about 60.79% of variance in Variables that depend on independent variables explain variables that depend on dependent variables. From the random effects model, the variables namely ROA, ROD, CTA are major significant contributors to CTD. The ratios selected for the study justify the model of the study because all the ratios have shown a positive relationship as an independent variable having a good response to the dependent variable *i.e.* cash to deposit ratio. Since the banks in Oman must operate on certain principles of Islamic principles with conditions of rules and regulations banks have strictly followed the instructions given by the Government of the country and central bank of Oman. Independent variables which proved to be very effective namely ROA+ROE+ROD+OPA+ATO+CTA

The dependent Variable selected for the study was CT. Before conducting a panel data technique for the study, fixed and random effect of the model was conducted and in both the tests the results were good and responsive. Fixed effect model has shown that impact of independent variables on dependent variables was excellent because the percentage is above 60% which shows that banking industry in Oman are working efficiently, and it has justified significant at 0.5% level and 1% level of significance. The most significant results have been seen in the case of independent variables, namely ROA, ROD & CTA.

2. Findings of Research

It is evident from the positive response of the contribution of above ratios because return on assets is very positive and contributing to the growth of the economy and it means deposits are used for the development of infrastructure and industries in the country which not only signifies good indication of economic growth of the country but also helps in controlling inflation and enhances sound purchasing power of the people. Return on deposits reflects efficiency in the mobilization of the deposits of the banks but also gives good returns to the depositors which enhance the economic well-being of the bank customers and the people. The third most effective variable clearly indicates that the proportion of investment to the cash and deposits is being done in a sensible manner with the intention of development of different sectors of the country but also confidence of the banks in the process of investment.

Conclusion

Present empirically study of bank performance and difference between Islamic and conventional banking based on their customer deposits. Data from conventional and Islamic banks' annual reports is used as secondary data. There is a large amount of data available on the official banks' websites. The liquidity ratios, profitability and efficiency of the two categories of banks are analyzed in detail. Analysis of the data confirms alternate hypotheses that Islamic and conventional banking are performing at their best. Still, the majority of the performance measures for the combined banking system show a positive trend. In this way, we can see the combined banking industry growing and better performance. The future of banking seems brighter. There are certain financial ratios that can be analyzed in order to determine how banking strategies will fare. It would have been more powerful to analyze Oman's financial ratios using a larger sample and advanced statistical tools. Islamic financial institutions (IFIs) play a crucial role in the economic development of the Middle East by providing financial services that align with Islamic principles, such as risk-sharing and ethical investments. These institutions contribute to the growth of various sectors, including infrastructure, healthcare, real estate, and energy. The unique operational model of IFIs, grounded in Sharia law, differentiates them from conventional banks. Their focus on prohibiting interest (Riba), excessive speculation (Gharar), and unethical investments fosters a financial system that emphasizes fairness, social responsibility, and stability. Governments in the Middle

East have played a pivotal role in fostering the growth of Islamic finance by establishing favorable regulatory frameworks, promoting Sharia-compliant products, and ensuring alignment with international financial standards. Such support has allowed IFIs to grow rapidly and become an integral part of the region's financial ecosystem. The growth of Islamic finance in the Middle East has had a significant global impact. The region's IFIs are now playing a key role in global financial markets, attracting international investors seeking ethical and stable investment opportunities. This has positioned the Middle East as a global hub for Islamic finance. Despite their success, Islamic financial institutions face several challenges, including regulatory harmonization, managing liquidity, and adapting to international financial regulations. However, these challenges also present opportunities for innovation and growth as IFIs continue to evolve and develop new financial products and services that meet the demands of a globalized economy. IFIs have the potential to contribute significantly to financial inclusion in the Middle East by offering banking services to unbanked populations, particularly in regions with a high proportion of Muslim populations who prefer Sharia-compliant financial services.

Future Prospects

The future of Islamic finance in the Middle East looks promising, with the continued growth of both Islamic financial products and institutions. As the global demand for ethical finance and sustainable investments rises, the region's IFIs are well-positioned to expand their influence and contribute to the development of a more inclusive and socially responsible global financial system. Islamic financing institutions in the Middle East provide an alternative to conventional banking systems, offering stability, risk-sharing, and ethical investments. Their contributions to regional economic growth, along with their role in fostering financial inclusion, make them an essential component of the Middle Eastern banking sector and a model for other regions seeking to implement similar financial systems.

Credit Authorship Contribution Statement

Gaurav Kumar: Conceptualization; Software, Data curation, Investigation; Writing - original draft; Visualization.
A.V.N. Murty: Validation, Supervision, Methodology, review and editing.
M.V.K. Srinivasa Rao: Formal analysis

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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Factors Affecting Firm Performance of Vietnamese Export-Import Enterprises: A PLS-SEM Approach

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Abstract: Firm performance improvement is a top priority for export-import businesses. In order to assess corporate social responsibility, this study uses partial least squares structural equation modelling (PLS-SEM) to examine how logistics capabilities and business value mediate the firm performance of import-export businesses in Vietnam. Data is collected through convenient sampling. Samples include 427 respondents who are currently working in Vietnamese import-export companies. The questionnaire survey is distributed to respondents via the Google Form link. SmartPLS software 4.0 is used to process the data. The findings indicated that 05 factors, which are social responsibility, supply chain management, logistical capabilities, and commercial value, impact the companies' performance. Besides, the Brand image also serves as a mediating variable. This study empirically examined the results of earlier research and evaluated the relationship between variables in the research model. Practical Implications for the management of export-import companies are suggested. Additionally, the research limitations and future directions are proposed.

Keywords: business value; corporate social responsibility; export-import enterprise; firm performance; logistics capabilities.

JEL Classification: F18; C01; F23; M16; M14.

Introduction

Ensuring robust performance is a primary concern for managers in import-export enterprises within a tough economic landscape. Logistical competencies and corporate social responsibility are very vital. The operational efficiency of a business is fundamental to production continuity and growth. As economies become increasingly integrated, optimising operational efficiency is essential for all businesses. The principles of social responsibility significantly impact the global economic system and society (Baric, 2018). This concept has evolved over history and is now integral to modern corporations and companies' strategies and business models. It is argued that the importance of social responsibility will continue to grow amidst changes in the global economy, culture, and society (Taneja *et al.* 2011).

Many for-profit and nonprofit enterprises strive to positively impact internal and external stakeholders and build the company's reputation by engaging in social responsibility activitie (Tata & Prasad, 2015). In Vietnam, we are implementing commitments in trade agreements, focusing on liberalising various sectors, especially import and export (Abbott *et al.* 2009). Fulfilling social responsibility is closely linked to the country's overall sustainable development. Therefore, practising social responsibility is critical for achieving business efficiency, the foundation for business expansion (Thu *et al.* 2021). Moreover, logistics is the backbone of any company (Aziz *et al.* 2020). Logistics addresses transportation, goods and services-related challenges (Pascucci, 2021), helping reduce costs and improve competitiveness.

Thus, logistics capabilities can enhance overall operational efficiency (Wong *et al.* 2015). Zhao *et al.* (2001) assert that logistics capability is crucial for increasing customer expectations, customer loyalty, market efficiency, and financial performance. Carter (2005) examines how corporate social responsibility and supply chains affect business performance, with brand image as a mediating factor. Building upon this suggestion, the authors continue to inherit and develop the factor of logistics capability. Additionally, this study aims to evaluate the mediating role of business value in the relationship between social responsibility and firm performance. From the research results, the authors report the evaluation of the research model, propose managerial implications and point out the research's limitations.

1. Literature Review

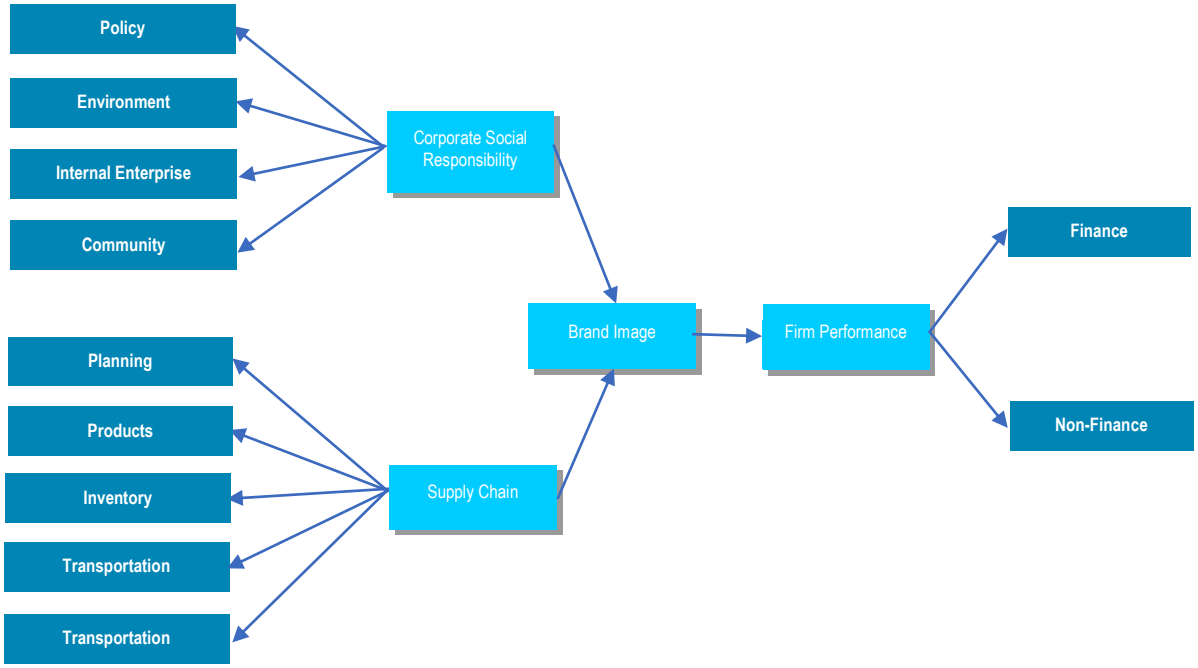
Wang *et al* (2024) state that Corporate social responsibility refers to the policies and strategies that businesses adopt to take actions that positively impact and contribute to the values and goals of society. According to Thu *et al.* (2021), social responsibility involves voluntarily fulfilling business ethics commitments of enterprises towards stakeholders such as employees, suppliers, customers, investors, the community, and the environment to enhance firm performance and contribute to social welfare.

Nowadays, many studies support the implementation of social responsibility to address some social and environmental issues (Le Thanh & Tham Duc, 2023). Social responsibility will help businesses achieve business value and improve operational efficiency (Thu *et al.* 2021). Various dimensions of business value have been studied from different perspectives, including the impact of social responsibility on customer attitudes, employee loyalty, customer satisfaction(Wei *et al.* 2020), and government trust (Thu *et al.* 2021; Wei *et al.* 2020). Brand image refers to the thoughts, beliefs, and perceptions that customers associate with a company (Cretu & Brodie, 2007; Keller, 1993). For example, a company's brand image is built upon various elements such as awareness, trust, and reasons customers remember about the company or its products (Martenson, 2007). Brand image mediates customers' decision-making when choosing import-export companies (Cretu & Brodie, 2007). Businesses can enhance their brand image through brand promotion, organising socially responsible events, participating in charitable activities, and assisting vulnerable groups. Many companies have their own logistics capabilities because they have the potential to manage logistics as part of their core business activities (Aziz *et al.* 2020).

According to Fawcett & Fawcett (1995), the following qualities are required for effective operational performance worldwide: delivery speed, service quality, flexibility, cost, and innovation. Çakır & Adiguzel (2022) define logistics competence as all assets, capacities, organisational procedures, business features, and company expertise. Logistics capabilities are defined as the internal skills and expertise within an enterprise to manage logistics activities such as transportation (Mandal *et al.* 2017; Odunjo, 2020; Shraah *et al.* 2022), warehousing and handling procedures (Al-Madi *et al.* 2021), sourcing of materials (Sazzadur & Khan, 2019), and customs procedures (Odunjo, 2020). Strong logistics capabilities help companies save time, costs, and human resources.

It (2022) investigated the effect of corporate social responsibility and supply chain on firm performance in agricultural enterprises in the Mekong Delta region, using brand image as a mediating factor. The variables included corporate social responsibility, supply chain, brand image, and firm performance. Among these, the mediating role of brand image had the most substantial impact on firm performance.

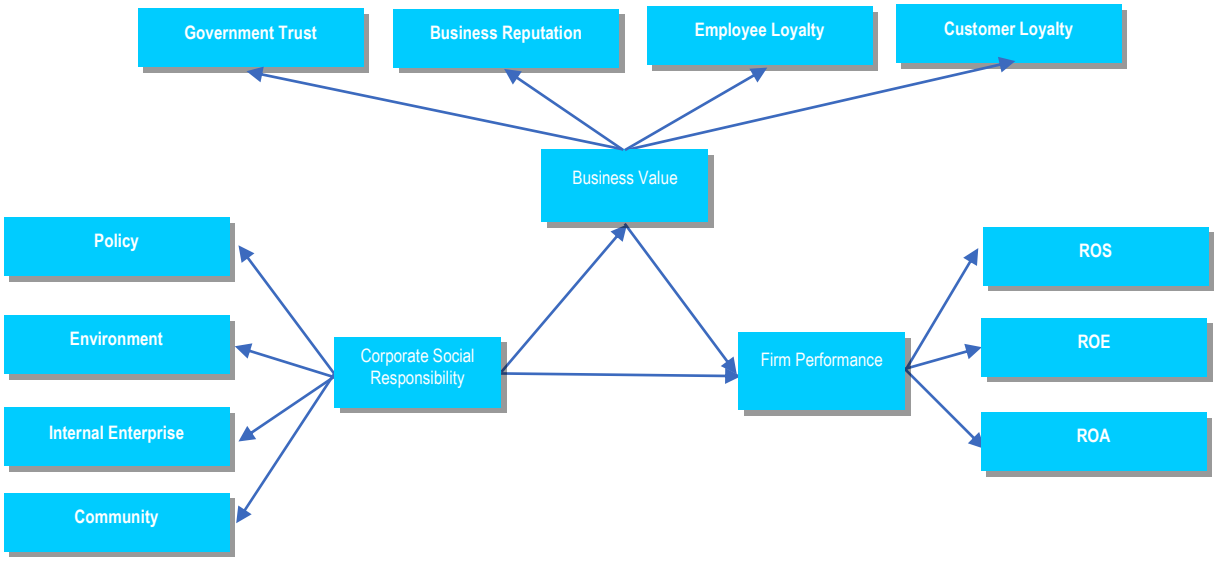
Figure 1. Proposed research model by It (2022)



Source: It (2022)

Nguyen *et al.* (2021) demonstrated that social responsibility has both direct and indirect positive impacts on firm performance. The study was based on 315 observations with survey participants, including directors, deputy directors, human resources managers, and CSR managers from seafood exporting companies. According to reports, CSR directly impacts company performance and indirectly positively impacts business value characteristics such as employee loyalty, consumer loyalty, corporate reputation, and government trust.

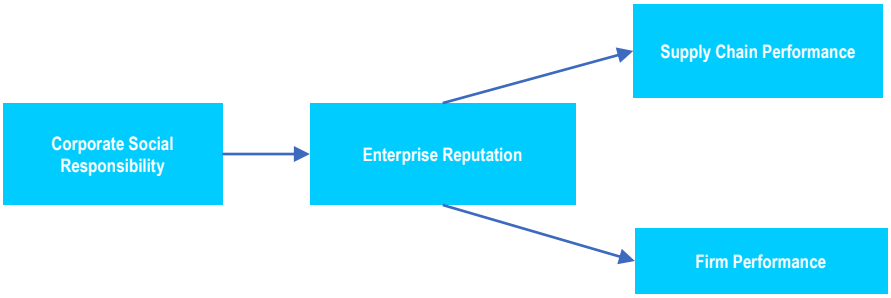
Figure 2. Proposed research model by Nguyen (2021)



Source: Nguyen (2021)

Based on 507 observations from businesses in Vietnam's food, seafood, and textile industries, Nguyen and Phan's (2021) study on the impact of CSR on the supply chain demonstrates that corporate reputation fully mediates the relationship between CSR and supply chain performance. Corporate social responsibility enhances both a business's reputation and its performance.

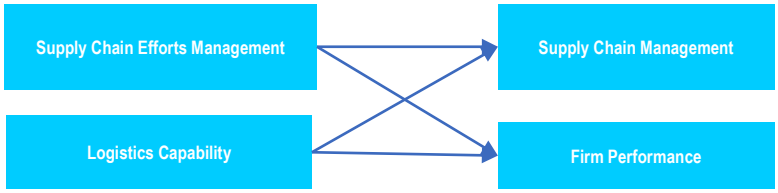
Figure 3. Proposed research model by Nguyen and Phan (2021)



Source: Nguyen and Phan (2021)

A nationwide survey of supply chain professionals in manufacturing companies was conducted in India to investigate the conceptual model empirically (Sezhiyan *et al.* 2011). The SEM analysis results found that the ability to manage supply chain efforts and logistics positively influenced the supply chain management (SCM) strategy. The company's overall performance was positively linked with SCM strategy, supply chain effort management, and logistics capability.

Figure 4. Proposed research model by Sezhiyan *et al.* (2011)



Source: Sezhiyan *et al.* (2011)

Aziz (2020) examined how logistics capability affected firm performance, why outsourcing would be necessary, and how companies might benefit if they outsourced services instead of establishing logistics capability. The study's findings indicated that logistics capability positively impacted the operational efficiency of manufacturing companies in Pakistan and influenced the decision to outsource logistics services. On the other hand, the study showed that outsourcing logistics services did not significantly impact manufacturing companies in Pakistan.

Figure 5. Proposed research model by Aziz *et al.* (2020)

Source: Aziz *et al.* (2020)

Supply chain management, evaluated through planning, production, and inventory management (Ray R. Venkataraman & Jeffrey K. Pinto, 2023), is conducted rigorously and scientifically. It enhances brand reputation among customers and partners (Ramos *et al.* 2022). Another study describes supply chain management as encompassing demand planning, sourcing, production, inventory management, transportation, and product tracking to drive future sales and maximise profits (Jaswanth *et al.* 2023). According to Khatri *et al.* (2024), building an effective brand relies on sustainable and tightly integrated supply chain practices. A well-organised supply chain establishes a company's market position and, most importantly, influences customer perception. The research by Nguyen *et al.* (2021) also confirms the positive impact of supply chain management on brand image, consistent with findings by Sezhiyan *et al.* (2011) and Tukamuhabwa *et al.* (2023). The supply chain forms the foundation for any business's success (Nureen *et al.* 2023). It involves delivering goods and services to add value for consumers and manage the supply chain efficiently (Khatri *et al.* 2024; Ramos *et al.* 2022; Waiyawuththanapoom *et al.* 2023). Numerous studies have demonstrated the relationship between supply chain management and firm performance. The research by Sufyati *et al.* (2022) shows that supply chain management positively impacts firm performance (Sezhiyan *et al.* 2011), in line with results found by Nguyen *et al.* (2021) and Waiyawuththanapoom *et al.* (2023). Based on these findings, the author proposes the following hypotheses:

H1: Supply chain management positively affects firm performance.

H4: Supply chain management positively affects brand image.

Siddiq & Javed (2014) found a positive relationship between social responsibility and firm performance. Corporate social responsibility is linked to profitability and contributes to employee commitment and customer loyalty (Mitra, 2021). It encompasses voluntary activities undertaken by import-export businesses to improve environmental quality and address social issues (Tiep, 2023). Meaningful business activities also enhance competitive advantage (Duong, 2024; Vu *et al.* 2022). Furthermore, social responsibility activities help improve market share and company profits (Lu, Ren, Zhang, Liang, *et al.* 2020; Lu, Ren *et al.* 2020; Yoon & Chung, 2018). A well-executed CSR strategy by an import-export business leads to higher financial capacity, customer trust, and employee engagement. Therefore, the author proposes:

H2: Corporate social responsibility positively affects firm performance.

Logistics capability is one of the critical competencies of import-export businesses, directly influencing their business model and strategy (Shraah *et al.* 2022). Regarding firm performance, the ability to organise logistics operations within a company significantly reduces costs and increases profits. Pisano & Hayes (1994) argue that a company's logistics capabilities are essential for exceeding customer expectations and improving market and financial performance. Many researchers, including Aziz *et al.* (2020); Karagöz & Akgün (2015); Sezhiyan *et al.* (2011); Shraah *et al.* (2022); Yuan *et al.* (2020), have emphasised that logistics capability positively impacts firm performance (Karagöz & Akgün, 2015), contributing significantly to achieving superior operational efficiency and sustainable competitive advantage over competitors (Cho & Ozment, 2005; Joong-Kun Cho *et al.* 2008; Karagöz & Akgün, 2015; Shraah *et al.* 2022). Therefore, the author proposes the hypothesis:

H3: Logistics capability positively impacts firm performance.

Brand image is a critical factor influencing how customers, partners, and relevant suppliers perceive a business (Tiep, 2023). These parties' purchasing behaviour or contract decisions are influenced by the company's reputation, which is affected by social responsibility activities (Nguyen *et al.* 2021). Social responsibility positively impacts a company's image and reputation (Lu, Ren *et al.* 2020). Recent studies indicate that customers participating in charity initiatives organised by businesses also enhance the company's image (Lu, Ren *et al.* 2020). Therefore, businesses should proactively engage in social responsibility activities to foster customer awareness and improve the brand image (Dawood, 2019). Implementing such activities enhances brand image and positively affects overall firm performance (Singh & Verma, 2017). Brand image enables businesses to fulfil social responsibility and increase firm performance (Nguyen *et al.* 2023). Based on these findings, the authors propose:

H5: Social responsibility positively impacts the brand image of import-export businesses in Vietnam.

H7: Brand image positively impacts firm performance.

Business value encompasses government trust, employee loyalty, and customer loyalty. Social responsibility can enhance employees' commitment to the company, and they work harder when the business fulfils its social responsibilities (Kim *et al.* 2010). Corporate social responsibility (CSR) is crucial in collaboratively improving environmental and community issues alongside the government and local authorities (Wirba, 2023). Implementing CSR is believed to help businesses gain trust from the government and local authorities. Social responsibility is a secret business weapon that drives customer purchasing behaviour (Nguyen *et al.* 2021). Nguyen *et al.* (2023) demonstrates that social responsibility positively impacts customer loyalty. Business value mediates the relationship between social responsibility and firm performance (Nguyen *et al.* 2023). According to the research by Nguyen *et al.* (2021), effective implementation of social responsibility policies toward relevant stakeholders enhances business value, improving operational efficiency and increasing profitability. Effectively fulfilling social responsibility towards stakeholders helps businesses increase their business value and contributes to expanding production scale, attracting employees, and expanding export market share (Nguyen *et al.* 2021; Yoon & Chung, 2018). Therefore, the authors propose:

H6: Social responsibility positively impacts business value.

H8: Business value positively impacts firm performance.

This study evaluates corporate social responsibility through the mediating role of business value and logistics capabilities on the firm performance of import-export enterprises in Vietnam. In light of the above literature review, the following hypotheses are listed (Figure 6):

H1: Supply chain management positively affects firm performance.

H2: Corporate social responsibility positively affects firm performance.

H3: Logistics capability positively impacts firm performance.

H4: Supply chain management positively affects brand image.

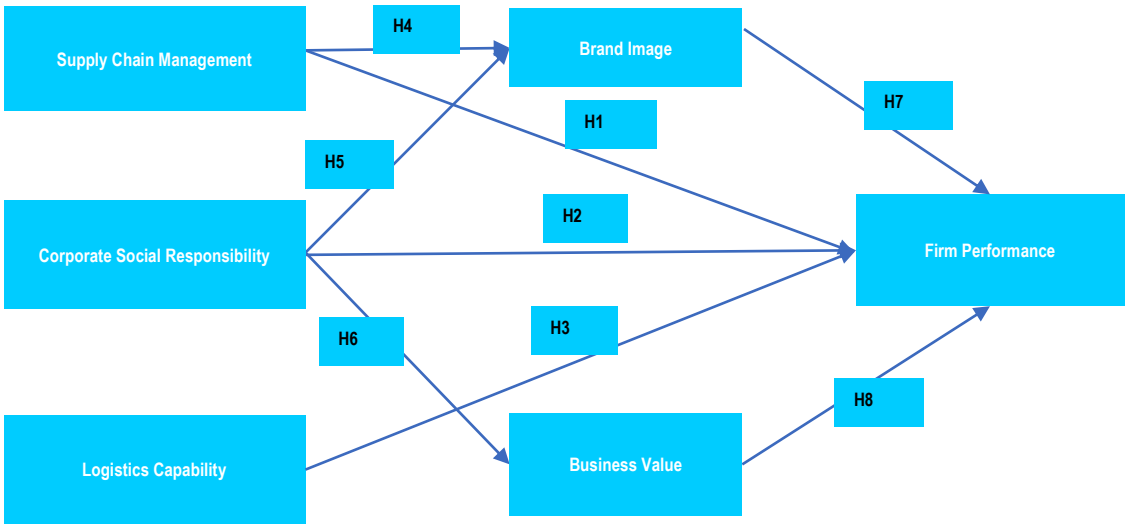
H5: Social responsibility positively impacts the brand image.

H7: Brand image positively impacts firm performance.

H6: Social responsibility positively impacts business value.

H8: Business value positively impacts firm performance.

Figure 6. Proposed research model



Source: summerized by authors

2. Method

The research employed 25 observed variables collected by synthesising previous research findings. The research sample was designed with a minimum of 125 observations to ensure a sufficiently large and reliable sample. However, the paper used 447 observations to enhance the reliability of the research results. The observed variables were collected using a 5-point Likert scale. The paper used the Google Form tool to present the questions and collect survey data. The data were then analysed using descriptive statistics, Cronbach's Alpha reliability test, outer loading test, and the PLS-SEM model with SmartPLS software version 4.0.

Table 1. Assessment of the Scale

Code	Observed Variables	Source	Factor loading
	1. Supply Chain Management (SCM)		
SCM1	The firm plans and controls objectives to achieve efficiency.	(Nguyen, 2022)	0.763
SCM2	The firm manages activities related to supply.		0.770
SCM3	The firm provides quality-assured products.		0.709
SCM4	The firm flexibly employs delivery methods.		0.743
	2. Corporate Social Responsibility (CSR)		
CSR1	Social responsibility towards employees significantly impacts the long-term development of the business.	(Jing *et al.* 2022)	0.759
CSR2	The firm consistently complies with government regulations	(Mykolenko *et al.* 2023)	0.808
CSR3	The firm cares about economic efficiency.		0.778
CSR4	The firm cares about sustainable development.		0.780
	3. Logistics Capability (LC)		
LC1	Goods are delivered to the specified location correctly	(Lu and Yang, 2010)	0.705
LC2	The warehouse system is equipped with all the necessary modern facilities.		0.818
LC3	The process of transporting raw materials for production runs smoothly		0.742
LC4	The delivery/shipping time for packaged goods to the point of sale is always on schedule."		0.832

4. Brand Image (BI)			
BI1	The product is of high-quality	(Lin *et al.* 2021)	0.823
BI2	The product has better features compared to competitors'		0.788
BI3	The brand has unique characteristics that differentiate it from its competitors		0.777
BI4	The brand does not disappoint customers.		0.754
BI5	The brand has established a strong foothold in the market.		0.827
5. Business Value (BV)			
BV1	The firm can increase its number of loyal customers	Thu *et al.* 2021	0.839
BV2	The firm creates positive motivation for employees through enthusiasm, responsibility, and work efficiency.		0.786
BV3	The government supports firms in finding local suppliers for input materials.		0.879
6. Firm performance (FI)			
FI1	Firm's market share increases	(Sezhiyan *et al.* 2011)	0.760
FI2	The firm's social responsibility programs increase		0.777
FI3	The firm's system is more modern		0.782
FI4	Cost- efficiency	(Joong-Kun *et al.* 2008)	0.703
FI5	Profit growth		0.822

Source: summerized by authors

The author collected and processed 427 valid responses that were used as data for the study. According to the results in Table 2, the number of male participants accounts for 63%, nearly double that of females, who account for 27%. Regarding educational levels, the number of respondents with qualifications lower than a bachelor's degree accounts for 2.3% - a minor proportion in the research sample, followed by college graduates, constituting 11.7%. At 71.8%, the majority hold university bachelor's degrees, while postgraduate degree holders represent 14% among managers and faculty." To determine whether survey participants were suitable for the research, the author posed questions to assess their interest in firm performance, corporate social responsibility, logistics capability, and the importance of brand image. All responses from the participants were relevant.

Table 2. Sample Description

Observation		Frequency	Percentage	Observation		Frequency	Percentage
Gender	Male	270	63%	**Occupation**	Export-Import/ International business staff	210	49%
	Female	157	27%		Export-Import/ International business manager	10	2.3%
Education qualification	Lower than bachelor's degree	10	2.3%		Export-Import/ International business lecturer	20	4.6%
	College bachelor's degree	50	11.7%		Final-year student/intern in the field of export-import	187	43.7%
	University bachelor's degree	307	71.8%				
	Postgraduate degree	60	14%				

Source: data analyzed by SPSS application

3. Research Results

The observed variable is considered reliable when the outer loading exceeds 0.7 (Hair *et al.* 2019). According to the results presented in Table 1, all outer loadings meet the required threshold and are retained for further study. From the research results in Table 3, Cronbach's Alpha ranges from 0.735 to 0.853, which all surpass the threshold (>0.7). Researchers widely use composite reliability, and authors have a consensus that a threshold of

0.7 is appropriate for evaluation (Bagozzi & Yi, 1988; Sarstedt *et al.* 2019). The composite reliability data analysis shows that all values exceed 0.7, ranging from 0.834 to 0.895. Therefore, the factors (corporate social responsibility, supply chain, logistics capabilities, brand image, business value, and firm performance) meet the reliability criteria for the model. (Hair *et al.* 2019) suggest that a scale has convergent validity if the Average Variance Extracted (AVE) exceeds 0.5. This threshold implies that, on average, the latent construct accounts for at least half of the variance in its associated indicators. The convergent validity of the scale in this research is confirmed by the AVE values ranging from 0.557 to 0.698.

Table 3. Assessment of the Measurement Model

	Cronbach's Alpha	Composite Reliability	Average Variance Extracted (AVE)
SCM	0.735	0.834	0.557
BI	0.782	0.874	0.698
BI	0.853	0.895	0.631
FI	0.827	0.879	0.592
LC	0.783	0.858	0.602
CSR	0.788	0.863	0.611

Source: data analyzed by SmartPLS application

Henseler *et al.* (2015) state that values below 0.9 ensure discriminant validity. In contrast, Clark & Watson (1995) and Kline (2016) advocate for a stricter threshold of 0.85. In this study, the Heterotrait-Monotrait (HTMT) correlation ratios for all variables do not exceed the standard threshold (<0.85), ensuring discriminant validity (Table 4).

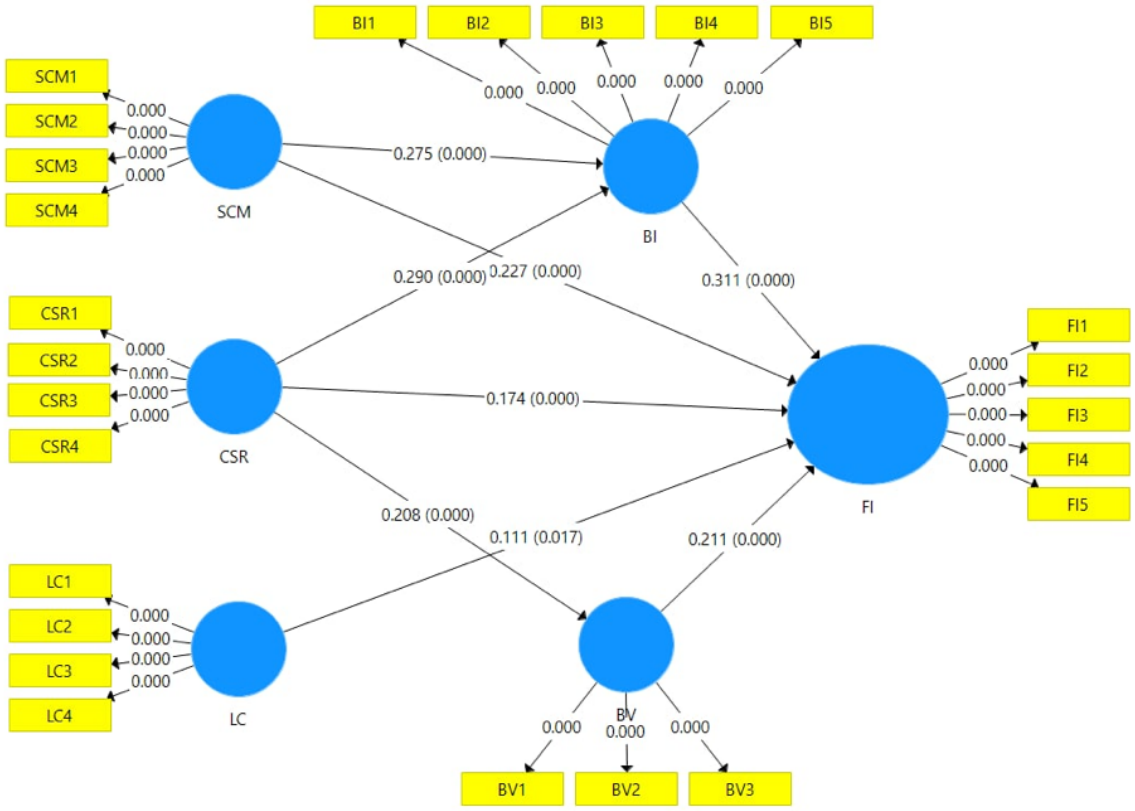
Table 4. Discriminant Validity Result- Fornell–Larcker and HTMT

		Supply Chain Management	Business Value	Brand Image	Firm performance	Logistics Capability	Corporate Social Responsibility
Fornell-Larcker	Supply Chain Management	0.747					
	Business Value	0.350	0.835				
	Brand Image	0.398	0.175	0.794			
	Firm performance	0.522	0.403	0.522	0.770		
	Logistics Capability	0.213	0.191	0.121	0.250	0.776	
	Social Responsibility	0.425	0.208	0.406	0.449	0.068	0.782
HTMT		Supply Chain Management	Business Value	Brand Image	Firm performance	Logistics Capability	Corporate Social Responsibility
	Supply Chain Management						
	Business Value	0.460					
	Brand Image	0.500	0.215				
	Firm performance	0.669	0.501	0.622			
	Logistics Capability	0.279	0.248	0.144	0.300		
	Social Responsibility	0.555	0.262	0.493	0.551	0.098	

Source: data analyzed by SmartPLS application

The results of the structural model assessment are displayed in Figure 7. The paper utilised R-squared, F-square, and path coefficients to evaluate the structural model. Estimating path coefficients relies on consistency for each dependent variable and the expected outcomes, as per Hair *et al.* The VIF result indicates that the relationships among the predictors do not violate the assumption of multicollinearity, as all coefficients fall within an acceptable range (VIF = 1.417 - 2.240 < 3), confirming no violation of multicollinearity in the research model.

Figure 7. Model assessment result



Source: data analyzed by SmartPLS application

The R-squared (R2) value indicates the predictive power of the model. A higher Adjusted R-squared number, which approaches 1, means that the independent variables account for a greater portion of the variance in the dependent variable. This value goes from 0 to 1. The R-squared (R2) value indicates the predictive power of the model. A higher Adjusted R-squared number, which approaches 1, means that the independent variables account for a greater portion of the variance in the dependent variable. This value goes from 0 to 1.

Table 5. R-squared and Adjusted R-squared value

	R-squared	Adjusted R-squared
BV	0.043	0.041
BI	0.227	0.223
FI	0.472	0.466

Source: data analyzed by SmartPLS application

Using Jacob Cohen's effect size (1988), a table of f-squared values is proposed to assess the importance of independent variables. Table 6 shows effect sizes ranging from small to large, within the range from 0.022 to 0.141.

Table 6. F-Squared value

	BV	BI	FI
SCM		0.080	0.067
BV			0.073
BI			0.141
FI			
LC			0.022
CSR	0.045	0.089	0.043

Source: data analyzed by SmartPLS application

Once again, the Bootstrap resampling method assessed the model's reliability. This research employed Bootstrapping with a resampling size of 1,000 observations to confirm the study hypotheses, with detailed results presented in Table 7.

Table 7. Hypothesis Test Results

Hypothesis	Path	Original Sample	Standard Deviation (STDEV)	t-statistics	p-value	Results
H1	SCM → FI	0.227	0.053	4.270	0.000	Supported
H2	CSR → FI	0.174	0.048	3.608	0.000	Supported
H3	LC → FI	0.111	0.046	2.438	0.015	Supported
H4	SCM → BI	0.275	0.051	5.404	0.000	Supported
H5	CSR → BI	0.290	0.060	4.851	0.000	Supported
H6	CSR → BV	0.208	0.053	3.896	0.000	Supported
H7	BI → FI	0.311	0.047	6.546	0.000	Supported
H8	BV → FI	0.211	0.047	4.456	0.000	Supported

Source: data analyzed by SmartPLS application

4. Discussions

Regarding the impact levels of explanatory variables on the firm performance shown in Table 7, it is found that the brand image has the strongest influence on firm performance (β=0.311), followed by the impact of the supply chain (β=0.227), business value (β=0.211), social responsibility (β=0.174). Finall, the impact of logistics capabilities on firm performance (β=0.111). The result also reveals the mediating effect of brand image and business value. It is reported that corporate social responsibility impacts brand image (β=0.290), supply chain impacts brand image, and social responsibility impacts business value (β=0.208). The analysis indicates that besides the variables that directly affect the firm performance of import-export enterprises, such as supply chain management, business value, social responsibility, logistics capabilities, and brand image, there are also indirect effects via supply chain management and social responsibility on firm performance.

Furthermore, social responsibility indirectly impacts brand image and business value, affecting firm performance. The structural analysis and tests confirm that the hypotheses H1 to H8 are all supported (p-values <0.05). The research confirms that supply chain management positively impacts the brand image. This result aligns with the findings of Nguyen *et al.* (2021) and Tukamuhabwa *et al.* (2021). Secondly, supply chain management also positively affects firm performance, with a coefficient of β = 0.227 and a p-value of 0.000. This finding is consistent with the research of Nguyen *et al.* (2021); Nguyen *et al.* (2023). Thirdly, the results show that business value positively influences firm performance, aligning with the research of Nguyen *et al.* (2021). Fourthly, brand image emerges as the most influential factor in firm performance. This result echoes the findings of Nguyen *et al.* (2023) and Tulcanaza-Prieto *et al.* (2020). Fifthly, logistics capabilities also contribute positively to firm performance. This result aligns with the study by Shraah *et al.* (2022b) and Sezhiyan *et al.* (2011b). Sixthly, social responsibility has a strong and positive impact on the business value, with a coefficient of β = 0.208 and a p-value of 0.000. This finding corresponds to the study by Nguyen *et al.* (2021). Finally, social responsibility also strongly and positively impacts brand image and firm performance. The mediating role of brand image has also been validated, meeting the required threshold. This result aligns with the findings of Nguyen *et al.* (2021).

Conclusions and Further Research

The findings of this research indicated that 05 factors, which are social responsibility, supply chain management, logistical capabilities, and commercial value, impact the companies' performance. Brand image also serves as a mediating variable. Firms should embrace modern technologies such as IoT and AI to optimise supply chain management processes to minimise costs and enhance operational efficiency. Integrating information systems across departments and with partners will improve forecasting capabilities and allow for flexible responses to market changes. Developing risk management strategies will also help mitigate the impact of unexpected events such as natural disasters or economic crises, ensuring supply chain stability and continuity.

On logistics capabilities, firms must invest in logistics infrastructure, including warehouses and transportation vehicles, to improve storage and transportation capabilities. Firms should also focus on training and skill development for logistics personnel to enhance their professional capabilities and problem-solving abilities. Technological solutions also effectively improve logistics performance and optimise operational processes. On social responsibility, implementing sustainable development strategies minimises negative environmental and societal impacts. Transparently and regularly reporting social responsibility activities will build

trust with stakeholders. Additionally, active participation in community programs improves the company's image and creates significant social value, contributing to the community's sustainable development. On business value, companies should create new products and services, enhancing business value. Developing customer-centric strategies to improve customer experience and satisfaction will help increase revenue and profits. Optimising business processes is also critical in reducing operating costs, improving efficiency and profitability, and enhancing competitiveness in the market. On brand image, effective marketing strategies are pivotal in strengthening brand recognition and value in the market. Firms can leverage social media platforms to connect with customers and build and maintain a positive brand image. Managing reputation and promptly addressing communication crises are also necessary to protect and develop the brand image and customer trust.

The research scope still needs to be expanded, focusing only on the Vietnam area. The study sample is also restricted, and few interviews have yet to be conducted with senior managers. The paper has another limitation regarding the deep insight of relationships between factors, and other relevant factors were not taken into consideration, such as supply chain effort management, supply chain management strategies (Sezhiyan *et al.* 2011), and outsourcing logistics (Shraah *et al.* 2022). Future studies could address these factors to enhance the model, increase the sample size, and broaden the surveyed population for more objective results. Furthermore, researchers may contextualise their work within the digital transformation framework and circular economy.

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Credit Authorship Contribution Statement

Dat Quoc Dao is responsible for conceptualization, project administration, writing – original draft, methodology, visualization, investigation.
Phat Quang Tran is responsible for formal analysis, data curation, investigation.
Cuong Quoc Nguyen is responsible for validation, investigation, supervision, writing – review and editing.
Minh Hong Cao is responsible for writing – review and editing, investigation, validation.

Declaration of Competing Interest

We have no known financial 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 confirm that no generative AI or AI-assisted tools were employed in the development or writing of this manuscript.

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Optimization of Management of Agricultural Business Stuctures for Increasing Economic Efficiency

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Abstract: Agriculture is one of the main sectors of the economy of Ukraine, which provides food security, creates jobs, and promotes the development of rural areas. Changes in the world economy, new technologies, and changes in consumer preferences require agricultural businesses to adapt and improve management approaches. The aim of the article was to create effective approaches to optimizing the management of agricultural businesses to increase their economic efficiency. The research employed financial, statistical, comparative analysis, and SWOT analysis. The results showed that the agricultural sector of Ukraine has great potential for growth but faces a number of challenges. The area of agricultural land in Ukraine (41.5 million hectares) exceeds the area of Germany and France, but the productivity and skill level of workers remain lower. In 2023, the export of agricultural products of Ukraine amounted to € 24 billion, which is significantly inferior to Germany and France. The profitability of agricultural companies of Ukraine was 9.0%, while in Germany it was 12.0%, and in France - 15.5%. This emphasizes the need for more effective management strategies. The need for transition to sustainable agriculture through the implementation of ecological practices that conserve natural resources and ensure food security is determined. The academic novelty of this study is a systematic approach to the analysis and optimization of the management of agricultural businesses in Ukraine. Prospects for future research are the development of management models for agricultural companies that consider the specifics of small and medium-sized enterprises (SMEs), with the aim of increasing their competitiveness.

Keywords: sustainable development; resource management; innovation; agricultural policy; economic factors; optimization.

JEL Classification: M21; O13; O40; Q10.

Introduction

In the conditions of globalization and rapid technological changes, agriculture is becoming an increasingly important element of the economic system of each country. Agricultural businesses are not only a source of food security, but also important participants in economic relations that ensure employment, investment, and regional development. However, despite their strategic importance, many agricultural enterprises face numerous challenges. These challenges are associated with low economic efficiency, outdated management methods and lack of adaptability to rapidly changing market conditions.

The modern agricultural sector is going through a period of transformation caused not only by economic factors, but also by changes in the social and ecological environment. The growing demand for high-quality and

environmentally friendly products, as well as requirements for sustainable development, require agricultural enterprises to quickly adapt and implement new technologies. These technologies not only optimize production processes, but also improve management decisions, which entails increased productivity and product quality (Grober and Grober, 2020).

Optimization of the management of agricultural businesses becomes especially relevant in view of the need to increase their competitiveness. Modern approaches to management include the integration of the latest technologies, improvement of business processes, implementation of a quality management system and efficient use of resources. Optimizing financial flows, analysing market trends and consumer needs are also important components of this process, which allows businesses to quickly respond to changes in the market environment (Yan *et al.* 2024).

In addition, the importance of cooperation between agricultural enterprises and scientific institutions for the implementation of innovative developments that can increase production efficiency is increasing (Guo *et al.* 2024). For example, the use of the latest agronomic methods, such as precision farming, can significantly reduce the costs of fertilizers and plant protection products, as well as increase yields. So, in turn, results in an increase in the profitability of enterprises.

However, optimization of management in the agricultural sector is not reduced to technological innovations. Human resources (HR) are equally important, which require training and development for effective work in the modern market. Implementation of training programmes, development of leadership skills and a team capable of working under the conditions of uncertainty are the key to successful adaptation of agrarian businesses to new challenges (Ilchuk *et al.* 2023).

So, optimizing the management of agricultural businesses not only contributes to increasing their economic efficiency, but also ensures sustainable development of the agricultural sector as a whole, forming the basis for future growth and stability. In view of constant changes and challenges, it is important to look for new solutions and improve existing management practices, focusing on innovation and integration of modern technologies.

In addition, important aspects of optimization are the analysis of the external environment, the study of consumer needs, and adaptation to changes in the demand for agricultural products (Markovych *et al.* 2023). Agricultural companies that are able to quickly respond to changes have competitive advantages that allow them to function successfully even under uncertain conditions. Therefore, research and development of effective management strategies are key tasks for increasing the economic efficiency of agricultural businesses.

Therefore, the research is focused on the study of management optimization practices in the agricultural sector, the analysis of existing management models, and their adaptation to the specifics of Ukrainian agriculture. The aim of the study is to formulate and substantiate effective approaches to optimizing the management of agricultural businesses in order to increase their economic efficiency. The aim involved the fulfilment of the following research objectives:

- Analyse the structures of agricultural enterprises in Ukraine;
- Determine trends in the development of the agricultural sector;
- Explore opportunities to increase the resilience of agricultural businesses structures to economic, environmental, and social challenges.

The importance of the study is stipulated by the need to increase the efficiency of Ukraine's agricultural sector in the context of global competition, economic instability and climate change. Given the significant role of the agro-industrial complex in shaping the country's GDP, ensuring food security and export development, the study allows us to identify the key factors that affect the productivity and profitability of agricultural enterprises. The strategic approaches to managing the agricultural sector proposed in this paper can serve as a basis for developing effective government support programmes aimed at stimulating innovation, attracting investment and expanding international cooperation, which will contribute not only to the economic growth of the sector but also to increasing its resilience to external challenges.

1. Literature Review

The existing studies show that agriculture needs to adapt to new conditions associated with globalization, changes in consumer demand and environmental requirements. In particular, according to Abdullayev *et al.* (2024), agriculture is a critically important sector of the economy that directly affects food security. At the same time, according to Zelisko *et al.* (2024), many agricultural enterprises face problems of low productivity because of outdated technologies and management methods. In such conditions, optimization of management becomes necessary to increase economic efficiency.

An important aspect of modern management in agriculture is the introduction of innovative technologies. The study by Guo *et al.* (2024) demonstrates how precision farming and process automation can significantly reduce production costs and increase yields. In addition, Farace and Tarabella (2024) note that the use of the latest agronomic methods, such as biotechnology, allows to increase the resistance of plants to diseases and stresses.

The study of Gadanakis (2024) is an important contribution to the development of the theory and practice of optimizing the management of agricultural businesses. The author emphasizes the importance of digitization in agribusiness, pointing out that the integration of information technologies into management processes allows optimizing resource costs and increasing the accuracy of forecasting. Digitization of agribusiness can be achieved by implementing such technologies as precision agriculture, big data (BD), artificial intelligence (AI), and the Internet of Things (IoT). These technologies enable agricultural companies to collect and analyse large amounts of data, which helps them to make more informed decisions about production, marketing, and logistics (Hryvkivska *et al.* 2024).

The research of Yang (2024) is significant in the development of the theory and practice of optimizing the management of agricultural businesses. The author of the study shows that creating a favourable social climate in teams can significantly increase labour productivity and employee involvement in the management process. A favourable social climate in teams can be achieved with the help of various measures aimed at improving working conditions, interaction between employees and enhancing their motivation (Kik *et al.* 2024). In addition, the reseachers emphasize the importance of developing social skills among employees of agricultural enterprises, as this enables them to interact more effectively with each other and with management, which, in turn, can lead to improved results (Jensen *et al.* 2024). HR also play a key role in optimizing management. According to Noja *et al.* (2023), the insufficient qualification of workers is one of the main reasons for the low efficiency of agricultural enterprises.

Regarding economic aspects, Qiu *et al.* (2024) note that the efficiency of agricultural business structures can be evaluated through financial indicators, such as profitability and capital turnover. At the same time, Rossokha and Nechyporenko (2023) emphasizes that agricultural enterprises must adapt their strategies to the changing economic environment, which requires regular monitoring of market trends and consumer demand. The study by Zhu *et al.* (2024) reveals the development of the theory and practice of optimizing the management of agricultural business structures. The author emphasizes the importance of investments in agricultural infrastructure, as it creates conditions for reducing costs and increasing the overall efficiency of business structures. According to Yan *et al.* (2024), investment in the agricultural infrastructure can be directed to the development of such areas as transport infrastructure, storage and processing of products, as well as information systems. This enables agricultural enterprises to reduce logistics costs, increase production speed and efficiency, and improve product quality.

According to a study by Akintuyi (2024), investment in agricultural infrastructure can have a significant positive impact on the development of agricultural enterprises. A key element in the process of management optimization is strategic management. The study by Fei *et al.* (2025) points to the importance of developing long-term strategies that take into account not only current needs but also prospects for the development of the agricultural sector. The literature review shows that optimization of the management of agricultural business structures is a complex and multifaceted process. This process requires further research and the integration of innovative technologies to increase production efficiency and improve product quality. The introduction of modern technologies plays a key role in increasing the competitiveness of agricultural enterprises on the global market.

2. Method

Research Design

The research was conducted in several stages, which provided a systematic approach to the analysis of management practices of agricultural business structures. The main stages of the research:

1. Preparation and planning. The research objectives were determined at this stage, the hypotheses were advanced, and research questions were formulated. We conducted an analysis of academic literature related to the management of agricultural structures, in particular, innovative methods of optimization.
2. Data collection. We selected statistics for 2018–2023. Information was collected from open sources and studies to compare the Ukrainian experience with other countries.

3. Data analysis: Data processing and financial analysis were carried out. Statistical methods were used to study the dynamics of the development of agricultural enterprises.
4. Interpretation of the results. The results of the analysis gave grounds to identify key trends, problems, and opportunities for management optimization. The strengths and weaknesses of agricultural businesses were identified with the help of SWOT analysis.

Sampling

A total of 100 agricultural enterprises from different regions of Ukraine were selected to ensure the representativeness of the study. The sample included enterprises of different sizes - small, medium and large, specializing in different types of agricultural activity, operating in different climatic conditions, and using different management models. The sample covers a variety of enterprises to investigate the effect of factors such as size, specialization, and regional location on their performance. The subjects were selected using a randomized method to avoid bias. France and Germany were also included in the sample because of their important role in the European agricultural industry. France is one of the largest producers of agricultural products in the European Union (EU), and Germany is a major exporter of agricultural products. The inclusion of these countries in the sample made it possible to compare the efficiency of Ukrainian and European agricultural enterprises. This made it possible to identify best practices and management strategies used in France and Germany, and to analyse the influence of different regulatory environments, market conditions, and cultural factors on the efficiency of enterprises in different countries.

Methods

Several practical methods were used for the research:

1. Financial analysis. Financial reports and indicators of enterprises were analysed to assess their efficiency and profitability. Special attention was paid to the dynamics of profitability and efficiency of resource management.
2. Statistical analysis. Statistical methods (correlation analysis) were used to identify the relationship between the indicators of financial performance of enterprises and their management practices.
3. Comparative analysis. Comparison of performance indicators of enterprises for different years and between different countries, including Ukraine, France, and Germany.
4. SWOT analysis. It was used to determine the strengths and weaknesses of enterprises, as well as to assess opportunities and threats in the market.

Instruments

The following tools were used to conduct the research:

- Microsoft Excel for processing and analysis of financial indicators, construction of tables and graphs.
- SPSS for statistical data analysis and correlation analysis.

3. Results

In modern conditions of agricultural production, the integration of modern management approaches is especially important. In particular, according to the State Statistics Service of Ukraine, there were 21,256 agricultural enterprises in Ukraine as of 2021. Enterprises cultivating more than 1,000 hectares occupy 48.8% of the total area of agricultural land. In Ukraine, there is a tendency to decrease the number of small agricultural enterprises cultivating areas of less than 100 hectares. Their number decreased from 16,900 in 2018 to 14,500 in 2023. Instead, there is an increase in medium-sized enterprises that cultivate between 100 and 1,000 hectares. Their number increased from 3,800 in 2018 to 5,000 in 2023 (State Statistics Service of Ukraine, 2024).

Analysis of the structure of agricultural enterprises in Ukraine shows a tendency towards the concentration of land and resources in larger agricultural companies. This can lead to increased productivity but also threatens the livelihood of small farmers. It is necessary to develop policies that support small and medium-sized entrepreneurs in the agricultural sector to ensure their competitiveness and sustainability.

The dynamics of the profitability of agricultural enterprises in Ukraine from 2018 to 2023 shows certain fluctuations in profitability indicators (ROE) and their change (Table 1).

The profitability of agricultural enterprises in Ukraine gradually declined from 15.3% in 2018 to 9% in 2023, indicating increasing pressure on the sector because of economic and political challenges, including the COVID-19 pandemic and full-scale war. At the same time, the agricultural sector's share of exports fluctuated, reaching

49.5% in 2021, but declining to 45% in 2022 because of geopolitical concerns. In 2023, the share of the agricultural sector increased again to 47.8%, which confirms its key role in the economic stability of the country.

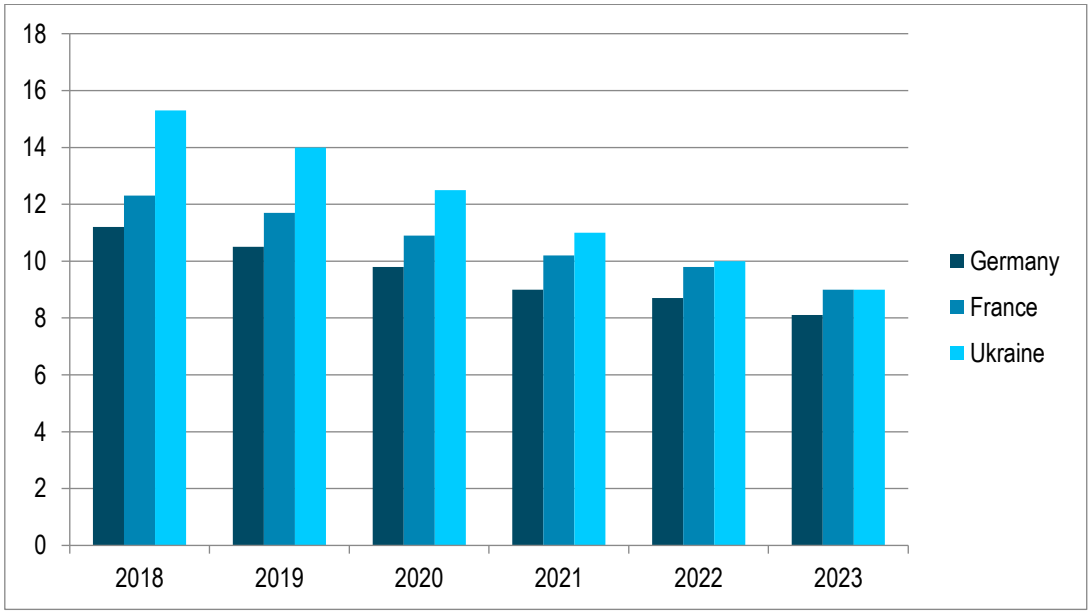
Table 1. Dynamics of profitability of agricultural enterprises in Ukraine (2018–2023)

Year	Return on Equity (ROE) (%)	Change (%)
2018	15.3	-5.56
2019	14.0	-8.49
2020	12.5	-10.71
2021	11.0	-12.00
2022	10.0	-9.09
2023	9.0	-10.00

Source: developed by the authors.

Analysis of the dynamics of the profitability of agricultural enterprises in Germany, France, and Ukraine for 2018–2023 shows a general tendency to decrease efficiency. The highest profitability was observed in Ukraine, but it decreased from 15.3% in 2018 to 9% in 2023. Similar processes are observed in Germany and France, where the indicators also decreased: from 11.2% to 8.1% in Germany and from 12.3% to 9% in France. These changes may be the result of macroeconomic challenges, market fluctuations, and changes in the agricultural sector (Figure 1).

Figure 1. Comparison of the profitability of agricultural enterprises in Germany, France, and Ukraine for 2018–2023



Source: graphed by the authors.

A comparison of the agricultural sectors of Ukraine, Germany, and France indicates significant differences in economic indicators. Ukraine, with an area of agricultural land of 41.5 million hectares, produces only €12.5 milliard of agricultural products. This is significantly lower than in Germany, where the indicator is €45.6 milliard, and in France - €71.4 milliard. The qualification level of workers in Ukraine is 60%, while in Germany it is 80%, and in France - 85%. Exports also show a contrast: Ukraine exports are €24 milliard, while Germany exports are €50 milliard, and France - €70 milliard. These figures emphasize the need to improve management and invest in modern technologies to improve the efficiency of the agricultural sector in Ukraine (Table 2).

Despite the challenges faced by the agricultural sector, its importance in the economy of Ukraine is undeniable, which makes it necessary to identify the key strengths and weaknesses of the sector using a SWOT analysis. It was established that the agricultural sector of Ukraine has strong points, such as high-quality products, qualified specialists and natural resources. However, it also has weaknesses such as dependence on weather conditions, financing problems, and low investment activity. The agricultural sector of Ukraine has opportunities for development, such as the expansion of exports and the introduction of modern technologies, but it is also exposed to threats, such as economic fluctuations and competition from importers (Figure 2).

Table 2. Comparison of the agricultural sector of Ukraine with Germany and France

Countries	Areas of agricultural land (million ha)	Production of agricultural products (€ milliard)	Skill level of workers in the agricultural sector (%)	Profitability (ROE) (%) in 2018	Profitability (ROE) (%) in 2023	Exports of agricultural products (€ milliard) in 2018	Exports of agricultural products (€ milliard) in 2023
Ukraine	41.5	12.5	60	15.3	9.0	19.6	24.0
Germany	16.7	45.6	80	18.5	12.0	45.6	50.0
France	29.4	71.4	85	20.0	15.5	63.1	70.0

Source: tabled by the authors.

Figure 2. SWOT analysis of the agricultural sector of Ukraine

Source: developed by the authors.

SWOT analysis of agricultural enterprises of Ukraine showed that the sector faces a number of internal and external challenges despite the significant potential for growth. To achieve stability in the conditions of global competition, enterprises need to adapt to changing market conditions. Recommendations arising from this analysis may include the introduction of modern technologies to increase productivity and production efficiency, as well as the expansion of sales markets through active participation in international exhibitions and fairs. It is also important to ensure access to financing that will enable agricultural enterprises to invest in modernization and development.

It should be noted that the improvement of personnel qualifications and the involvement of specialists in agronomy and management can significantly increase the efficiency of company management. It is also necessary to develop strategies for minimizing the risks associated with climate change and economic fluctuations. Therefore, the focus on adaptation to new conditions is required to optimize the management of

agricultural business structures in Ukraine. Investment in technology and human capital development are also important, which will contribute to increasing the competitiveness of the agricultural sector at the international level (Table 3).

Table 3. Stages of optimizing the management of agricultural business structures

Stage	Activity description	Result
1. Analysis of the current situation	- Financial analysis - Assessment of resources - SWOT analysis	Determining strengths and weaknesses, opportunities and threats
2. Definition of goals	- Short-term goals - Long-term goals	Clearly defined goals for improving efficiency
3. Strategy development	- Optimization of production processes - Supply management - Investment in innovation	Strategic recommendations for improving activities
4. Implementation of changes	- Staff training - Involvement of consultants	Training of employees and support in optimization
5. Monitoring and evaluation	- Definition of KPIs - Regular analysis	Tracking the progress and effectiveness of implemented changes
6. Feedback	- Assessment of results - Collection of reviews	Improving strategy based on practical experience
7. Continuous improvement	- Adaptation to changes - Innovative approach	Sustainability and adaptability of business in the market

Source: developed by the authors.

The practice of managing the productivity of agricultural enterprises in Ukraine shows the need to develop and implement specialized management methods, functions, and organizational structures. This contributes to increasing the competitiveness of farms. The concept of strategic management of agricultural enterprises should be developed based on the analysis and the possibilities of adaptation to market conditions. It should be oriented to the demand and needs of the market. It is important to develop effective relationships between labour, financial and information resources, to stimulate productivity and minimize costs.

Effective management requires flexibility, adaptability and regular review of objectives in line with market changes. Optimization of management in the agricultural sector includes the use of modern innovations in programming, modelling, and forecasting. The efficiency improvement strategy should be an integrated system of organizational and informational principles, tools and mechanisms that increase the competitiveness of farms.

Strategy development begins with market analysis, resource assessment, determining clear goals, creating a business plan, and implementing new technologies. A risk management system should minimize threats such as climate change and price fluctuations. It is also important to invest in staff training and develop partnerships in the agro-industrial complex.

Figure 3. Principles of strategic management

Source: developed by the author

Farmers must adhere to a strategic plan, ensuring a sequence of actions and a systematic approach to development. Efficiency is achieved through resource optimization, which not only increases productivity, but also reduces costs. Flexibility enables quick adaptation to changes, and balance takes into account economic, social, and environmental aspects. Minimizing risks through identifying threats and developing strategies is a key aspect of productivity management in the agricultural sector (Figure 3).

Therefore, the management of agricultural business structures in Ukraine requires constant improvement and adaptation to changing market conditions. Stable development of the agricultural sector can be achieved through the support of small and medium-sized entrepreneurs, facilitate their access to resources and markets, and encourage cooperation between all participants in the agricultural chain.

4. Discussion

A comparison of the results obtained with studies of strategic management in the agricultural sector reveals common trends and different approaches that have been applied in recent studies. Thus, the research of Svitovyi (2022) and Trusova *et al.* (2023) emphasizes the importance of adaptability in the strategic management of agricultural enterprises. Their conclusions emphasize that the ability to adapt to market changes is critical for the survival and successful functioning of agricultural companies. The study of Slobodianyk *et al.* (2021) focuses on technological changes, which indicates the growing role of digitalization, which, according to the authors, is a key factor for increasing the adaptability and competitiveness of agricultural companies.

The studies of Svitovyi (2022) and Trusova *et al.* (2023) emphasize the importance of adaptability in the strategic management of agricultural enterprises. Their conclusions emphasize that the ability to adapt to market changes is critical for the survival and successful functioning of agricultural companies. The research conducted by Slobodianyk *et al.* (2021) focuses on technological changes, which indicates the growing role of digitalization. According to the authors, the latter is a key factor for increasing the adaptability and competitiveness of agricultural companies.

Environmental aspects and sustainable development are becoming increasingly important in the agricultural sector, which is reflected in the study of Tykhenko (2022). The author emphasizes the need to integrate sustainable practices into the strategy of agricultural companies, which not only corresponds to global trends, but also ensures long-term competitiveness in the market. Our own results confirm this opinion, because agricultural companies that implement environmental initiatives are able to ensure not only sustainable functioning but also improve their image in society.

The importance of institutional support is also a relevant issue in the studies of Tykhenko (2022) and Shandova (2023). They claim that effective interaction between agricultural enterprises and state institutions can significantly increase the efficiency of agricultural companies. This shows that proper government policy and support can become a driving force for the development of the agricultural sector, in particular, under economic instability, which is also indicated in the conducted research.

The results of Williams and Triest (2023) demonstrate that innovative technologies have significant potential to increase productivity in the agricultural sector. These results are consistent with the data obtained, which indicate the positive impact of innovations on the efficiency of agricultural companies. However, the study of Pruntseva (2020) indicates the barriers to the introduction of innovations that require additional measures to overcome them. This emphasizes the importance of creating a favourable innovation environment for agricultural companies.

The research conducted by Maksym *et al.* (2022) on the circular economy and Kaminskyi *et al.* (2020) on sustainable production models point to new paradigms in strategic management that can become the basis for future strategies of agricultural companies. These new models are aimed at reducing waste, rational use of resources and supporting sustainable development. This is especially important in the context of global climate change and growing demand for ecological products. A comparison of the obtained results with current studies emphasizes that strategic management in the agricultural sector of Ukraine requires a comprehensive approach. This approach should include adaptability, technological development, environmental friendliness, innovation, and state support. It will enable agricultural enterprises not only to cope with modern challenges, but also to succeed in view of constant changes, ensuring sustainable development, and increasing competitiveness. So, the research results not only confirm the relevance of existing theoretical approaches but also introduce new aspects into the understanding of effective strategic management in the agricultural sector of Ukraine. The aim of the research corresponds to the obtained results, as it implied the identification of effective approaches to the optimization of the management of agricultural business structures. The obtained results confirm the need for a comprehensive approach to strategic management in the agricultural sector. The practical use of research results

can be aimed at the development of strategic plans for the development of agricultural enterprises, the introduction of innovative technologies and environmental practices, the creation of a favourable innovation environment, and the development of new production and consumption models.

Limitations

The study covers the period from 2018 to 2023, which may not be sufficient to identify long-term trends. Technological changes, government policies and programmes, the impact of climate change, and other factors may require a longer period for analysis.

Recommendations

Recommendations for increasing the efficiency of the agricultural sector of Ukraine: investment in modern technologies and innovations, product diversification, as well as strengthening cooperation and clustering.

Conclusions

The agricultural sector of Ukraine has significant potential for growth but faces a number of internal and external challenges. Ukraine has a larger area of agricultural land than Germany and France, but lower agricultural productivity. In 2021, the area of agricultural land in Ukraine was 41.5 million hectares, while in Germany — 16.7 million hectares, and in France — 29.4 million hectares. The employee qualification in the agricultural sector of Ukraine is 20%, 25% lower than in Germany and France. The same situation with exports. In 2023, the exports of agricultural products of Ukraine amounted to €24 milliard, while in Germany - €50 milliard, and in France - €70 milliard. In 2023, the profitability of agricultural enterprises in Ukraine was 9.0%, while in Germany - 12.0%, and in France - 15.5%. This indicates the need to implement more effective management strategies and innovations to improve the economic situation in the sector.

The agricultural sector of Ukraine has such strengths as high-quality products, qualified specialists, and natural resources. However, there are also weaknesses, such as dependence on weather conditions, financing problems, and low investment activity. Enterprises need to adapt to changing market conditions in order to achieve stability in the conditions of global competition. Recommendations arising from the study may include the introduction of modern technologies to increase productivity and production efficiency. Furthermore, it is important to expand sales markets through active participation in international exhibitions and fairs. The scientific novelty of the study lies in the development of new theoretical approaches and practical recommendations for the strategic management of the agricultural sector of Ukraine in the context of global challenges. In particular, the relationship between the level of employees' qualifications, investment activity and export potential of agricultural enterprises is determined. A set of measures to increase productivity through the introduction of digital technologies, innovative management methods and diversification of sales markets is proposed. The results obtained can serve as a basis for the formation of effective state policies to support agricultural business, stimulate investment and increase the competitiveness of the industry.

In addition, the obtained data can help in the elaboration of policies that support the development of the agricultural sector. Information about the structure of agricultural enterprises and their profitability can become the basis for the creation of support programmes for small and medium-sized agricultural businesses. It can also help to stimulate investment in technology and innovation. The practical value of the research conducted is the development of recommendations and strategies that can be used by agricultural enterprises to increase their economic efficiency and competitiveness in the market.

Credit Authorship Contribution Statement

Sofia Scutari: Conceptualization, Investigation, Writing – original draft, Methodology;
Petru Catan: Project administration, Data curation, Supervision;
Oleg Scutari: Software, Visualization, Funding acquisition Software, Validation, Formal analysis.

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 Challenges and Opportunities of Artificial Intelligence for Entrepreneurs. Case Study of the Rabat-Salé-Kénitra Region

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Abstract: In today's rapidly evolving work environment, artificial intelligence (AI) is becoming a key driver of innovation and efficiency for entrepreneurs. However, with this technological progress come significant regulatory challenges that need to be addressed. This article examines how entrepreneurs can navigate these regulatory requirements while harnessing the potential of AI. The study was conducted with a sample of 50 entrepreneurs from the Rabat-Salé-Kénitra region. Data was gathered through a self-administered questionnaire, and hypotheses were tested using a structural equation model. The findings confirm that both the opportunities presented by AI and the regulatory challenges it brings have a strong, positive impact on its implementation. On the other hand, the lack of technological skills was found to have a negative but insignificant effect on the adoption of AI

Keywords: artificial intelligence; entrepreneurs; technological opportunities; regulatory challenges; innovation.

JEL Classification: O00; O36; L26; C10.

Introduction

In an ever-evolving economic landscape, artificial intelligence (AI) is emerging as a key driver of transformation and innovation for businesses (Jorzik, P., *et al.* 2024). This groundbreaking technology is redefining operational and strategic paradigms, offering new opportunities while presenting complex challenges. Entrepreneurs, in particular, find themselves at a crossroads, faced with an increasingly sophisticated environment where adopting cutting-edge technologies like AI can represent both unprecedented opportunities and a minefield of potential obstacles.

Artificial intelligence encompasses a wide range of technologies that enable computer systems to perform tasks once thought to be the domain of human intelligence. These capabilities include, but are not limited to, self-learning, recognizing complex patterns, and making nuanced decisions (Gil de Zúñiga *et al.* 2024). This technological advance opens up vast possibilities for entrepreneurs: from automating repetitive processes to fine-tuning operations and creating highly personalized customer experiences.

AI thus promises to redefine operational efficiency and drive entrepreneurial innovation. However, its integration into the business world raises fundamental questions, particularly concerning regulation, data privacy, and ethical considerations. These multidimensional challenges require a holistic approach, combining visionary strategy with social responsibility.

As AI continues to transform industries, entrepreneurs are at the forefront of this technological revolution. They stand to benefit from the vast potential AI offers, but they must also confront the associated risks.

Navigating this ecosystem is no easy feat, as technological innovation often collides with evolving regulatory frameworks, emerging ethical concerns, and shifting societal expectations.

Against this dynamic and complex backdrop, a central question arises: How can entrepreneurs effectively overcome regulatory challenges while fully capitalizing on the opportunities offered by artificial intelligence in a rapidly evolving professional context?

This question prompts several critical areas of reflection. It requires exploring the mechanisms through which AI can transform existing business models and foster entrepreneurial innovation. At the same time, it necessitates a thorough understanding of the specific challenges posed by AI in terms of regulatory compliance, data protection, and business ethics.

To address this issue comprehensively, a multidisciplinary approach is essential. This approach must combine a deep understanding of the technological aspects of AI, an analysis of current and emerging regulatory frameworks, and a reflection on the ethical and societal implications of adopting AI in the entrepreneurial context.

By exploring these interconnected dimensions, this research aims to provide entrepreneurs with actionable insights and concrete strategies. The goal is to equip them to successfully navigate this new technological paradigm, maximizing the benefits of AI while minimizing the associated risks of its adoption and use.

1. Literature Review

1.1 Artificial Intelligence

In The Science of Artificial Intelligence (AI) aims to enable machines to perform tasks that humans typically carry out using their intelligence. AI, in its essence, seeks to replicate the cognitive processes that define human problem-solving, decision-making, and learning. This can range from simple tasks like recognizing patterns to more complex ones, such as autonomous decision-making or natural language processing. The true potential of AI lies in its ability to adapt and learn from experiences, much like humans do. Unfortunately, the concept of AI first emerged in 1956 (Ayhan, D. & Ahmet, C. T, 2024), and it is often more accurate to refer to it as "Heuristic Computing," a term that better captures the goal of finding solutions through trial and error, approximations, and pattern recognition.In this course, we will not focus on intelligent machines or programs, as those terms refer to specific forms of AI that can mimic human intelligence to varying degrees (Longo *et al.* 2024). Instead, we will dive deeper into the foundational principles of AI, its applications, and how it influences various sectors today. By understanding the underlying mechanisms, entrepreneurs and professionals alike can appreciate the balance between AI's potential for enhancing human capabilities and its challenges, such as ensuring ethical use and addressing regulatory concerns. Another interpretation, provided by Thomas, emphasizes the analysis of human intellectual activities for which no known methods are available in advance. This perspective suggests that AI, in its essence, revolves around solving problems that were once considered impossible to tackle by machines, often because no predefined methods existed to achieve the solutions. In this sense, AI continues to push the boundaries of what machines can accomplish. Thomas's interpretation aligns with the idea that once a method becomes fully understood and can be codified; it ceases to be regarded as AI. This dynamic nature of AI's definition reflects its ongoing evolution and its role in revolutionizing industries and systems globally (Griffiths, T. L, 2020). In July 1956, a pivotal conference was held at Dartmouth (USA), which lasted for eight weeks during the summer. This conference, which brought together some of the brightest minds in mathematics and computer science, marked a significant turning point in the development of AI. The event was organized by young American researchers John McCarthy and Marvin Minsky, alongside seasoned researchers Nathaniel Rochester and Claude Shannon. The initial goal of the gathering was to discuss and lay the groundwork for what would later be recognized as the field of Artificial Intelligence. While the conference was initially planned for 11 participants, it expanded to host 20 attendees, including influential figures such as Warren McCullough, Julian Bigelow, Claude Shannon, and Ross Ashby. The gathering of these experts, who came from diverse backgrounds, laid the foundation for AI as a field of research. The participants engaged in debates about the nature of intelligence, the potential of machines to simulate it, and how these ideas could transform society. At the time, McCarthy, one of the key organizers, coined the term "Artificial Intelligence" to set his work apart from the emerging field of "cybernetics," which was led by Norbert Wiener and focused on communication and control processes in both humans and machines (Haenlein, M. & Kaplan, A., 2019).

This period marked the birth of two distinct schools of thought. McCarthy's AI community, which was primarily based in the United States, focused on creating machines that could simulate aspects of human cognition. In contrast, the European cybernetics and systems theory movement, which was centered on

understanding complex systems and feedback mechanisms, focused more on the interconnectedness of systems. These two communities were initially in competition, but their collaboration and cross-pollination of ideas laid the groundwork for future innovations. Over the years, these two schools of thought continued to evolve, with AI experiencing periods of rapid growth, often called "the summers of AI," and times of stagnation, known as the "AI winters," during which funding and interest in the field decreased significantly (Hutton, D.M. 2011). The concept of Artificial Intelligence is not singular but encompasses various sub-concepts and is applied across different domains. AI, in its broadest sense, can be categorized into three main types: Weak AI (or Narrow AI, ANI), General AI (AGI), and Superintelligent AI (ASI) (Ridzuan *et al.* 2024). While the ultimate goal for many researchers is to achieve AGI, the field remains largely focused on Weak AI and General AI at present. These different types of AI represent different levels of cognitive ability and autonomy that machines can possess. Weak AI, also known as Narrow AI, refers to AI systems designed to perform specific tasks or solve particular problems. These systems are highly effective in their designated domains but are limited to the tasks they are programmed for. A prime example of Weak AI is speech recognition, where AI systems can understand and process human speech with high accuracy (Ridzuan *et al.* 2024). However, these systems cannot perform tasks outside their specific programming. In contrast, General AI (AGI) is more advanced and refers to AI systems that can perform a wide range of tasks, similar to how humans can think, learn, and adapt to new situations. While AGI remains a theoretical concept, it is considered the next milestone in AI research. These systems would possess the ability to learn from diverse experiences and make decisions across various domains without needing specific programming for each new task. A system like ChatGPT is a generative model that has demonstrated remarkable abilities in natural language processing but still lacks the broader cognitive flexibility that AGI would require (Ridzuan *et al.* 2024; Hutton, D.M. (2011)).

Superintelligent AI (ASI), according to Ridzuan *et al.* (2024), is still a theoretical concept. This form of AI would go beyond human cognitive abilities, performing tasks and making decisions in ways far superior to human intelligence. Although ASI is not yet a reality, it raises important questions about the future of AI and its potential impact on society. As the field continues to evolve, the focus remains on Weak AI (ANI), which, while limited, is already making significant strides in fields such as healthcare, finance, and autonomous systems.

1.2 Regulatory Challenges

At present, Morocco lacks a dedicated law to regulate Artificial Intelligence (AI). The complexity and rapid growth of AI technologies have caused a delay in establishing comprehensive regulatory frameworks worldwide. While many regions are catching up, Europe recently adopted the **AI Act** in December 2023 (Busch *et al.* 2024), a milestone that reflects the urgency of regulating this transformative technology. In the United States, the government has also moved to regulate AI, with a decree issued to guide its development and ensure its ethical use. Meanwhile, the **Bletchley Council**, an advisory body, has embraced a collective approach to address the risks associated with AI and its integration into various sectors of society. However, globally, regulatory measures often struggle to keep pace with technological progress, and the timing of such legislation rarely aligns with the pace at which new technologies like AI emerge. Given the rapid development of AI, it is imperative that regulatory bodies act quickly and decisively to manage its integration responsibly (Díaz-Rodríguez *et al.* 2023).

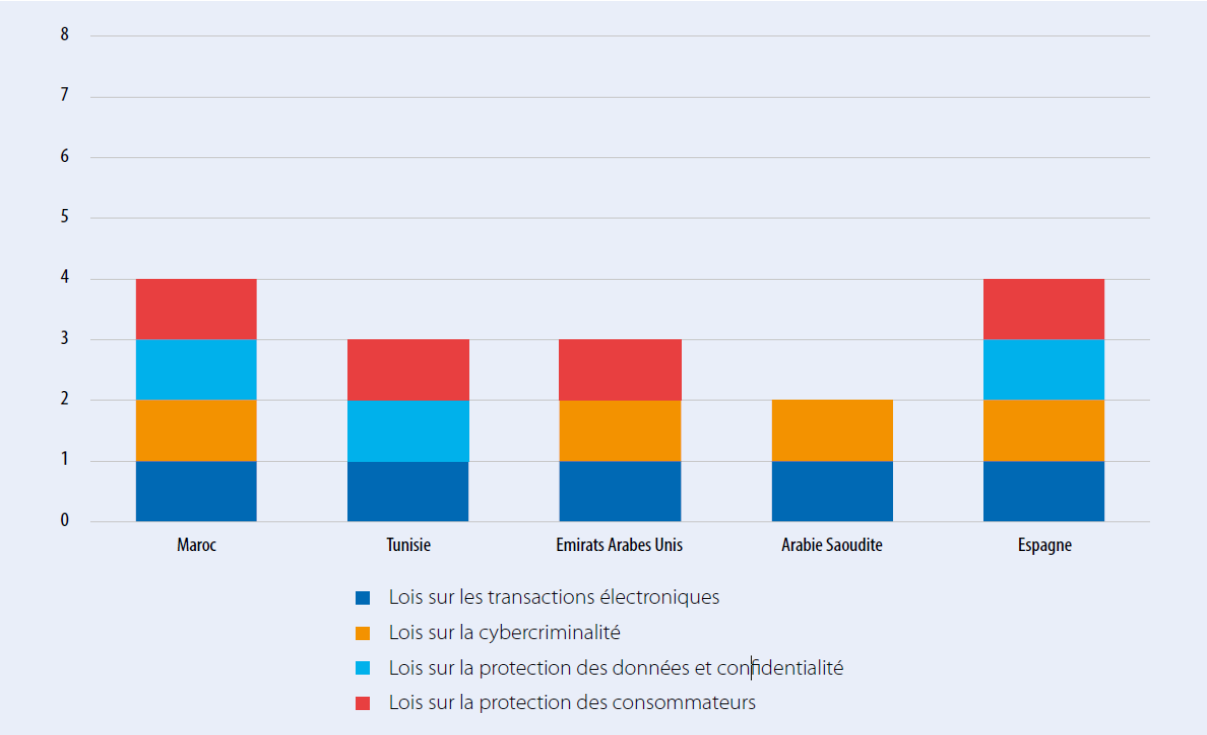
In Morocco, the existing regulatory framework covers several areas that could be applicable to AI, particularly in the realm of human rights. Key areas of concern include:

- Discrimination, particularly algorithmic bias in AI systems;
- Violations of individual freedoms, such as data privacy issues and freedom of expression;
- Concerns about the manipulation and misuse of personal data, which could lead to surveillance or unauthorized profiling.

Despite the absence of an AI-specific law, Morocco has developed a framework of laws that regulate cyberspace, touching on critical issues such as electronic transactions, consumer protection, data protection, and cybersecurity. The country has enacted data protection laws that ensure personal data is handled responsibly, and there are specific measures in place to flag and remove harmful online content. These measures aim to protect the digital rights and freedoms of Moroccan citizens, ensuring that technology is used ethically and does not infringe upon personal liberties. Morocco has also taken steps to address online hate speech, disinformation, and fake news through various regulations designed to combat these threats (Moroccan Data Protection Authority, 2022). In addition to these measures, Morocco introduced Open Data initiatives in 2011, with the creation of an Open Data portal to promote transparency and the sharing of public sector data. By 2022, Morocco ranked 35th globally in the Open Data Watch index, reflecting its commitment to data openness and accessibility. Furthermore, the country's e-government development index (EGDI) improved significantly from 0.5729 in 2020

to 0.5915 in 2022, signaling progress in digital governance. Morocco now ranks 101st globally in this index, which measures the development of e-government services. The country also places 128th in the Electronic Participation Index, demonstrating efforts to enhance citizen engagement through digital means (Open Data Watch, 2022).

Figure 1. Cyberlois available in Morocco compared with other countries



Source: Adapted, Global Cyberlaw Tracker.

While Morocco's existing legal frameworks are a solid foundation, the complexity of AI technologies poses new challenges. As AI systems become more advanced and autonomous, the issue of accountability becomes increasingly important. AI technologies, particularly in sectors such as healthcare, finance, and law enforcement, can significantly impact decisions that affect individuals' lives. This raises the question of how responsibility should be assigned when an AI system makes an error or causes harm. Who is held accountable for the decisions made by machines, especially as AI systems are often designed to learn and adapt without direct human intervention? This issue of accountability is central to ongoing regulatory debates and needs to be addressed to ensure that the benefits of AI are maximized without sacrificing public trust.

In general, the issue of responsibility in AI regulation is closely tied to civil liability law, which deals with the attribution of fault in the event of harm or injury. However, Morocco currently lacks specific provisions or legal structures to regulate AI and its related technologies. This gap in the regulatory framework presents a significant challenge, as AI systems continue to evolve rapidly, creating a need for regulations that are flexible and responsive to the fast-changing technological landscape. Without specific laws, it will be difficult to address the ethical, legal, and social implications of AI, especially as its use becomes more widespread across industries (Atakishiyev, S *et al.* 2024). The country must address this regulatory gap to ensure that AI technologies are used responsibly, ethically, and in a way that aligns with national interests and global standards.

1.3 Opportunities Offered by AI

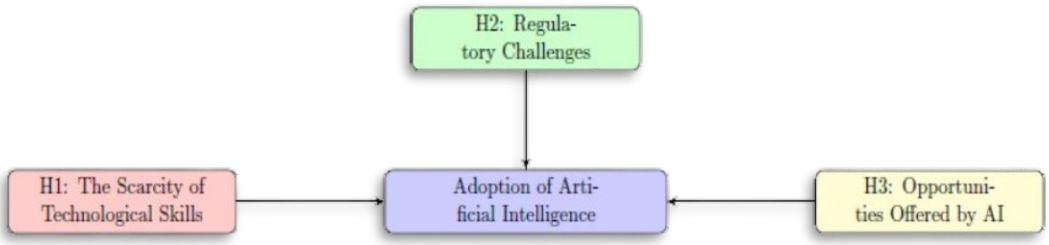
Artificial Intelligence (AI) is opening doors to transformative possibilities, suggesting a new cycle of economic development. Morocco stands at a pivotal moment were embracing this cornerstone of the Fourth Industrial Revolution could bring widespread benefits across multiple sectors. By integrating AI into its national strategies, Morocco can enhance the quality of life for its citizens through better healthcare, safer transportation, and cost-effective services tailored to their needs (EL ARABI, H. & HAFIDI ALAOUI, M. S, 2024). For instance, AI-powered diagnostic tools can help detect diseases early and personalize treatment plans, leading to improved patient outcomes and reduced healthcare costs (Kalra, N *et al.* 2024). In transportation, AI systems like advanced driver-assistance programs can significantly enhance road safety by reducing accidents and optimizing traffic flow

(Guner Tatar *et al.* 2024). The potential of AI extends beyond healthcare and transportation. AI can democratize education and training, making knowledge and skills more accessible, especially in underserved regions. This became evident during the COVID-19 pandemic, where AI-powered platforms supported remote learning, tracked population health through mobile apps, and facilitated real-time communication between governments and citizens (World Health Organization, 2021). Moreover, AI can improve workplace safety by automating high-risk tasks, minimizing human exposure to hazardous conditions. For example, in Morocco's thriving automotive industry, AI plays a critical role in developing autonomous vehicles, using **machine learning** to train cars to react effectively in emergencies or prevent accidents altogether (Alahmari, N *et al.* 2023). AI's ability to drive innovation is equally transformative. In Morocco's tourism sector—a key economic pillar—AI has the potential to revitalize operations and customer engagement. Machine learning enables the creation of intelligent chatbots, which act as virtual assistants equipped with natural language processing and cognitive intelligence. These chatbots can handle thousands of inquiries simultaneously, offering personalized recommendations, assisting with bookings, and providing cultural insights to enhance the tourist experience. This not only improves efficiency but also strengthens the identity and branding of Moroccan businesses. In public services, AI's capabilities are redefining how governments can operate more efficiently and sustainably. AI can optimize energy consumption, streamline waste management, and enhance public transportation systems, resulting in cost savings and environmental benefits. Additionally, specialists predict that AI will play a growing role in the judicial system and crime prevention. AI-powered systems can quickly analyze vast datasets, assess risks, and even predict criminal behavior, enabling law enforcement agencies to act proactively. For instance, platforms like social media already utilize AI to monitor and flag illegal activities or harmful content, creating safer digital spaces (Knott, A *et al.* 2024). These opportunities highlight AI's potential to revolutionize industries, improve governance, and elevate Morocco's standing as a technological leader in Africa. However, realizing this potential requires addressing challenges such as the scarcity of skilled talent and regulatory hurdles. By developing strategies to foster innovation while managing risks, Morocco can leverage AI to achieve sustainable and inclusive growth.

Hypotheses: Based on our analysis, we propose the following hypotheses:

- **H1**: The scarcity of technological skills negatively impacts AI adoption.
- **H2**: Regulatory challenges positively impact AI adoption.
- **H3**: Opportunities offered by AI positively impact AI adoption.

Figure 2. Conceptual framework of our study



Source: Author's Development

2. Data And Methodology

Our research focuses on analyzing the regulatory challenges and the opportunities offered by artificial intelligence for entrepreneurs in a professional context. The study was conducted based on a questionnaire provided through Google Forms, which contained 19 closed-ended questions, including single choice, multiple choice, and frequency questions. The areas covered in this questionnaire focus on various aspects related to artificial intelligence, regulatory challenges, the scarcity of technological skills, and the opportunities offered by AI. We sent the questionnaire via email, LinkedIn, etc., to a series of contact lists, using the convenience sampling method. The response collection from entrepreneurs took one month, and we managed to obtain 50 responses. Almost all items were rated on 5-point Likert scales.Our sample was distributed as follows: 35.3% women and 64.7% men, with 56.9% of respondents being between 25 and 34 years old, and 35.3% being under 25. To analyze the problem, namely, how can entrepreneurs effectively address regulatory challenges while fully

capitalizing on the opportunities offered by artificial intelligence in a rapidly evolving professional context, we used structural equation modeling methods based on SPSS and Smart PLS software.

Methodology

The structural equation modeling method was chosen for this study due to its ability to simultaneously analyze multiple complex relationships between latent and manifest variables. This approach is particularly suited for research problems involving theoretical models that integrate causal relationships across different dimensions. In fact Here are the steps of our methodology

a.Model Measurement and Exploratory Factor Analysis

To run this model, we used SPSS v.26. For the analysis, we proceeded in three steps, from exploratory factor analysis to confirmatory factor analysis, then we tested the structural model. Finally, we performed a principal component analysis (PCA) to reduce and structure our data. (Tables 1, 2, 3)

b.Confirmatory Factor Analysis

We used confirmatory factor analysis (CFA) using SMARTPLS v.26 software to predict the measurement model, and the results are presented in (Tables 4 and 5).

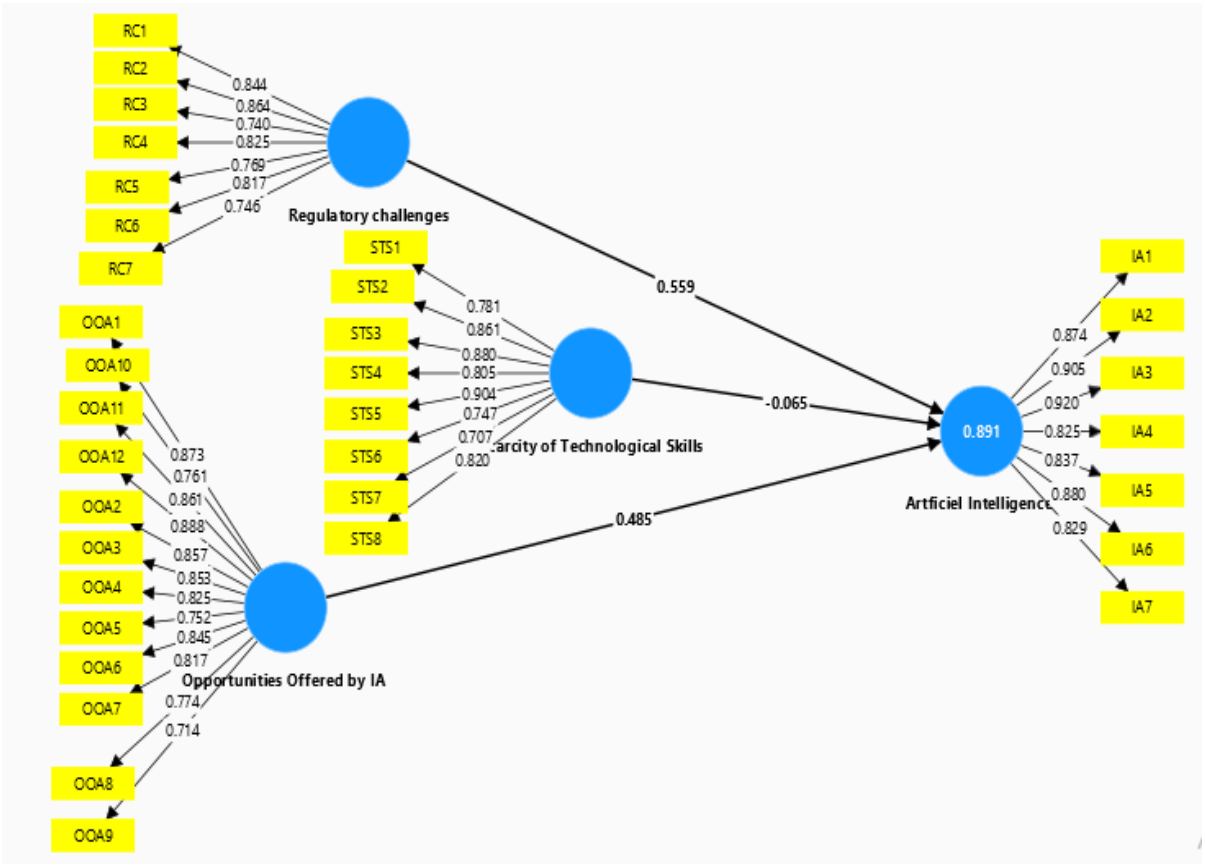
c.Reliability and Validity Analysis

The Cronbach's α for each of the six measurement constructs, such as Artificial Intelligence, Regulatory Challenges, Skill Scarcity, and Opportunities Offered by AI, exceeded the threshold value of 0.70, thus showing acceptable reliability as suggested by Bagozzi & Yi (1989) (Table 1). The composite reliability and validity were evaluated with values ranging from 0.922 to 0.961, surpassing the proposed threshold of 0.70 (Lance *et al.* 2006) (Table 3). To determine convergent validity, Table 7 shows that the values of the average variance extracted (AVE) range from 0.663 to 0.738, which is considered acceptable (Fornell & Larcker, 1981).

d.Discriminant Validity, Descriptive Statistics, and Correlations

Discriminant validity was assessed according to the criteria set by Fornell & Larcker (1981). Table 4 shows that the values on the diagonals, which are the square root of the AVE, represent discriminant validity, and the values below the diagonals are the correlations between the variables.

Figure 3. The conceptual model of the study under Smart PLS



Source: Author's Development

Table 1. Factor Analysis with Varimax Rotation

Factors	Variables	Relative Contribution	Eigen values	Total Explained Variance	Cronbach's Alpha
Artificial Intelligence	IA1	,895	11.516	73.919	,948
	IA2	,899			
	IA3	,916			
	IA4	,819			
	IA5	,824			
	IA2	,869			
	IA3	,815			
	IA4	,825			
Regulatory Challenges	RC1	,819	8,624	64,678	,907
	RC2	,848			
	RC3	,707			
	RC4	,806			
	RC5	,799			
	RC6	,841			
Scarcity of Technological Skills	STS1	,777	10,252	66,814	,927
	STS2	,849			
	STS3	,870			
	STS4	,793			
	STS5	,912			
	STS6	,755			
	STS7	,731			
	STS8	,821			
Opportunities Offered by AI	OOA1	,874	14,287	67,330	,955
	OOA2	,842			
	OOA3	,842			
	OOA4	,804			
	OOA5	,734			
	OOA6	,825			
	OOA7	,831			

Source: Author's Development

Table 2. Kaiser-Meyer-Olkin (KMO) Index and Bartlett's Sphericity Test

Variables	KMO Index and Bartlett's Test		
" Artificial Intelligence "	Kaiser-Meyer-Olkin Index for Measuring Sampling Adequacy.		,877
	Bartlett's Test of Sphericity	khi-deux approx.	360,529
		Ddl	28
		Signification	,001
" Regulatory Challenges "	Kaiser-Meyer-Olkin Index for Measuring Sampling Adequacy.		,806
	Bartlett's Test of Sphericity	khi-deux approx.	230,433
		Ddl	21
		Signification	,001
" Scarcity of Technological Skills "	Kaiser-Meyer-Olkin Index for Measuring Sampling Adequacy.		,871
	Bartlett's Test of Sphericity	khi-deux approx.	281,153
		Ddl	28
		Signification	,001

Variables	KMO Index and Bartlett's Test		
" Opportunities Offered by AI "	Kaiser-Meyer-Olkin Index for Measuring Sampling Adequacy."		,912
	Bartlett's Test of Sphericity	khi-deux approx.	561.121
		Ddl	66
		Signification	,001

Source: Author's Development

Table 3. Test d'individualité des items

	Artificial Intelligence	Scarcity of Technological Skills	Regulatory Challenges	Opportunities Offered by AI
CR	0,957	0,940	0,922	0,961
AVE	0,738	0,665	0,663	0,672
RC1			0.841	
RC2			0.862	
RC3			0.737	
RC4			0.824	
RC5			0.772	
RC6			0.820	
RC7			0.751	
IA1	0.891			
IA2	0.900			
IA3	0.912			
IA4	0.820			
IA5	0.827			
IA6	0.874			
IA7	0.820			
IA8	0.821			
OOA1				0.872
OOA2				0.858
OOA3				0.854
OOA4				0.827
OOA5				0.754
OOA6				0.846
OOA7				0.815
OOA8				0.772
OOA9				0.712
OOA10				0.760
OOA11				0.861
OOA12				0.887
STS1		0.782		
STS2		0.861		
STS3		0.880		
STS4		0.807		
STS5		0.904		
STS6		0.747		
STS7		0.704		
STS8		0.819		

Source: Author's Development

Table 4. Variable corrélation root square of AVE

	Artificial Intelligence	Scarcity of Technological Skills	Regulatory Challenges	Opportunities Offered by AI
Artificial Intelligence	0.859			
Scarcity of Technological Skills	0.748	0.815		
Regulatory Challenges	0.921	0.695	0.802	
Opportunities Offered by AI	0.880	0.872	0.822	0.820

Source: Author's Development

3. Case Studies

In the context of our article, the study focuses on analyzing the impact of regulatory challenges related to Artificial Intelligence (AI) and their influence on the opportunities offered by this technology to entrepreneurs, specifically in the Rabat-Salé-Kénitra region. The main objective was to understand how regulations influence the competitiveness and innovation of entrepreneurs in an environment where AI is becoming a driver of economic transformation.

What was done:

A thorough analysis was conducted using advanced statistical tools such as SPSS and Smart PLS to assess the impact of regulations on opportunities related to AI. Structured questionnaires were distributed via Google Forms to a wide range of entrepreneurs in the targeted region to collect data on their perceptions of regulatory challenges and AI-related opportunities. The study also utilized Likert scales to measure respondents' attitudes and opinions.

How it was achieved:

The production process of the study involved several key steps:

Survey design: Questionnaires were developed to collect data on entrepreneurs' perceptions of the regulatory challenges associated with AI and the opportunities it offers.

Data collection: Once the questionnaires were ready, they were distributed to entrepreneurs in the Rabat-Salé-Kénitra region, specifically targeting those who use or are in contact with AI-based technologies.

Data analysis: The collected data were analyzed using statistical tools to identify relationships between variables (*e.g.*, the impact of regulatory challenges on business competitiveness).

The logic behind the approach:

The idea behind this research was to understand the complex interactions between regulations and the opportunities offered by AI. In a global context where AI represents both a growth opportunity and a regulatory challenge, it is essential to understand how these factors interact at the local level. The aim was to provide practical recommendations for entrepreneurs to navigate a complex regulatory environment while leveraging new technologies.

This work is innovative because it provides a region-specific perspective on a global issue, addressing an area that is still developing. The study enriches the existing literature on AI regulation, particularly in developing countries where regulatory challenges are often more pronounced and less studied.

What is important and new:

This study is particularly important because it offers a detailed, localized view of regulatory challenges while shedding light on the practices of entrepreneurs in a developing environment. The analysis also provides concrete solutions to the challenges they face, which is crucial for encouraging innovation while adhering to ever-evolving regulations. The rigorous methodological framework and the collected data allow for practical recommendations based on robust analysis.

In summary, this study makes a significant and novel contribution to the understanding of the interaction between regulation and technological innovation in the field of AI.

Table 5. Structural Model Estimation (Path Coefficients)

	Original sample (O)	Sample mean (M)	Standard deviation (STDEV)	T statistics (|O/STDEV|)	P value
The scarcity of technological skills -> Artificial Intelligence	-0,027	0,005	0,120	0,228	0,819
Regulatory challenges -> Artificial Intelligence	0,607	0,582	0,121	5,017	0,000
Artificial Intelligence -> Opportunities offered by AI	0,406	0,411	0,147	2,753	0,006

Source: Author's Development

4. Discussions

This research highlighted the regulatory challenges faced by entrepreneurs regarding the opportunities offered by artificial intelligence in a professional context. In fact, the analysis of the model allows for drawing important conclusions about the scarcity of technological skills and artificial intelligence (Table 5).

• Relationship between "the scarcity of technological skills" and artificial intelligence the results of the statistical estimates from our model show a negative correlation between the scarcity of technological skills and artificial intelligence (β = -0.027), T = 0.228. However, the examination of the p-value = 0.819 implies a non-significant relationship between the two variables.

This result confirms our first hypothesis, which states that the scarcity of skills has a negative impact on artificial intelligence. This means that the adoption of AI is hindered by the shortage of the necessary technological skills required for its development and implementation. According to a study by Capgemini (2019), this slows down entrepreneurs who wish to integrate artificial intelligence (AI) into their operations. The lack of qualified talent can lead to several challenges.

Firstly, there is a barrier to innovation. Entrepreneurs may have innovative AI-based ideas, but without access to experts capable of developing and implementing these solutions, these projects may never come to fruition. This can delay the growth of the business and limit its competitiveness.

Secondly, the high cost of talent: Due to the shortage of AI specialists, available experts are in high demand. This drives up their salaries, making it more expensive to recruit such profiles. For small businesses or startups with limited resources, this can be a significant barrier to AI adoption, especially with the complexity of AI technologies. In fact, working with AI technologies requires a combination of technical skills, such as proficiency in programming languages (Python, R), understanding machine learning algorithms, big data processing, and AI ethics. The high level of specialization required limits the number of professionals capable of mastering these technologies.

Moreover, the delay in implementation: The lack of internal AI skills can lead to delays in project implementation, as it is necessary to train staff or hire external consultants. This can delay the adoption of new technologies, which is crucial in sectors where rapid innovation is a competitive advantage.

Additionally, increased dependence on external providers: In the absence of internal skills, entrepreneurs often have to rely on service providers or consultants to develop AI solutions. This dependency can limit their ability to innovate quickly and adapt solutions based on the evolving needs of the business.

Finally, a lack of agility: Without the necessary skills, it is harder for a company to adjust or optimize its AI systems. This can prevent the company from fully leveraging AI to improve its processes or offer new products or services.

Furthermore, the scarcity of AI skills can severely limit entrepreneurs in their ability to adopt and fully exploit the potential of artificial intelligence, hindering their growth and competitiveness.

• Relationship between 'Regulatory Challenges' and Artificial Intelligence

The results of the statistical estimates from our model show a positive correlation between regulatory challenges and artificial intelligence (β = 0.607), T = 5.017. However, the examination of the p-value = 0.000 ($p \leq 0.05$) implies a significant relationship between the two variables.

This result confirms our second hypothesis, which states that regulatory challenges have a positive impact on artificial intelligence. This means that it is essential for regulation to be implemented quickly for better adoption of AI. First, in encouraging responsible innovation, regulatory challenges push entrepreneurs to adopt a more

ethical and responsible approach in developing AI solutions. By integrating ethical considerations and safety standards into their products, they can stand out in the market and attract ethically-minded customers.

Second, the creation of clear standards. In fact, regulations can provide clear frameworks regarding the use of AI. This helps entrepreneurs understand the legal requirements and market expectations, thereby facilitating the integration of AI into their business processes without the fear of violating laws.

Additionally, strengthening consumer trust. Strong AI regulations, particularly in data protection and transparency, enhance consumer trust. Entrepreneurs who comply with these standards can increase their credibility and acceptability in the market, which can promote their growth.

Not to mention, facilitating access to financing. Companies that demonstrate their compliance with regulations may find it easier to secure funding, as investors are increasingly concerned with ethical and regulatory issues. A positive regulatory framework can thus open financing opportunities for entrepreneurs.

Finally, protection against abuse: Regulatory challenges aim to prevent potential abuses related to AI, such as discrimination or privacy violations. By implementing measures to protect consumers, entrepreneurs can avoid reputation crises and legal issues, allowing them to focus on innovation.

• Relationship between 'Opportunities Offered by AI' and Artificial Intelligence

The results of the statistical estimates from our model show a positive correlation between the opportunities offered by AI and artificial intelligence ($\beta = 0.406$), $T = 2.753$. However, the examination of the p-value = 0.006 ($p \leq 0.05$) implies a significant relationship between the two variables.

his result confirms our third hypothesis, which states that the opportunities offered by AI have a positive impact on artificial intelligence. First, AI enables entrepreneurs to access advanced tools and technologies that facilitate the development of innovative products and services. With AI, it becomes possible to automate repetitive tasks, analyze large amounts of data, and improve the quality of offerings. This leads to an increase in operational efficiency, allowing businesses to focus on value-added activities.

Moreover, AI strengthens data-driven decision-making. Entrepreneurs can leverage advanced analytics systems to better understand consumer behaviors and preferences, thereby identifying crucial market trends. This allows them to adjust their business strategy and offer solutions that are better tailored to their customers' needs.

AI also fosters the personalization of customer experiences. By using machine learning algorithms, entrepreneurs can provide personalized recommendations and services, thus increasing customer satisfaction and loyalty. This ability to customize offerings is a major competitive advantage in the market.

Furthermore, the rise of AI paves the way for new business models and emerging sectors. Entrepreneurs now have the opportunity to launch innovative startups or diversify their activities by integrating AI technologies, which can enable them to position themselves in untapped markets. Finally, the promise of AI attracts significant investments. Entrepreneurs who adopt AI-based solutions are often seen as high-potential players, which facilitates access to funding and resources to support their growth.

1. Relevance of the topic in the current context

Artificial intelligence (AI) is a rapidly growing field, and its impact on entrepreneurs and businesses has become a central topic in economic and technological discussions. By exploring the regulatory challenges related to AI and how they influence the opportunities offered by this technology, this article addresses a current and crucial issue. In a world where regulations are constantly evolving, understanding these challenges is fundamental to the success of entrepreneurs.

2. Originality and contribution to research

The article provides an in-depth analysis of the interactions between the opportunities offered by AI and the regulatory challenges in a specific professional context. It offers innovative perspectives on the impact of regulation on innovation and business competitiveness. This study stands out with its entrepreneur-focused approach in the Rabat-Salé-Kénitra region, bringing a new geographical and contextual contribution that may not have been sufficiently explored in existing literature.

3. Rigorous methodology

The study uses a robust statistical evaluation method, including structural equations based on tools such as SPSS and Smart PLS, enabling reliable and robust conclusions. The use of structured questionnaires (via Google Forms) and Likert scales ensures a clear and consistent methodological approach. These methods are well-detailed, allowing other researchers to replicate the study and verify the results.

4. Potential impact on entrepreneurial practices

One of the most important aspects of this article is its ability to influence entrepreneurial practices. By identifying the specific regulatory challenges faced by entrepreneurs and the opportunities AI can offer, the article provides practical recommendations for navigating a complex environment. This type of applied research can directly assist entrepreneurs in adapting their strategies, overcoming regulatory hurdles, and leveraging new technologies to enhance their competitiveness.

5. Relevance for policymakers and researchers

In addition to being useful for entrepreneurs, this article also offers valuable insights for policymakers regarding public policy and regulation. The study highlights the need for clear and adaptive regulations to encourage innovation and support business growth. Therefore, this article can be useful not only for industry practitioners but also for public policies aimed at fostering innovation while protecting citizens' interests.

6. Current challenges and future perspectives

This article does not limit itself to a simple analysis of present challenges but also proposes future directions, particularly on how regulations could evolve to better support technological progress. Furthermore, the article paves the way for future research, such as exploring new dimensions of AI-regulation interactions in other regions or sectors.

In summary, this article is significant because it addresses a relevant and timely issue, employs a rigorous methodology, and offers practical solutions for entrepreneurs and policymakers. This makes it not only worthy of reading but also a valuable contribution to advancing knowledge in an evolving field.

However, Exploration of the Interaction Between AI and Regulation: The study provides an in-depth perspective on how regulatory challenges influence the opportunities offered by artificial intelligence, a field where knowledge is still developing. By focusing on the impact of regulation on innovation and business competitiveness, this research enriches discussions on the regulatory impact on emerging technologies.

1. Geographical and Contextual Contribution: By specifically focusing on entrepreneurs in the Rabat-Salé-Kénitra r egion, this study provides a new and unique contribution by examining regional contexts that are often underexplored in existing literature. This opens the way for a better understanding of the local dynamics of AI and regulation, particularly in developing countries.

2. Robust Methodological Approach: The use of advanced tools such as SPSS and Smart PLS, along with structured questionnaires and Likert scales, strengthens the credibility of the research and allows for precise analyses. This solid methodological framework contributes to expanding scientific knowledge by providing reliable foundations for further research in the same field.

3. Practical and Theoretical Implications: This research goes beyond the theoretical analysis of regulatory issues by offering practical recommendations for entrepreneurs, making it both academic and applied. This dual approach enriches existing knowledge by combining theory and practice.

4. Opening Avenues for Future Research: The article does not limit itself to the results obtained, but also suggests directions for future research, such as studying AI-regulation interactions in other regions or sectors. This shows that the research is not an end in itself, but a starting point for further work.

In summary, this research makes a significant contribution to advancing scientific knowledge on the impact of AI regulation, while offering new perspectives and opening avenues for future research.

Conclusions

Artificial Intelligence (AI) technology presents both a challenge and an opportunity for current entrepreneurs. The rapid advancements in this field open up unprecedented opportunities for innovation, operational efficiency, and value generation. However, entrepreneurs must face a complex and ever-changing regulatory environment.

To meet these challenges, it is essential to remain vigilant regarding regulations and establish solid compliance strategies. Collaboration with specialists in AI law and ethics is also recommended to anticipate and respond to legal requirements while avoiding potential risks.

By leveraging the opportunities offered by artificial intelligence, entrepreneurs have the potential to transform their business models, optimize their processes, and improve customer experience. However, it is crucial to integrate AI thoughtfully, considering its ethical and societal consequences. Adopting a balanced approach that combines technological innovation with social responsibility allows entrepreneurs not only to overcome regulatory constraints but also to position themselves as leaders in an increasingly competitive market.

Moreover, despite the multitude of challenges, artificial intelligence presents a favorable environment for those willing to invest in knowledge and innovation while respecting current regulations. Such a strategic approach offers the opportunity to benefit from technological progress and build a resilient and sustainable business, ready to face future challenges.

This article has explained how the opportunities offered by AI, regulatory challenges, and the scarcity of technological skills impact artificial intelligence among entrepreneurs in the Rabat-Salé-Kenitra region. In fact, our results show that the relationship between the scarcity of technological skills and artificial intelligence (AI) is characterized by a negative correlation. The results of a study indicate that this scarcity limits the adoption of AI by entrepreneurs because the lack of qualified talent leads to various obstacles. First, it hinders innovation because even with promising ideas, entrepreneurs struggle to find experts capable of realizing them. Additionally, the high costs of AI specialists become a barrier for small businesses, which often have limited budgets. The complexity of AI technologies requires specific technical skills, which reduces the number of available professionals. The lack of internal skills also leads to delays in project implementation, forcing companies to rely on external consultants, limiting their agility and ability to innovate quickly. In summary, the scarcity of AI skills represents a major challenge for entrepreneurs, hindering their ability to fully leverage the potential of this technology.

On the other hand, the relationship between regulatory challenges and AI is positive, with regulations promoting faster adoption of this technology. Regulatory challenges encourage entrepreneurs to adopt an ethical approach to AI solution development, distinguishing them in the market. By providing clear frameworks, regulations help entrepreneurs navigate legal requirements while strengthening consumer trust. By complying with these standards, businesses can also facilitate access to funding, as investors are increasingly concerned with ethical and regulatory issues. Moreover, these challenges aim to prevent abuse related to AI usage, thus protecting entrepreneurs from potential crises.

Finally, the opportunities offered by AI translate into a positive relationship that stimulates innovation and business efficiency. AI allows entrepreneurs to access advanced technologies, thus facilitating the development of innovative products and services. By automating tasks and analyzing massive data, businesses can improve their operational processes and personalize customer experiences. The rise of AI also opens the door to new business models, encouraging entrepreneurs to explore untapped markets. Furthermore, AI attracts investments, as businesses that integrate it are seen as high-potential players, facilitating their growth. In sum, artificial intelligence offers entrepreneurs significant opportunities to innovate, grow, and enhance their competitiveness in the market.

Limitations and Perspectives

The study presents several limitations that should be taken into account. First, the regulatory context surrounding AI is rapidly evolving and varies from country to country. This means that while the study explores current legislative frameworks, it could quickly become outdated with the emergence of new laws. This limits the universal applicability of its conclusions, especially for entrepreneurs operating in diverse regulatory environments. Additionally, the study suffers from a lack of concrete examples. While it addresses legislative frameworks and suggests strategies, it remains theoretical and does not provide practical examples showing how entrepreneurs can actually navigate these regulations while using AI. This lack of pragmatism limits the usefulness of the study for those seeking practical solutions.

Moreover, the reliance on external expertise is another limitation. The study does not sufficiently address the challenges related to entrepreneurs' dependency on external consultants to understand and comply with regulations. This can be a major obstacle, particularly for small businesses that lack the financial resources or flexibility to hire such experts, potentially affecting their agility and competitiveness.

On the other hand, the study also presents interesting perspectives. It highlights opportunities for regulatory innovation for entrepreneurs. By adopting a proactive approach, entrepreneurs can not only comply with regulations but also contribute to shaping policies that better meet their needs, collaborating with regulators to create a favorable environment for innovation.

Furthermore, the study suggests that entrepreneurs can differentiate themselves by adopting ethical standards in the field of AI. By becoming leaders in this area, they can not only comply with current regulations but also enhance their market reputation by positioning themselves as ethical and responsible players.

When managed well, AI adoption can also lead to the acceleration of internal processes. By automating certain tasks and using predictive analytics tools, entrepreneurs can gain competitiveness while remaining

compliant with legislative requirements. This synergy between technological innovation and compliance could encourage faster adoption of AI, even in sectors where regulations are strict.

Moreover, the importance of this study lies in its ability to provide concrete insights for local entrepreneurs, by identifying regulatory obstacles and challenges related to the scarcity of skills, while highlighting strategies to effectively and responsibly leverage the potential of AI. By offering a detailed analysis of current trends and suggesting pragmatic approaches to navigate regulations, this study serves as a valuable guide for entrepreneurs looking to innovate while adhering to ethical and legal standards. It also contributes to expanding knowledge on the impact of AI within a specific regional context, marking a significant advancement in studies on the digital transformation of businesses in Morocco.

Credit Authorship Contribution Statement

The authors 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 during the preparation of this work.

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Artificial Intelligence in Accounting: Revolutionizing Financial Management in the Digital Landscape

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Abstract: The use of artificial intelligence (AI) builds up the accounting system efficiency, increases data entry accuracy and simplifying the accounting process. The aim of the study is to prove the effectiveness of modern AI-based information technologies (IT) in accounting and the possibilities of AI application for process optimization. The effectiveness and efficiency were proven using comparison methods, statistical analysis, graphical cause-and-effect analysis, modelling using the linear regression method. The assessment was carried out using quantitative and qualitative indicators of labour productivity and process optimization. The results of the study showed that 18 accounting department employees on average are needed to perform standard transactions in the companies studied without AI. With AI, 1 person can handle such a volume of work. Accordingly, with the implementation of AI, the average reduction in Transaction Processing Time per Week is 696.26 hours. Regression analysis confirmed that the implementation of AI increases the companies' productivity in terms of Transaction Processing Time. Reducing the Data Processing Complexity by one unit leads to a reduction in transaction processing time by 592.69 seconds. Each percent increase in Data Entry Accuracy contributes to a reduction in processing time by 5135.51 seconds. The prospects for implementing AI in accounting include further improving algorithms to increase the accuracy and speed of transaction processing, optimizing material and time consumed.

Keywords: artificial intelligence; accounting; financial management; digital environment; automation; machine learning; data analytics.

JEL Classification: M11; M15; M21; M41; C01.

Introduction

Solving complex accounting issues in the system of economic information flow and the formation of business on an increasing scale of accounting becomes relevant and appropriate. The solution implies the adoption and use of AI and programmes based on it. AI enables arranging information, provide quick access to databases, analyse and structure information, perform complex calculations in a short period of time, eliminate human error, etc. This is not a complete list of advantages, but it justifies the need to move accounting to a new level (Brukhanskyi, Spilnyk, 2020).

The latest implementation was AI, blockchain technologies, large databases. These technologies and programmes based on them have reduced the monotony and uniformity of work to almost zero, increasing the potential for data processing. Therefore, the use of AI in business management has become a relevant topic. Questions about developing strategies and methods for using AI form the basis of many studies by researchers and prominent figures (Gupta *et al.* 2021).

At the same time, these innovations do not leave aside the economic aspects of life and development. So, the integration of the achievements of the scientific and technical process into the life of enterprises and farms is reflected in accounting, which is a constant tool of economic information (Benko, Moskaliuk, 2022). The combination of AI, the achievements of scientific progress and human economic activity, which leads to the growth and prosperity of the economy, leads to increased forms of control and accounting. This leads to the search for new safe and effective methods of solving problems, one of which is the implementation of AI. AI accumulates, groups and systematizes information, and is used for business management (Butynets *et al.* 2022; Zaporozhets, 2020).

Globalization of business management processes consists in using the latest digital technologies that improve the quality of management processes, speed up accounting, increase the effectiveness of activities, and enhance security. However, the globalization process is accompanied by a number of problems that arise in any innovation processes (Smiesova *et al.* 2019). This is especially true for accounting, where these implementations must be organized from the perspective of law, regulation, and reliability. Moreover, the process must be accompanied by maintaining confidentiality for each enterprise (Al-Okaily & Alsmadi, 2024). Therefore, the issues of creating uniform legal norms for the digital process and developing applied tasks for the implementation of ITs of a specific type are relevant.

An important feature of the study is that it fills the existing gaps in the scientific literature on the implementation of AI in accounting activities, offering a quantitative assessment of its impact on the performance of accounting systems. The novelty of the work is the proposed approach to modeling the speed of transaction processing after the implementation of AI and identifying key factors that affect the efficiency of automated processes.

The aim of the research is to reveal the potential of modern AI-based ITs in accounting and the possibilities of its application for process optimization. Research objectives:

- Analyse the work of the enterprise for the year using traditional accounting methods (manual accounting, use of Excel tables, and classic accounting programmes) and AI-based programmes;
- Conduct a comparative analysis of the obtained data by qualitative and quantitative performance indicators (number of errors, processing time of transactions, processing complexity, etc.);
- Describe the relationship between the studied indicators using a causal cyclic diagram;
- Conduct a regression analysis of the impact of indicators on productivity, expressed through the indicator of transaction processing time.

1. Literature Review

Globalization opens up great opportunities for business and entrepreneurship, providing a number of positive tools in their work. Economic aspects are aimed at facilitating business and accounting, and therefore their implementation should be based on research data confirmed by time. Prominent researchers have shown a general assessment of AI in the areas of accounting (Nikonenko *et al.* 2022, Wang *et al.* 2022). In contrast, the work (Savkiv, Kuzmin, 2023) reflects the prospects for introducing AI into accounting when transitioning to a new level of reporting. The works (Hasan, 2021; Thapa & Camtepe, 2021) reflect a number of shortcomings and unresolved issues, such as protecting confidential data, conducting training, and the difficulties of transitioning to a new level of programmes and tools that appear today. The study (Sunardi *et al.* 2020) reproduces the problems of fraud and lack of transparency in reporting. The article (Cho, 2024; Lysenko *et al.* 2024) examines the issues of harmonization of international standards and cooperation at the level of global cybersecurity. The researchers' results are valuable for outlining the key problems of accounting in the context of progress and globalization.

However, the authors' approaches lack specifics, as they define the AI implementation as a universal way to solve problems without providing specific evidence.

More practical results were obtained in works describing the AI integration into the accounting of companies. Such issues of implementing AI into the accounting system as the selection of effective software and the need to monitor the updating of programmes are described in (Pravdiuk *et al.* 2022). The researcher (Pilevych, 2020) described the first stages of implementation. These steps are complex, require a lot of attention and effort. A number of researchers note that the successful integration of AI into accounting requires training and brings the accountants' competencies into line with modern requirements (Lelyk *et al.* 2022). The results of (Megits *et al.* 2022) show that the current profiles of accountant competence do not meet the latest requirements for business analytics competencies. These conclusions are consistent with the findings of (Xu *et al.* 2021), which describe the problem of the lack of specialists of the appropriate level and provides a base of the necessary software. However, the mentioned studies lack recommendations for actions that need to be taken to ensure a safe and effective transition. Instead, Damerji and Salimi (2021) provide some important recommendations that ensure a more effective implementation of AI in accounting. In particular, the researchers found a significant impact of accounting students' technology readiness on the successful AI integration into accounting.

As for the prospects for the impact of AI on the accounting profession itself, researchers are inclined to believe that the tasks and skills of the profession will change significantly in the coming decade. In particular, AI will take over a significant share of the tasks of an accountant (Leitner-Hanetseder *et al.* 2021). At the same time, other researchers (Riinawati, 2021) believe that AI, given the stereotyped thinking, lack of independent thought and professionalism, will not be able to completely replace an accountant. Other researchers are working to eliminate the shortcomings of AI. For example, using Explainable AI methods Zhang *et al.* (2022) seek to solve the problem of the lack of explanation of AI results.

The researchers who have shown the AI application in the financial and economic analysis of an enterprise's activities reached valuable conclusions. The work (Bilous *et al.* 2023) reproduces the results of the analysis of financial and economic activities using AI. The work is practical, shows positive trends, but does not sufficiently describe the advantages of using AI by different companies, their experience and mistakes. The study (Zhylin, M. 2024) shows data analytics, inventory control, analysis of costs and deviations in the system's operation, which is the basis for making investment decisions. The researchers (Kulynych *et al.* 2020) show the possibilities of identifying problems, improving management processes, planning a budget, calculating costs, describing development plans, etc. Han *et al.* (2023) noted the possibilities of AI for recognizing and applying patterns to expand decision-making. However, all issues are presented somewhat one-sidedly in the studies. There are no practical recommendations and concepts for a holistic approach to generalized experience in building modern information technologies and programmes.

Specific benefits of using AI in accounting, supported by quantitative calculations based on the results of a survey, are provided in (Vărzaru, 2022). The researchers found that the implementation of AI allows for significant reduction of processes and improvement of the use of accounting information. Based on the survey conducted by other specialists, Bakarich & O'Brien (2021) also found that AI has not yet had a significant impact on accounting at the time of writing their work. In particular, this applies to robotic process automation (RPA) and machine learning (ML). However, according to the results of the researchers, significant changes are expected in the future. Rane (2023) analysed the use of ChatGPT as an example of generative AI (GenAI) in accounting. The researchers identified such benefits as automation of data entry, categorization and creation of reports, reduction of errors and operational costs. At the same time, the work lacks a quantitative analysis of the impact of the implementation of AI on specific aspects of accounting activities and determination of the level of effectiveness of innovations.

Although AI cannot completely replace humans, it is capable of planning, forecasting, calculating profitability, financial performance of a company, identifying weaknesses, drawing conclusions, and making a development forecast. The need for further research is determined by continuous AI development, which provides ample opportunities for improving the efficiency of accounting. This study contributes to the existing knowledge on the AI use in accounting by analysing its impact on specific aspects of accounting activities and assessing efficiency.

2. Methodology

2.1. Research Design

The preparatory stage of the study included the selection of companies, indicators, and data formatting for analysis. The main stage involved the analysis of the selected indicators before and after the AI implementation using a number of scientific methods. The final stage involved the evaluation of the obtained data.

2.2. Sample

To assess the effectiveness of implementing AI in accounting, a sample of companies was formed for the study. The total number of companies considered for the sample was 14 companies. The companies were selected based on the international status of the company and the duration of AI-based accounting. Such international-class companies with branches in Ukraine, Romania, Poland, the USA, Germany, Colombia, Italy, Spain and Chile include SoftServe, Infopulse, Intellias, GlobalLogic, and Sigma. This list also includes Data Science UA, Lemberg Solutions, Artelogic, Innovecs, Toptal, Bayesian Health, Coinbase, Gigster, and GlobalLogic Germany GmbH. All of these companies implemented AI-based programmes. The selected number of companies is sufficient for the study. These companies used Docyt AI and BotKeeper-based accounting programmes.

The efficiency of the accountant was assessed by using the selected quantitative indicators of labour productivity and process optimization. They include the average number of input data entries, the speed of processing banking transactions, the number of types of banking transactions. These data were collected and calculated from standard accounting programmes SAP, M.E. Doc and BAS Accounting. However, one cannot judge the accountant's efficiency by quantitative indicators alone. It is necessary to take into account qualitative indicators, such as the correctness of data entry, the complexity of data processing, the typicality and monotony of work. The following indicators served as qualitative indicators of the work performed: the number of errors made, the repeatability and uniformity of errors.

2.3. Methods

The study employed *the method of comparing the obtained data* on the efficiency of the enterprise using traditional methods and using AI. Traditional methods include manual accounting, the use of Excel tables, and classic accounting programmes. The programme for traditional accounting (SAP, M.E. Doc and BAS Accounting) recorded the receipt of *quantitative data* by time and the number of registrations. The total number of data registrations or banking transactions was determined per day and per reporting period. The final result was the percentage of registrations that met the established standards and time. The number of errors made when entering data was also recorded. The registration time is considered to be the period from the moment the data entered the system to the moment they were processed by the accountant or AI. The accuracy of information recording was deduced from the data on the number of errors made, repeatability and uniformity of errors in accordance with the amount of incoming information flow. The indicator of process optimization and efficiency of the enterprise was compiled based on data from the SoftServe company, which was collected from the moment AI was introduced.

Qualitative indicators, such as the correctness of data entry, the complexity of data processing, were determined as the ratio of the number of errors to the total volume of transactions, taking into account the indicators of typicality and monotony of work, which means the multiple repetition of monotonous short-term operations, actions, cycles. This indicator was introduced for the work of an accountant based on programmes without AI, as the typicality and monotony of work disappears with the introduction of AI-based programmes. The accountant's work was assessed during the year from October 2022 to October 2023 to cover all accounting periods.

Using the method of *comparison* relative to the observed indicators made it possible to preliminarily assess that the efficiency for each of the studied indicators has significantly increased. S*tatistical analysis* of the indicators clarified the increase in efficiency. The findings obtained through *graphical cause-and-effect analysis* gave grounds for building a *causal cyclic diagram*, which helped to show the relationships between the indicators and the direction of the relationship. The model built using the linear regression method helped to determine the impact of indicators on increasing productivity, expressed through the transaction processing time, as well as predict this indicator.

2.4. Instruments

The data were collected from SAP, M.E. Doc and BAS Accounting programmes and company reporting. The effectiveness of AI implementation was studied based on Docyt AI and BotKeeper software. StatPlus Pro for Windows and Excel was used for calculations and statistical data processing.

3. Results

AI-based programmes are advisable to implement for solving monotonous tasks of the same type or for non-standard tasks with high complexity. AI-based programmes and tools solve a number of issues with fairly high efficiency. Table 1 presents the results of a study on the implementation of AI-based software Docyt AI in accounting in a number of companies.

Table 1. Results of AI implementation in accounting

Company		Transaction type	Number of transactions in the company for the reporting period	Number of transactions per day, pcs	Number of transactions per month, pcs	Transaction processing time, s	Number of errors	Correctness of data entry,%	Data processing complexity	Percentage of registrations for the reporting period, %	Taking into account the complexity of the work, and the coefficient of typicality and monotony of the work
SoftServe	Without AI	Invoice Processing Banking transactions Customer Incoming Emails	398	6	134	7265	25	6.28	65	33.67	42.08
	With AI			18	398	22	0.5	0.13	0.06	100	
Infopulse	Without AI		618	9	200	10865	23	3.72	58	32.36	40.45
	With AI			28	618	21	0.51	0.08	0.08	100	
Intellias	Without AI		706	12	266	14465	29	4.11	77	37.68	47.09
	With AI			32	706	23	0.45	0.06	0.1	100	
GlobalLogic	Without AI		552	17	376	20465	18	3.26	68	68.12	85.14
	With AI			25	552	22	0.51	0.09	0.069	100	
Data Scince UA	Without AI		838	24	530	28865	31	3.70	66	63.25	79.05
	With AI			38	838	23	0.62	0.07	0.098	100	
Lemberg Solutions	Without AI		1388	36	794	43265	21	1.51	71	57.20	71.50
	With AI			63	1388	19	0.55	0.04	0.12	100	
Innovecs	Without AI		1278	29	640	34865	34	2.66	73	50.08	62.59
	With AI			58	1278	18	0.81	0.06	0.13	100	
Artelogic	Without AI		486	9	200	10865	22	4.53	65	41.15	51.44
	With AI			22	486	22	0.48	0.10	0.06	100	
Sigma	Without AI		618	12	266	14465	31	5.02	58	43.04	53.81
	With AI			28	618	21	0.56	0.09	0.08	100	

Toptal	Without AI		728	17	376	20465	23	3.16	77	51.65	64.56
	With AI			33	728	20	0.45	0.06	0.1	100	
Bayesian Health	Without AI		794	24	530	28865	18	2.27	68	66.75	83.43
	With AI			36	794	19	0.62	0.08	0.069	100	
Coinbase	Without AI		926	24	530	28865	33	3.56	66	57.24	71.54
	With AI			42	926	25	0.61	0.07	0.098	100	
GlobalLogic Germany GmbH	Without AI		1366	38	838	45665	19	1.39	71	61.35	76.68
	With AI			62	1366	16	0.55	0.04	0.12	100	
Gigster	Without AI		1212	29	640	34865	0.36	0.03	73	52.81	66.01
	With AI			55	1212	24	0.52	0.04	0.13	100	

Source: developed by the authors

Table 1 shows that AI-based programmes have a high level of efficiency, reliability, and reproducibility. The number of errors has been reduced to almost zero, work efficiency has been increased, all incoming information is processed on time, quickly, thoroughly, communication is being established, communication with clients is being carried out, and paperwork with partners is being carried out. Table 2 is proposed below to assess how much productivity has increased with the implementation of AI, where the change in indicators in percentages is determined for each company. The Table does not reflect indicators that were already presented in Table 1 in percentage terms.

Table 2. Percentage increase in indicators after the AI implementation

Company	Number of transactions per day	Number of transactions per month	Transaction Processing time	Number of errors	Data entry accuracy
Increase/decrease, %					
SoftServe	200.00	197.01	-99.70	-98.00	6.15
Infopulse	211.11	209.00	-99.81	-97.78	3.64
Intellias	166.67	165.41	-99.84	-98.45	4.05
GlobalLogic	47.06	46.81	-99.89	-97.17	3.17
Data Scince UA	58.33	58.11	-99.92	-98.00	3.63
Lemberg Solutions	75.00	74.81	-99.96	-97.38	1.47
Innovecs	100.00	99.69	-99.95	-97.62	2.60
Artelogic	144.44	143.00	-99.80	-97.82	4.43
Sigma	133.33	132.33	-99.85	-98.19	4.93
Toptal	94.12	93.62	-99.90	-98.04	3.10
Bayesian Health	50.00	49.81	-99.93	-96.56	2.19
Coinbase	75.00	74.72	-99.91	-98.15	3.49
GlobalLogicGermany GmbH	63.16	63.01	-99.96	-97.11	1.35
Gigster	89.66	89.38	-99.93	44.44	-0.01

Source: developed by authors

Table 2 shows that the number of transactions per day (month) has increased for all studied companies, but the growth varies depending on the specific company. For example, for Infopulse, the increase in the number of transactions per month is 209%, for Bayesian Health – about 50%. The time and complexity of processing transactions for all companies have decreased by more than 99%, the number of errors has decreased by 96.56-98.45% for most companies, except for Gigster. This is the only company where this indicator has increased by 44.44%, which could potentially be determined by inefficiency or errors in the automation process. Having these

data, it is possible to calculate how many employees in the accounting department are needed on average to perform standard transactions without AI and with the AI (Table 3). According to the table, this indicator is 18 (17.43) people without AI and 1 person (0.03) with AI. In hours per week, the average reduction in transaction processing time per week with AI is 696.26 hours.

Table 3. Determining the number of accounting department employees before and after the implementation of AI

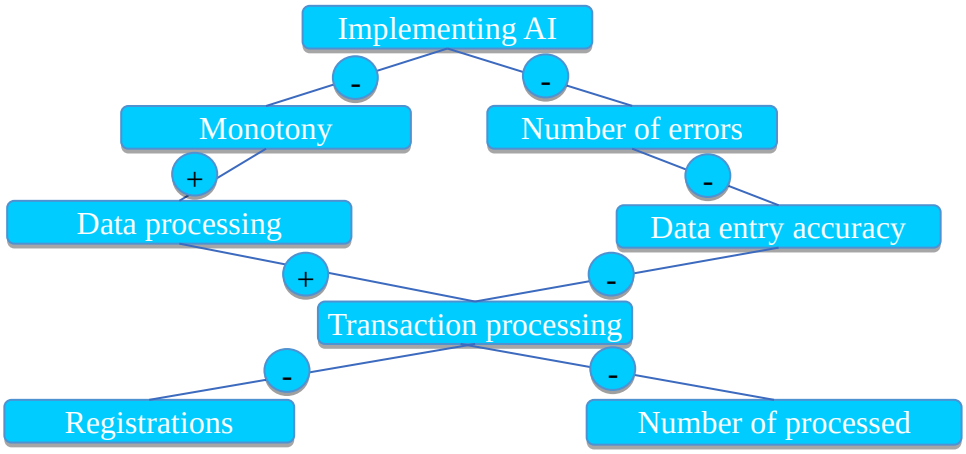
	Average number of transact+tions per day	Average number of transactions per working week (5 days)	Average transaction processing time	Average transaction processing time per week, s	Average transaction processing time per week, hours	Required number of employees assuming a 40-hour working week
Without AI	20.43	102.14	24579.29	2510598.47	697.39	17.43
With AI	38.57	192.86	21.07	4063.78	1.13	0.03
Change	18.14	90.71	-24558.21	-2506534.69	-696.26	-17.4

Source: developed by authors

The obtained results were visualized by building a causal cyclic diagram (Figure 1). The diagram reflects the relationship between the studied indicators. The "+" sign on the relationship line means that the increase (decrease) of one indicator is accompanied by an increase (decrease) of another, that is, the relationship is direct, "-" indicates an inverse relationship between the indicators.

The changes that had the greatest impact on the change in the productivity of accounting systems in companies which implemented AI were assessed through a regression analysis. The transaction processing time was used as a key productivity indicator, which was a dependent variable in the analysis. The independent variables were the complexity of data processing and the correctness of data entry. The causal cyclic diagram shows that these indicators are causally related to the transaction processing time. The diagram shows that the increase in processing complexity is accompanied by an increase in processing time (and vice versa), meaning that the relationship is direct. In turn, an increase in the correctness of entry reduces the processing time of operations, which indicates an inverse relationship between the indicators. The indicators of monotony, the number of errors, the percentage of registrations, and the number of processed operations were not included in the model due to insufficient specifics and/or multicollinearity. As shown in the diagram, these indicators do not interact with the number of processed operations through clear cause-and-effect relationships. They mainly affect variables already included in the model or are the result of reducing transaction processing time. Therefore, these indicators do not provide the model with reliable information to explain the variation of the independent variable and were not considered in it.

Figure 1. Causal cyclic diagram of relationships between the studied indicators



Source: developed by authors

The chosen approach to building the regression model allowed to obtain a fairly high-quality model. The correlation coefficient was 0.943, which indicates a strong positive relationship between the dependent and independent variables. In particular, this indicates the importance of the factors included in the model for predicting the number of processed transactions. The coefficient of determination was 0.888, and the adjusted

coefficient of determination was 0.879. This indicates that about 88% of the variation in the processing time of operations can be explained by the independent variables included in the model. Table 4 contains the results of the ANOVA analysis.

Table 4. Results of the ANOVA analysis

	df	SS	MS	F	Significance F
Regression	2.00	5505398486.07	2752699243.04	99.56	0.00
Residual	25.00	691199958.03	27647998.32		
Total	27.00	6196598444.11			

Source: developed by authors

The Significance F and F-statistic values in Table 4 indicate the statistical significance of the constructed regression model. The regression sum of squares (SS Regression = 5505398486.07) accounts for a significant proportion of the total variance (SS Total = 6196598444.11), and therefore the model explains well the variation in the number of processed transactions. The residual sum of squares SS Residual = 691199958.03 indicates the proportion of unaccounted variation. Table 5 presents the regression results.

Table 5. Regression results

	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%
Intercept	511.70	1408.05	0.36	0.72	-2388.23	3411.62
Data processing complexity	592.69	46.65	12.70	0.00	496.60	688.77
Data entry accuracy	-5135.51	834.64	-6.15	0.00	-6854.48	-3416.53

Source: developed by authors

According to the results of the regression analysis, both independent variables included in the model are statistically significant at $p<0.05$. The regression coefficient for data processing complexity indicates that an increase in the complexity indicator by one unit causes an increase in the transaction processing time by 592.69 seconds. Each percentage increase in the data entry accuracy contributes to a decrease in processing time by 5135.51 seconds. The regression model has the form:

*Transaction processing time = 511.7 + 592.69 * Data processing complexity – 5135.51 * Data entry accuracy.*

The obtained results allow us to better understand which factors affect the increase in the efficiency of the accounting system with the AI implementation. The calculated regression coefficients give companies a clear idea of whether the AI implementation in the companies' activities meets their expectations regarding increased productivity. The constructed model can be used to predict the increase in productivity of companies with the AI implementation.

4. Discussions

All over the world, there is an active introduction of smart technologies into economic activities. The use of many digital practices and programmes has shown good results, which is reproduced in the works of researchers (Savkiv, Kuzmin 2023; Lysenko *et al.* 2024). The results of the author's study are consistent with the conclusions (Bilous, Kundeus, 2023; Pilevich, 2020), which proved the effectiveness of the AI introduction in accounting. Our study confirm the opinion of (Megits *et al.* 2022; Pravdyuk *et al.* 2022), which showed that companies where AI was introduced develop more progressively and have more opportunities.

The advantages of using AI are shown in many studies through the use of questionnaires and interviews. As in the author's study, Vărzaru (2022) proved that AI contributes to a significant reduction in accounting processes. Abdullah and Almaqtari (2024) concluded that AI in accounting allows to increase efficiency, accuracy and improve decision-making capabilities. Emetaram and Uchime (2021) noted that the AI implementation significantly increases the accountants' productivity. Judging by the mentioned studies, the AI effectiveness of is confirmed in the practice of countries with different levels of development — Romania, Saudi Arabia, Nigeria. However, the methods used by the researchers have certain limitations caused by the subjectivity of the respondents' views. Unlike these studies, the quantitative impact of AI on specific aspects of accounting was confirmed in the author's study by calculating the percentage of efficiency increase. Moreover, regression analysis identified the degree and direction of the influence of individual efficiency indicators on increasing work productivity.

The results of some studies contradict the author's study. In particular, Bakarich and O'Brien (2021) and Gonçalves *et al.* (2022) noted that the digitalization of accounting is only at the initial stage and has a minor impact on the main processes. At the same time, the author's work found that the AI technologies implemented by the studied companies are already having a significant impact on efficiency. The mentioned studies took into account the practice of developed countries, such as the USA and Portugal, so the found differences cannot be explained by the insufficient level of technological development in the respective countries. Instead, the differences can be explained by different approaches to sampling: the author studied large international companies, while the mentioned studies focus on small businesses. This assumption is confirmed by the work of Nóbrega *et al.* (2023), who noted the lack of potential of small and medium-sized enterprises to implement AI because of weak financial capacity.

The practical application of the author's findings is to quantify the efficiency gains from AI implementation. The regression model obtained in the work allows predicting efficiency gains after AI implementation. This information may be useful for enterprises that plan to use AI in their operations.

4.1. Limitations

The limitations of this study are determined by the difficulties of development in recent years, which is associated with the pandemic. It should be noted that the sample of companies was formed on the basis of their willingness to participate in the study and reluctance to submit their data for analysis. Besides, the software package was selected for the study based on the programmes that the companies currently work with.

4.2. Recommendations

The obtained results give grounds to provide the following recommendations:

- Increasing the data entry accuracy and reducing the processing complexity significantly reduce the time for processing operations. Therefore, it is advisable to give preference to solutions that include automatic verification, error correction and data structuring when implementing AI;
- Successful implementation of AI depends, among other things, on the ability to use new technologies. Therefore, the implementation of training and education of personnel is an effective solution for increasing efficiency.

Conclusions

Taking into account the undisclosed aspects of the problems of AI implementation by other authors, the work revealed the potential of AI for fast, reliable and timely processing of accounting information. The effectiveness of AI implementation was proven based on the study of several programmes. It was determined that the implementation of innovative technologies based on AI in the accounting system can significantly increase the efficiency of accounting activities, affecting labour productivity.

The work found that 18 accounting department employees on average are needed in the studied companies to perform standard operations without AI. With AI, 1 person can handle this amount of work. The average reduction in transaction processing time per week with AI is 696.26 hours. It was also found that the implementation of AI by large companies affects productivity, expressed through the indicator of the transaction processing time. The constructed regression model demonstrates that this indicator is significantly influenced by such indicators as the data processing complexity and the data entry accuracy. It was found that by reducing the complexity of processing by one unit, the processing time of transactions is reduced by 592.69 seconds. Each percentage increase in the correctness of data entry contributes to a reduction in processing time by 5135.51 seconds.

The determined percentage changes in the efficiency of various aspects of accounting after the AI implementation allow companies to determine whether the implementation of AI meets their goals. The regression model obtained in the work makes it possible to predict the increase in efficiency after the AI implementation. This could be useful for businesses that plan to use AI in their operations. Further research could be aimed at determining the impact of risks on the effectiveness of AI implementation, such as data loss, cyberattacks, etc.

Credit Authorship Contribution Statement

Mohammad Ahmad Alnaimat: Conceptualization, Investigation, Methodology, Project administration, Software, Formal analysis, Writing – original draft, Supervision, Data curation, Validation, Writing – review and editing, Visualization, Funding acquisition;

Inna Korsun: Conceptualization, Investigation, Methodology, Project administration, Software, Formal analysis, Writing – original draft, Supervision, Data curation, Validation, Writing – review and editing, Visualization, Funding acquisition;
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Mykyta Artemchuk: Conceptualization, Investigation, Methodology, Project administration, Software, Formal analysis, Writing – original draft, Supervision, Data curation, Validation, Writing – review and editing, Visualization, 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 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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Modelling the Risks of the Exporter's Company in Times of Crisis

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Abstract: Exporting companies face numerous risks generated both within the country and by importing countries. Therefore, early detection and analysis of national and international risks is relevant and urgent. The aim of the study is to analyse the relationship between the volume of Ukrainian exports and macroeconomic indicators of Ukraine and importing countries. This will reveal the potential impact of fluctuations in these indicators on changes in the level of major export risks. The study employed economic and statistical analysis, correlation and regression analyses. The study determined the key influencing factors on the activities of Ukrainian exporting companies depending on the importing country. The level of gross domestic product (GDP) per capita is an important factor influencing the volume of exports from Ukraine to Poland, Spain, and Germany. Exports to Poland are also closely correlated with fluctuations in the local currency. Exports to China and Turkey do not significantly depend on changes in local macroeconomic indicators. Macroeconomic indicators of Ukraine - GDP per capita, customs, as well as other import duties and taxes on international trade - significantly affect the total volume of exports. The obtained results and drawn conclusions are of practical importance for Ukrainian exporters in terms of raising awareness of the described risks, and the recommendations provided on the basis of the study will contribute to their mitigation. The prospect of further research is to identify differences in the exporters' risks depending on the field of their activity.

Keywords: export relations; taxes; tax risk; foreign economic activity; fiscal policy; entrepreneurship.

JEL Classification: F13; F42; F62; L26.

Introduction

The foreign economic activity of states is in complex relationships with various economic, geopolitical, and social factors generated both at the level of individual countries and on a global scale (Ratten, 2020; Caldara & Iacoviello, 2022). These factors unevenly affect countries' export opportunities and their competitiveness in the international arena (Haque *et al.* 2020; Catanzaro & Teyssier, 2021). At the same time, export orientation is a key direction of economic growth, stimulates innovation and increases the competitiveness of the national economy (Kulikov *et al.* 2022).

Ukraine is an important exporter of numerous types of products (Ivanov, 2022), in particular, grain, oil, ferrous and non-ferrous metals, some food products, etc. (Júnior *et al.* 2022; Zubko, 2024). However, to date, Ukraine's foreign economic activity, in particular, in export issues, faces significant challenges related to the full-scale war in the country (Lytvynova *et al.* 2022; Chepeliev *et al.* 2023). These challenges, in addition to the obvious problems caused by the destruction of infrastructure, the occupation of territories and the blockade of logistics routes, affect the economic indicators of Ukraine and other countries (Glauber *et al.* 2023; Lin *et al.* 2023).

The worsening economic and geopolitical conditions make exporters of Ukraine face the aggravation of numerous risks: economic, trade, customs, currency, political, tax, etc. (Hoekman *et al.* 2020; Heiland & Yalcin, 2021). However, the specifics of foreign economic activity is that the exporters' activity is influenced not only by local problems, but also by the situation in the countries that import their products (Smiesova *et al.* 2019; Pan *et al.* 2023). Therefore, the study of export risks should cover not only national indicators, but also the main macroeconomic indicators of importing countries (Rasshyvalov *et al.* 2024).

The aim of the research is to analyse the relationship between the volume of Ukrainian exports and macroeconomic indicators of Ukraine and importing countries. This will reveal the potential impact of fluctuations in these indicators on changes in the level of major export risks. The topic of the study is important given the insufficient research on the risks of exporters in wartime. What is new in the work is the construction of quantitative models of the impact of internal factors and macroeconomic conditions in importing countries on the volume of the country's exports under martial law. The aim involves the fulfilment of the following research objectives:

- Study the change in the volume of Ukrainian exports to the main importing countries before and after the start of the war;
- Conduct correlation and regression analyses between the total export volume of Ukraine and its macroeconomic indicators;
- Conduct a correlation-regression analysis between the volume of Ukrainian exports to the main importing countries and their macroeconomic indicators;
- Identify the impact of fluctuations in the main macroeconomic indicators of countries on export risks and provide recommendations for mitigating the main risks for Ukrainian exporters.

1. Literature Review

Exporting companies constantly face numerous risks, the spectrum and impact of which varies depending on the specifics of the industry, the economic situation in partner countries, logistical factors, etc. Wei (2024) used the cross-border e-commerce industry as an example and identified risks related to cross-border settlement, taxation, supervision, logistics, intellectual property protection, and privacy. Zhang *et al.* (2023) noted the lack of effective risk warning services in cross-border trade. The researchers pointed to the low accuracy of the assessment and the weak ability to detect hidden risks, which is associated with the use of outdated analysis models, unreliable resources and incomplete data.

The noted problems can affect companies regardless of the stability of external conditions. In turn, external conditions, especially global crisis, can deepen existing problems, but also create new atypical tests for exporters. The recent spread of the COVID-19 virus was one of the biggest economic shocks of this century, prompting numerous studies on the impact of this phenomenon on exports. According to Azim *et al.* (2024), the main consequences of the pandemic for international economic relations, include unilateralism, protectionism, growing uncertainty, declining economic indicators, reduced demand in importing countries, etc. Heinzova *et al.* (2023) noted that COVID-19 created new risks associated with various national restrictive measures that took precedence over economic measures. The researchers used the example of small companies in the Czech Republic and found a significant drop in exports due to the risks posed by COVID-19, as well as risks related to the partners' payment morale of. Bass *et al.* (2024) examined global exports to the United States of America (US), Japan, and EU countries during pandemic. The researchers found a decline in exports of products

dependent on China but noted an increase in exports from countries that use more automated production processes. Shingal (2024) noted a significant decline in global services exports, particularly in tourism, transport, and financial services. Bond (2024) confirmed a significant impact of the pandemic on both exporters and importers, with the duration and strength of the impact varying markedly across industries.

The full-scale war in Ukraine became another global shock (Sokhanvar & Bouri, 2023). Rose *et al.* (2023) observed that disruptions in grain exports due to an invasion affect not only the countries involved in the conflict but also other regions of the world. At the same time, as in the previous study, Steinbach (2023) established that the consequences for other countries are much weaker than for Ukraine and the Russian Federation. Orhan (2022) found that the impact of war spreads through various global channels: financial and commodity markets, trade, migration links. The main areas of influence are financial sanctions, disruptions in logistics chains, and rising prices for raw materials.

Some studies note a significant impact of other crisis trends on export relations and risks. Song *et al.* (2024) investigated the peculiarities of export relations in the context of a trade war between the United States and China. Jiang *et al.* (2023) found that China's exports to the US declined during the trade war, but this shock was mitigated by the redirection of exports to other countries.

The conducted review gives grounds to note the multifaceted impact of crisis phenomena on companies that export their goods to other countries. In addition to new risks, the crisis creates new opportunities provided effective and timely measures. At the same time, the risks of Ukrainian exporters during a full-scale war are understudied. The existing studies do not cover risks, lack quantitative confirmation of the impact of such risks on the exporters' activities, and the specifics of importing countries are mostly not taken into account. This encourages further research using quantitative methods of analysis and taking into account a wide range of risks.

2. Methodology

2.1. Research Design

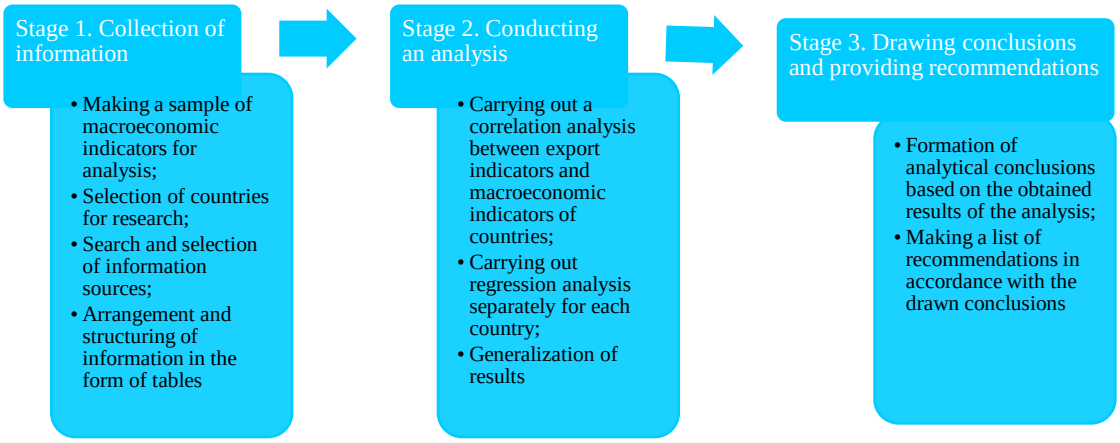
The research design includes three main stages: collecting information, carrying out correlation and regression analysis, drawing conclusions and providing recommendations. Figure 1 illustrates the research design in detail.

2.2. Sample

The sample of countries for the study, except Ukraine, consists of five countries that are the largest importers of Ukrainian products according to the latest data — the results of the first half of 2024. These countries are Poland, Spain, China, Turkey, and Germany.

The volume of Ukrainian exports in monetary terms is defined as the main indicator characterizing Ukraine's exports. This indicator is taken as the volume of exports of Ukraine to the respective country for the analysis by individual countries. When the influence of Ukraine's national indicators on its own exports was analysed, the indicator of the volume of exports is taken as the general volume of exports of Ukraine to all countries of the world.

Figure 1. Research design



Source: created by the authors

The main macroeconomic indicators for 2014-2024 considered in the study are as follows:

- GDP per capita (current US$) – the impact on exports may be a change in the purchasing power of the population in importing countries (economic risks);
- Customs and other import duties (current LCU) and Taxes on international trade (% of revenue) – an increase in customs duties and taxes on international trade for importers can increase the cost of imported goods, which leads to a decrease in demand for them (customs risks, trade risks, fiscal risks);
- Imports of goods and services (annual % growth) — indicates openness to imports, but the growth of the indicator may indicate high competition in the market of imported goods (risks of competitiveness, risks of demand);
- Customs and other import duties (% of tax revenue) – a high share of customs duties in total tax revenues indicates the high significance of such duties for the country. In times of crisis, this may prompt the government to increase customs duties, which has a negative impact on the prices of imported products (fiscal risks);
- Political Stability and Absence of Violence/Terrorism – political instability can lead to significant and unpredictable disruptions leading to economic losses (political risks);
- Official exchange rate (LCU per US$, period average) - fluctuations in the exchange rate are associated with changes in the cost of goods imported into the country (currency risks).

2.3. Methods

The study used economic and statistical analysis to demonstrate changes in the volume of Ukrainian exports to the main importing countries of Ukrainian products. Correlation and regression analyses were used as the main methods in the research. Correlation analysis made it possible to identify links between individual macroeconomic indicators of countries and the volume of Ukrainian exports to these countries. This type of analysis made it possible to reduce the sample of indicators for further calculations by removing indicators with weak correlations (different depending on the country of analysis) from it. Regression analysis made it possible to expand the results of correlation analysis, taking into account the influence of several independent variables on the dependent one (export volume).

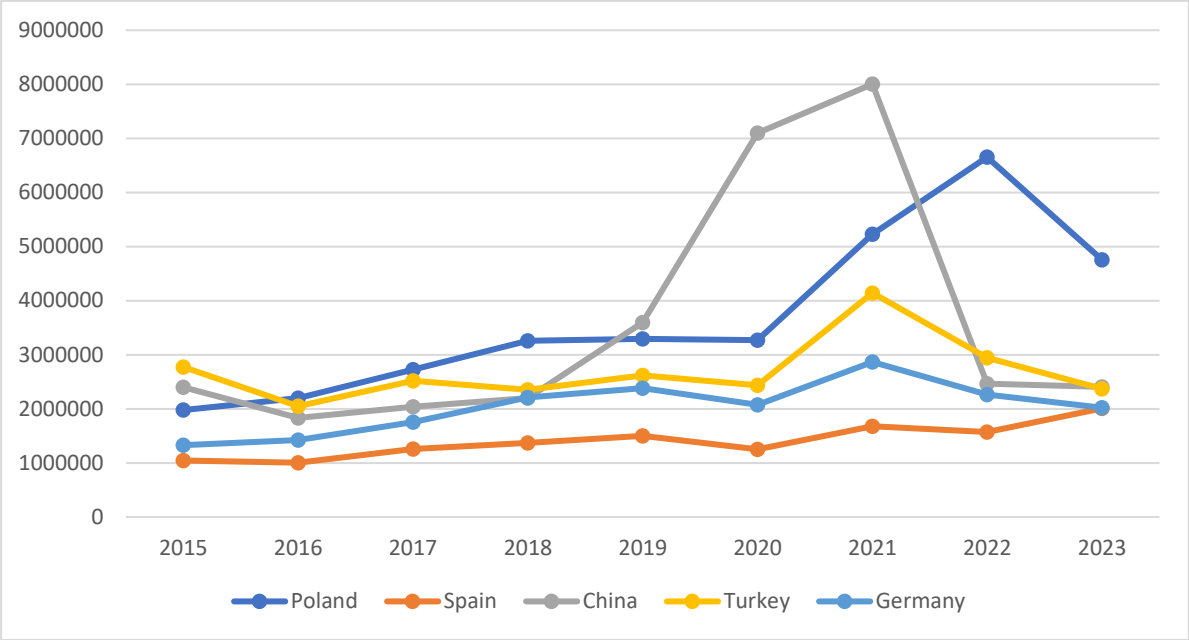
3. Results

Ukraine is an important exporter of grain, sunflower oil, flour and other food products, ferrous and non-ferrous metals, chemicals, etc. Poland, Spain, China, Turkey, and Germany are one of the main importers of Ukrainian products. However, the development of Ukrainian exports is significantly hampered by the full-scale invasion of the Russian Federation into the territory of Ukraine. Figure 2 shows that Ukraine's exports experienced a significant drop in the year the war began - 2022.

Exports to China and Poland have seen a particularly noticeable decline. China is a major importer of agricultural products, but the Russian blockade of Ukrainian ports has seriously disrupted the functioning of logistics chains. The drop in exports to Poland is related to the ban on the import of certain categories of goods from Ukraine to this country and the blockade of the border by Polish carriers. In addition to the noted reasons, the decline in exports was certainly influenced by the occupation of Ukrainian territories, the destruction of infrastructure, the reduction of the workforce, and other consequences of the war.

Despite the noted obvious reasons for the war-related drop in exports, it is also worth studying how the crisis changed the relationship between Ukraine's exports and national macroeconomic indicators. In addition, an important academic task is to assess the relationship between the volume of exports of Ukraine to other countries and the macroeconomic indicators of these countries. This will reveal the main risks of exporters of national products, which are generated both at the internal and external levels. For this purpose, a correlation and regression analysis was conducted in the work, the results of which are presented in Table 1. The table shows the results of the correlation analysis between the volume of Ukrainian exports to the main importing countries and their macroeconomic indicators. The table also contains the results of the analysis between the indicator of total exports from Ukraine and national macroeconomic indicators.

Figure 2. Export volume of Ukraine by the largest importing countries



Source: built by the authors based on data from the State Statistics Service of Ukraine

Table 1. Results of correlation analysis

Indicators	Exports, thousand US$					
	Poland	Spain	China	Turkey	Germany	Ukraine
GDP per capita (current US$)	0.942987	0.898899	0.56975	0.213249	0.971414	0.738007
Customs and other import duties (current LCU)	n/a	n/a	-0.20618	0.241587	n/a	0.164633
Imports of goods and services (annual % growth)	0.288956	0.384923	n/a	-0.02768	0.112097	0.192209
Customs and other import duties (% of tax revenue)	n/a	n/a	-0.58122	0.15656	n/a	-0.39011
Taxes on international trade (% of revenue)	n/a	n/a	-0.49403	0.082591	n/a	-0.33269
Political Stability and Absence of Violence/Terrorism	-0.41935	0.231913	-0.28447	0.614049	-0.0396	0.634897
Official exchange rate (LCU per US$, period average)	0.729352	-0.14401	0.148142	0.239439	-0.37208	-0.09409

Source: calculated by the authors based on (World Bank Group; State Statistics Service of Ukraine)

The volume of Ukrainian exports is closely related to the GDP per capita in such countries as Poland, Spain, and Germany. The total volume of exports from Ukraine is also closely correlated with GDP per capita in Ukraine itself. A high strength of correlation is also observed between indicators of the volume of exports and the indicator of political stability in Turkey and Ukraine. Besides, the official exchange rate in this country is closely correlated with the volume of Ukrainian exports to Poland. A regression analysis for each country can provide a more complete picture, allowing for the influence of several variables at the same time. The models took into account variables that, according to the results of the correlation analysis, correlate with the volume of Ukrainian exports at least at the level of 0.3.

Ukraine

Table 2 presents the results of the regression analysis between the total volume of exports from Ukraine and its domestic macroeconomic indicators. The dependent variable in this case is the total volume of exports from Ukraine. According to the coefficient of determination (0.94), the obtained model has a high explanatory power, which indicates its high quality.

Table 2. Results of the regression analysis according to the indicators of Ukraine

	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%	Lower 95%	Upper 95%
Intercept	-1475739	15103653	-0.09771	0.926865	-4.3E+07	40458725	-4.3E+07	40458725
GDP per capita (current US$)	11753.44	2123.304	5.535447	0.005206*	5858.2	17648.67	5858.2	17648.67
Customs and other import duties (% of tax revenue)	-2.5E+07	5412972	-4.58048	0.01018*	-4E+07	-9765183	-4E+07	-9765183
Taxes on international trade (% of revenue)	31711635	6768897	4.684904	0.009413*	12918165	50505106	12918165	50505106
Political Stability and Absence of Violence/ Terrorism: Estimate	-5955624	4900963	-1.21519	0.291112	-2E+07	7651630	-2E+07	7651630

** The variable is significant at 0.05*

Source: calculated by the authors based on (World Bank Group; State Statistics Service of Ukraine)

GDP per capita, Customs and other import duties, and Taxes on international trade turned out to be statistically significant indicators. Moreover, Customs and other import duties have the opposite direction of communication, that is, their increase is associated with a decrease in the volume of exports. This can be explained by the dependence of Ukrainian manufacturers on imported components or raw materials, which ultimately leads to a decrease in national exports. In turn, the growth of GDP per capita and the share of taxes on international trade may indicate an improvement in the economic situation and an increase in foreign economic activity. This has an overall positive effect on national exports.

Poland

The results of the regression analysis between the macroeconomic indicators of Poland and the volume of Ukrainian exports to this country are presented in Table 3. The volume of Ukrainian exports to Poland is the dependent variable, the macroeconomic indicators of Poland are an independent variable. The model can explain up to 96% of the variation in the dependent variable.

The significant independent variables in this case were the GDP per capita in Poland, as well as the official exchange rate of the local currency against the US dollar. GDP per capita, among other things, characterizes the purchasing power of the country's population. Therefore, with its growth, local demand for imported goods, including Ukrainian ones, increases. The strengthening of the local currency is also positively related to the volume of Ukrainian exports, because it makes imported products relatively cheaper and more accessible. In addition to the observed indicators, Intercept is statistically significant in this model. Therefore the volume of Ukrainian exports may be affected by other variables not included in the model.

Table 3. Results of the regression analysis for Poland

	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%	Lower 95%	Upper 95%
Intercept	-1.3E+07	2618308	-4.85354	0.008318*	-2E+07	-5438471	-2E+07	-5438471
GDP per capita (current US$)	534.1746	85.04142	6.281346	0.00328*	298.0617	770.2874	298.0617	770.2874
Political Stability and Absence of Violence/ Terrorism: Estimate	261246.4	1333704	0.19588	0.854252	-3441710	3964203	-3441710	3964203
Official exchange rate (LCU per US$, period average)	2042864	712604	2.86676	0.045617*	64358.41	4021370	64358.41	4021370

** The variable is significant at 0.05*

Source: calculated by the authors based on (World Bank Group; State Statistics Service of Ukraine)

Spain

Table 4 contains the results of the regression analysis for Spain. In this case, the dependent variable is the volume of Ukrainian exports to Spain. The model explains well the changes in the volume of Ukrainian exports to this country, because the coefficient of determination reaches 0.81.

Table 4. Results of the regression analysis for Spain

	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%	Lower 95%	Upper 95%
Intercept	-2059815	809948.7	-2.54314	0.051696**	-4141854	22224.59	-4141854	22224.59
GDP per capita (current US$)	119.416	28.7511	4.153442	0.00888*	45.50898	193.3231	45.50898	193.3231
Imports of goods and services (annual % growth)	-760.016	6247.564	-0.12165	0.907914	-16819.9	15299.86	-16819.9	15299.86

** the variable is significant at 0.05*

*** the variable is significant at 0.1*

Source: calculated by the authors based on (World Bank Group; State Statistics Service of Ukraine)

The only significant variable at 0.05 in this case is GDP per capita. As in Poland, the positive correlation of this indicator with Ukrainian exports to Spain is explained by the growth of the purchasing power of the local population. At 0.1, Intercept is also significant, so the possibility of influence of other factors on the level of Ukrainian exports to Spain should not be excluded.

China

The explanatory power of the model obtained for China is significantly lower than previous models. The coefficient of determination is only 0.48, and the refined coefficient of determination is 0.18. The regression results are presented in Table 5.

Table 5. Results of the regression analysis for China

	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%	Lower 95%	Upper 95%
Intercept	15640710	22608765	0.691799	0.519867	-4.2E+07	73758390	-4.2E+07	73758390
GDP per capita (current US$)	-240.378	1021.489	-0.23532	0.823294	-2866.2	2385.442	-2866.2	2385.442
Customs and other import duties (% of tax revenue)	-1.3E+07	10687394	-1.2596	0.26341	-4.1E+07	14010982	-4.1E+07	14010982
Taxes on international trade (% of revenue)	11934705	10253511	1.163963	0.296956	-1.4E+07	38292195	-1.4E+07	38292195

Source: calculated by the authors based on (World Bank Group; State Statistics Service of Ukraine)

None of the independent variables has a significant impact on the volume of exports from Ukraine. Accordingly, variations in the volume of Ukrainian exports to China are related to other factors not considered in the model. Such factors may include logistical, political factors, etc.

Turkey

The model built for Turkey is characterized by a low explanatory power (the coefficient of determination is 0.37). The correlation analysis made it possible to judge that Turkey's macroeconomic indicators do not correlate with the volume of Ukrainian exports - except for the indicator of political stability. Table 6 contains the results of the regression considering this indicator.

Table 6. Results of the regression analysis for Turkey

	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%	Lower 95%	Upper 95%
Intercept	4472600	822869,6	5,435369	0,000971*	2526823	6418377	2526823	6418377
Political Stability and Absence of Violence/Terrorism: Estimate	1199477	582725,5	2,058392	0,078551**	-178449	2577404	-178449	2577404

** The variable is significant at 0.05*

*** The variable is significant at 0.1*

Source: calculated by the authors based on (World Bank Group, 2024; State Statistics Service of Ukraine, 2024)

At 0.05, only Intercept is a significant indicator in this model, so the volume of Ukrainian exports to Turkey may be affected by variables not included in the model. At 0.1, the index of political stability in Turkey is also significant. In other words, the stabilization of the political situation in Turkey and the corresponding development of international activities can be correlated with the increase in the volume of Ukrainian exports to this country.

Germany

Table 7 contains the results of the regression analysis for Germany. The model has a high explanatory power of 0.94. The dependent variable is the volume of Ukrainian exports to Germany.

Table 7. Results of the regression analysis for Germany

	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%	Lower 95%	Upper 95%
Intercept	-3820007	1886762	-2.02464	0.098784**	-8670084	1030070	-8670084	1030070
GDP per capita (current US$)	142.8799	16.47317	8.673491	0.000337*	100.5343	185.2255	100.5343	185.2255
Official exchange rate (LCU per US$, period average)	-836226	1679801	-0.49781	0.639734	-5154290	3481839	-5154290	3481839

** The variable is significant at 0.05*
*** The variable is significant at 0.1*
Source: calculated by the authors based on (World Bank Group; State Statistics Service of Ukraine)

The most influential indicator in this case, as well as for Poland and Spain, is GDP per capita. The influence of other factors not considered in the model is not excluded. The results obtained emphasize the importance of careful monitoring of risks, the implementation of proper anti-crisis management at the micro and macro levels, and the development of foreign economic relations.

4. Discussions

The results of the author's work emphasize the importance of such areas as careful monitoring of export risks, balanced management and diversification of exports, and international cooperation. These findings are consistent with the recommendations of other authors. Wei (2024) also emphasizes the need to develop cooperation with the government, industry associations and international organizations. Zhang *et al.* (2023) explain the need for the formation of a highly accurate warning service about the risks of international trade. Yatsenko *et al.* (2021) noted the importance of geographical diversification of Ukrainian exports. Jiao *et al.* (2022) and Jiang *et al.* (2023) examined the export response to a trade war between China and the US. Judging by the researchers' conclusions, one can also note the effectiveness of export and product diversification.

At the same time, Khomych & Manaienko (2020) focus more on issues of standardization and assessment of responsibility and supervision. The need for standardization was also noted in the work of Heinzova *et al.* (2023). Dealing with the issue of risk management effectiveness, the researchers noted that less than half of small Czech exporters do not have the ISO 31000 certificate. At the same time, this standard helps companies to define risk management principles, strategy, and risk management process.

In the study of the impact of COVID-19 on the export of countries, a number of authors identified industries that were not significantly affected by the crisis or even brought certain benefits. Bas *et al.* (2024) noted that countries with more automated production processes were less vulnerable to the shock caused by the COVID-19 pandemic. In addition, the vulnerability of exports of unskilled intensive production decreased rapidly. Veeramani & Anam (2021) determined that digital services proved to be the most resilient to the crisis conditions of the pandemic, especially in view of adequate government support and relevant initiatives. Hayakawa & Mukunoki (2021) also noted the unevenness of the impact of the pandemic on different industries, in particular, the production of medical products was marked by an increase because of COVID-19. The results obtained in the author's research do not cover the distribution of exports by industry but consider the peculiarities of exports to different countries. At the same time, identifying differences in the exporters' risks depending on the industry can be a promising direction of research. The practical significance of the work consists in revealing the main risks of exporters depending on the export countries and the internal situation in Ukraine. The results of the study can be useful for exporters from the perspective of taking into account the identified risks and applying recommendations for their mitigation.

4.1. Limitations

The conducted research has its limitations. In particular, it to the analysis of only the largest importing countries of Ukrainian products and also does not take into account the sectoral peculiarities of exports. In addition, data on individual indicators (Customs and other import duties (current LCU), Customs and other import duties (% of tax

revenue) and Taxes on international trade) for Germany, Poland, and Spain are missing. At the same time, these limitations do not significantly affect the main results, and the aim of the study was achieved.

4.2. Recommendations

The results obtained during the research give grounds to provide the following recommendations regarding mitigating the risks of Ukrainian exporters:

- In order to reduce foreign exchange risk, it is worth using hedging tools (in particular, forward and futures contracts), diversifying foreign exchange income, and creating foreign exchange reserves. This can have a positive effect on Ukrainian exports.
- Active state support for export relations (conclusion of free trade agreements, application of customs privileges) and optimization of fiscal policy to improve terms of trade.
- Develop alternative logistics routes, export risk insurance, state support for producers and investments in infrastructure, increasing the flexibility of production and goods.

Conclusions

The research identified the main factors influencing the activity of Ukrainian exporters, depending on the partner country. In particular, the level of GDP per capita is a significant factor influencing the volume of exports from Ukraine to such EU countries as Germany, Poland, and Spain. This indicates that the increase in the purchasing power of the population of these countries contributes to the growth of demand for imported, including Ukrainian, goods. Besides, exports to Poland are closely related to fluctuations in the exchange rate of the local currency. The strengthening of the currency in this case indicates an increase in the availability of Ukrainian goods for importers. Exports to China and Turkey are less dependent on changes in local macroeconomic indicators. It is worth assuming that other (logistical, political) factors play a more significant role in this case. Internal indicators of Ukraine have a significant impact on the total volume of exports, in particular, GDP per capita, Customs and other import duties, and Taxes on international trade. The growth of GDP per capita and the share of taxes on international trade indicates an improvement in the economic situation and an increase in foreign economic activity, which contributes to the development of exports. The feedback of the volume of exports with customs and other import duties may indicate a high dependence of the national producer on imported components and raw materials. Further research may relate to the identification of differences in the exporters' risks depending on the field of their activity. In particular, it is worth investigating the risks of exporters of Ukrainian grain as a product of strategic importance for Ukraine in view of the specifics of importing countries.

Credit Authorship Contribution Statement

Hassan Ali Al-Ababneh: Conceptualization, Investigation, Methodology, Project administration, 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.

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Impact of Remittances on Women's Longevity in North African Countries

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Abstract: This article aims to explore the impact of migrants' remittances on life expectancy and mortality rate of adult women left behind in north African countries. The study contributes to the literature by highlighting how remittances can support the achievement of sustainable development goals. At the same time, it investigates the extent to which remittances may challenge social policies in these countries. The empirical findings suggest that remittances significantly increase life expectancy of women in north Africa countries. Furthermore, migrants' remittances are negatively and significatively associated with the mortality rate for adult women. Assessing the impact of remittances by country, highlights the existence of significant differences between the countries in the sub-region. The results suggest that, although remittances have positive aspects on the conditions of women, in the absence of specific public policies, the situation of elderly women in these countries is likely to deteriorate due to the risks social isolation and economic precarity.

Keywords: North Africa; dynamic ordinary least squares; life expectancy; gender; mortality rate; remittances; demographic transformation; demographic transition.

JEL Classification: J14; J16; I15; I14; C10; R11.

Introduction

Between 1990 and 2022, the North African countries have made significant progress in terms of both economic development[1] and human development[2]. However, this economic and human growth has not been accompanied by a reduction in gender inequalities.[3] Despite this situation, certain aspects reflecting living conditions in these countries remain favourable to women, such as life expectancy[4] and adult mortality rates[5]. During the same

[1] The average GDP per capita in this sub-region increased by 2.5 times between 1990 and 2021, rising from $1,464 in 1990 to $3,790 in 2021 (World Bank).
[2] Between 1990 and 2021, the average Human Development Index (HDI) in the sub-region rose from 0.5465 to 0.7225. This average increased by 32% while the world average increased by 22% (UNDP).
[3] According to the UNDP in 2022, Algeria, Morocco, Egypt and Tunisia were ranked, respectively, in 114th, 110th, 93rd and 59th place in terms of gender inequality.
[4] According to the United Nations Population Division, life expectancy at birth indicates the number of years a newborn baby should live if the general rules of mortality at the time of its birth were to remain the same throughout its life. In 2021, female life expectancy at birth was 76 years, while male life expectancy was 71.5 years.
[5] According to the United Nations Population Division, the adult mortality rate is the probability of death for a person aged 15 before reaching age 60, if subject to age-specific mortality rates current during this period. In 2021, the adult female mortality rate was 90 (deaths per 1000) compared to an adult male mortality rate of 143.5 (deaths per 1000).

period, countries in this sub-region received significant amounts of remittances[6] from their emigrants. Some research shows that remittances enable households in home countries to overcome budgetary constraints that hinder their access to healthcare services. They conclude that remittances lead to an increase in household health budgets (Amuedo-Dorantes and Pozo, 2011; Gerber and Torosyan, 2013). Others have concluded that remittances represent informal social protection that allows household members to access health care (Petreski *et al.* 2018).

This article enriches the discourse on demographic transformation in North African countries through an innovative analysis of how remittances affect the mortality rate and life expectancy of women. While several studies have investigated determinants explaining the increase in life expectancy and decrease in adult mortality (see, for example: Akoto, 1994; Daoudi, 2001; Hajjem and Achour, 2001; Gaimard, 2008; Sajoux and Nowik, 2010; Tabutin and Masquelier, 2017; Jafrin *et al.* 2021), few articles have explored the impact of remittances on adult longevity in home countries (including: Zhunio *et al.* 2012; Amakom and Iheoma, 2014; Amega, 2018; Azizi, 2018; Ullah *et al.* 2019). Existing studies either cover a large panel of developing countries without regional differentiation in political and economic integration[7], or concentrate on specific areas[8] unrelated to the countries in this sub-region. This situation highlights the significance of this study in addressing this gap within the context of North African countries. Therefore, this research aims to fulfil this gap by examining the impacts of remittances on the life expectancy and mortality adult women in North African countries.

Concentrating this research on women in North African countries is interesting on several levels. First, it allows us to empirically explore the consequences of receiving remittances on a segment of the population that has been largely absent from the debate on the impact of migration on home countries (Moujoud, 2008; Cortes, 2016). Secondly, although North African women have made inroads into fields traditionally reserved for men[9], they still face various forms of gender-based discrimination.[10] This study investigates how remittances can improve longevity of North African women, while also paving the way for new research on migration and gender in this sub-region.

Focusing on the life expectancy and mortality rates of adult women helps inform policymakers in these countries about the challenges they may face in the coming years. In fact, women in these countries have been largely excluded from the labour market[11], depriving them of social protection in their advanced years. In addition, North African societies are experiencing profound social transformations that have reshaped the traditional pattern of family relationships. For years, these countries have witnessed a shift from extended households to nuclear households.[12] This shift in social organization reduces the intergenerational solidarity that previously served as a social safety net and alternative welfare system, protecting elderly individuals, especially women, from social isolation and economic precariousness. This article offers political and economic decision-makers a set of proposals to anticipate these changes.

The two main obstacles to estimating the impact of remittances on female life expectancy and mortality in North African countries are the size of the panel and the endogeneity of remittances. To overcome these obstacles, the Dynamic Ordinary Least Squares (DOLS) method, proposed by Stock and Watson (1993), was used. Our results indicate that remittances significantly increase life expectancy and significantly reduce the mortality rate for women. A more detailed analysis, which consists of assessing the impact of remittances by country, reveals the existence of significant differences between the countries in the sub-region, highlighting the specific local characteristics of each country.

This paper contributes to the existing literature on gender and migration in several ways. First, the paper uses data from North African countries for the period 1990 to 2021. To the best of our knowledge, we are not

[6] Between 1990 and 2021, these four countries received an average of just over $18 billion USD in remittances. This amount corresponds to an annual average of 4.5% of their GDP (World Bank).
[7] Among others: Zhunio *et al.* (2012); Azizi (2018).
[8] For example: (Amakom and Iheoma, 2014; Bare *et al.* 2021and Hao *et al.* 2023) on sub-Saharan African countries and Ullah et al., 2019 on Asian countries.
[9] For example, the gender parity rate for higher education enrolment in 2022 was 1.01 in Egypt, 1.12 in Morocco and 1.42 in Algeria and Tunisia (World Bank).
[10] Particularly in terms of employment and participation in the labour market. For example, in 2022, the female labor force participation rate in these four countries was only 19.5% (ILO estimate).
[11] Between 1991 and 2022, the participation rate of women in the labour force in these four countries was on average 22.4% (ILO estimate).
[12] In 2001, nuclear households represented three-quarters of Tunisian households. In 2002, 75% of Algerian households are nuclear. In 1998-1999, more than half of Moroccan households (58%) are nuclear.

aware of any papers estimating the impact of remittances on female life expectancy and mortality in the countries of this sub-region. Secondly, this study surpasses the limitations of previous research that estimated the impact of remittances on women's healthcare access by directly measuring its effects on women's longevity.

The rest of the article is organised as follows: after the introduction, the second section presents a review of the literature on the impact of remittances on access to the healthcare system and on adult life expectancy and mortality. The third section is dedicated to presenting the data and empirical models, while the fourth section outlines the methodological approach. The fifth section presents empirical results, while the sixth section is dedicated to the conclusion and policy recommendations.

1. Literature Review

International migration and its corollary remittances have attracted the interest of academic researchers. They have concluded that migrant remittances have an impact on several aspects of the economic and social development of home countries (see, among others: Adams and Page, 2003; Faini, 2007; Gupta *et al.* 2009; Adams and Cuecuecha, 2013; Bouoiyour, 2013; Bouoiyour *et al.* 2016, Zennati *et al.* 2025). In this context, especially since the late 2000s, research on migration and remittances has increasingly focused on the impact of human mobility on the health of individuals left behind in their home countries. The studies conducted have focused on various aspects related to the healthcare sector. The first trend reveals that emigrants interact with the healthcare systems of their host countries. Interactions with various stakeholders in this ecosystem enable emigrants to internalize new knowledge and practices. These new behaviours and information are then transferred to communities of origin through social remittances (Levitt, 1998). This dissemination contributes to an enhanced understanding of the benefits of modern preventive care (see, for example, Ponce *et al.* 2011). Other studies demonstrate that remittances enable households in home countries to overcome budgetary constraints that previously limited their access to healthcare service. They conclude that remittances imply an increase in household health budgets. This result has been observed in several countries of origin: Abraham and Tao (2021) in 130 developing countries, Valdero-Gil (2009) and Amuedo-Dorantes and Pozo (2011) in Mexico, Gerber and Torosyan (2013) in Georgia, Petreski *et al.* (2018) in Macedonia, Paul and Omeje (2022) in Nigeria, Basu and Biswas (2024) in Kenya and Li *et al.* (2024) in China. Moreover, it has been found that migrant remittances increase government health expenditures in developing countries (Williams, 2024).

Other researchers consider remittances as a form of informal social protection that enables household members to access healthcare (Petreski *et al.* 2018). Another line of research has highlighted that the impact of remittances on health includes improvements in the nutrition of populations in the countries of origin (for example: Combes *et al.* 2014; Sangwan and Tasciotti, 2023). They argue that remittances help stabilize food prices in countries of origin, enabling households to maintain their usual consumption levels and thereby improving nutritional status. In a study covering 122 developing countries between 1990 and 2015, Azizi (2018) argues that remittances reduce the prevalence of malnutrition. In a representative World Health Organization survey, Antón (2010) studies the impact of remittances on nutritional status in Ecuador in 2006. He concludes that remittances have a positive and significant effect in the short and medium term on nutritional status.

Since the mid-2010s, research has focused on the results and changes produced by the allocation of migrants' remittances in access to healthcare. In this regard, two areas have attracted the attention of researchers. The first area explores the relationship between remittance receipts and life expectancy in the home countries. Existing research indicates that remittances contribute to increasing life expectancy in home countries. Analysing the impact of remittances on human capital in 122 developing countries, Azizi (2018) finds that remittances improve life expectancy in home countries. In the same line, Kuziboev *et al.* (2024) finds that life expectancy is positively correlated with remittances in 11 CIS countries.[13] Additionally, Zhunio *et al.* (2012) explores the effect of remittances on the health of people staying in 69 developing countries. They find that remittances significantly increase life expectancy in the countries studied. Similarly, Amakom and Iheoma (2014) investigate the impact of remittances on health outcomes in 18 sub-Saharan African countries, concluding that remittances significantly enhance life expectancy in these countries of origin. Also, Amega (2018) focuses its research on 46 countries in sub-Saharan Africa. He concludes that remittances are positively associated with life expectancy in these countries. In the same vein, Bare *et al.* (2021) conclude that remittances contribute to higher life expectancy in 39 sub-Saharan African countries. In South Asian countries, Ullah et al (2019) analyse the effect of remittances on health indicators. They conclude that remittances are positively and statistically

[13] The CIS countries covered by this study are: Armenia, Azerbaijan, Belarus, Georgia, Kazakhstan, Kyrgyzstan, Moldova, Russia, Tajikistan, Ukraine, and Uzbekistan.

significantly associated with increased life expectancy in these countries. Another area attempts to analyse the impact of husband emigration on the health of wives left behind in the countries of origin and to identify the mechanisms by which these effects are transmitted. Lei and Desai (2021) show that wives who left behind had worse health compared to the wives of non-migrants. They attribute this effect to the limited number of remittances sent by migrant husbands and the additional responsibilities placed on women, such as caring for animals and managing household finances. Zhang *et al.* (2022) study the impact of adult children's migration on their parents' health in rural China. They find that, thanks to remittances, the migration of adult children leads to an improvement in the physical health of the parents. They add that this income effect is attenuated by the parental time allocation effect which has a negative effect on parents' health due to lack of care and increased working hours.

The second area of research interest relates to the adult mortality rate in the home countries. Although rare, existing studies highlight that remittances are positively associated with reducing adult mortality rates in countries of origin. In a study that estimates the impact of remittances on health outcomes in 46 sub-Saharan African countries, Amega (2018) concludes that remittances are negatively associated with adult mortality in sub-Saharan African countries.

The mechanism by which remittances reduce adult mortality and extend life expectancy lies in the impact of these funds on health outcomes. By studying the effect of remittances on health outcomes in 107 developing countries over the period from 1990 to2018 and using a panel vector autoregression (PVAR) model, Djeunankan and Tekam (2022) conclude that that remittances improve health outcomes in developing countries. Furthermore, by analysing the impact of remittances on Human Development Index (HDI) rankings. Ali *et al.* (2024) find that remittances significantly improve the well-being of populations in countries of origin through improved health outcomes. Kan (2021) shows that remittances have a positive and significant effect on the likelihood that household members seek direct medical care in tadjikistan. Moreover, he confirms the positive role of remittances in improving the well-being of left behind. On the other hand, remittances increase the healthy social and physical functioning of elderly adults Ojijieme *et al.* (2022).

2. Data and Empirical Model

2.1 Data

This study examines four developing countries in North Africa.[14] The data used in this study is annual and spans from 1990 to 2021. Living conditions are assessed using two indicators: life expectancy at birth (LE) and the adult female mortality rate (Mortality). The main variable of interest in this paper is per capita remittances (REM-CAPI), which is calculated as the total remittance inflows for a given year divided by the population size of that year. This measure was chosen over the remittance-to-GDP ratio because fluctuations in the latter could be attributed to both changes in GDP and the volume of remittances received. As noted by Escribà-Folch *et al.* (2015), this dual dependency complicates isolating the effect of remittances on the outcomes under study. To strengthen the robustness of our findings, we also introduce a second proxy of interest - annual total remittances received by the country (REMIT) - into our models.

Economic development is measured by gross domestic product (GDP) per capita, expressed in current U.S. dollars adjusted for purchasing power parity (GDP-CAPI). To assess the effect of public policies, two proxies are introduced: the ratio of government spending on education to GDP (EDUC-EXPE) and the percentage of current health expenditure as a share of GDP (HEAL-EXPE). Finally, urbanization is quantified by the urban population rate (URBA-POPU). [15]To account for the demographic characteristics of the countries in our panel, two variables have been introduced into our models. The first corresponds to the total fertility rate (**TFR**).[16] The second proxy measures the proportion of individuals aged 65 and over within the total population (**OVER-65**). All variables are sourced from the World Bank's World Development Indicators (WDI) database. To reduce variance, the variables REM_CAPI, REMIT, GDP_CAPI, HEAL_EXPE, EDUC_EXPE, and URBA_POPU were transformed by applying the natural logarithm

[14] This paper covers: Algeria, Egypt, Morocco and Tunisia. Libya was excluded for lack of data.
[15] This rate corresponds to the share of people living in urban areas compared to the total population.
[16] This rate represents the number of children that would be born to a woman if she lived to the end of her childbearing years.

2.2 Empirical Model

The baseline model used to estimate the impact of remittances on the longevity of women in North African countries is specified as follows:

$$\boldsymbol{log(Y)_{it} = \beta_0 + \beta_1 log(Rem - capi_{it}) + \gamma_i X_{it} + \epsilon_{it}} \quad (1)$$

Where:

i corresponds to the country (ranging from 1 to N, where N represents the number of countries in our panel). t refers to the time (ranging from 1 to T), covering the period from 1990 to 2021. β_0 is a constant, $Rem - capi_{it}$ is the amount of per capita remittances and X_{it} is the vector of variables that potentially affect Y_{it} and ϵ_{it} is the error term.

In this paper, women's longevity is measured by two proxies, life expectancy at birth[17] (LE) and the mortality rate of adult women[18] (Mortality).

Estimating the effect of remittances on women's longevity involves two empirical models, which build upon existing models (*e.g.*, Amakom and Iheoma, 2014; Azizi, 2018; Ullah *et al.* 2019).

$$\textbf{Model 1: } \boldsymbol{log(LE)_{it} = \beta_0 + \beta_1 log(Rem - capi_{it}) + \gamma_i X_{it} + \epsilon_{it}} \quad (2)$$

The vector of control variables X_{it} is composed of GDP per capita, the rate of government spending on health in GDP, the rate of population over 65, the rate of education spending in GDP and the total fertility rate.

$$\textbf{Model 2: } \boldsymbol{log(Mortality)_{it} = \beta_0 + \beta_1 log(Rem - capi_{it}) + \gamma_i X_{it} + \epsilon_{it}} \quad (3)$$

The vector of control variables X_{it} is composed of GDP per capita, the rate of government spending on health to GDP, the share of the population over 65 years of age among the overall population, the share of the urban population and the total fertility rate.

2.3 Empirical Methodology

Estimating the impact of remittances on women's longevity in North African countries involves several stages. Before applying cointegration techniques, we first need to verify the stationarity of all variables included in our model. To do this, we employ panel unit root tests based on the methodology of Im *et al.* (2003). Additionally, we apply the Fisher-type augmented Dickey-Fuller (ADF) panel unit root test, as proposed by Dickey and Fuller (1979)

When certain variables are integrated of order one, the issue of spurious correlations may arise. To address this, we analyze the cointegration between the dependent and independent variables in the panel dataset. The presence of cointegration rules out the bias from spurious correlations and confirms the existence of a long-term relationship between the variables in the model. The most commonly used test in the context of panel data models is that proposed by Pedroni (1999, 2001b). This test includes seven distinct statistical tests: four intra-dimensional statistics (Panel v-Statistic, Panel Rho-Statistic, Panel PP-Statistic, Panel ADF-Statistic) and three cross-sectional statistics (Group rho-Statistic, Group PP-Statistic, Group ADF-Statistic). When at least four of these statistics are significant, the null hypothesis is rejected, indicating the presence of a long-term relationship between the variables. To further assess the robustness of the cointegration results, we also apply the cointegration test proposed by Kao (1999), which is based on the DF (Dickey-Fuller) and ADF (Generalized Dickey-Fuller) tests. The null hypothesis is "H0: no cointegration," while the alternative hypothesis is "H1: cointegration exists." If the ADF test statistic is significant, the null hypothesis is rejected, implying that the series are cointegrated.

According to the existing literature, three methods have been commonly used to estimate long-term relationships in the presence of panel data: Panel Ordinary Least Squares (POLS) (*e.g.*, Azizi, 2018), Fully Modified Ordinary Least Squares (FMOLS), and Dynamic Ordinary Least Squares (DOLS) (*e.g.*, Hooy *et al.* 2015; Shahbaz *et al.* 2021). Several studies have highlighted that estimates obtained using the POLS method may be biased due to issues such as endogeneity (*e.g.*, Kao and Chiang, 2000; Pedroni, 2001a; Pedroni, 2001b; Narayan and Narayan, 2005; Shahbaz *et al.* 2021; Hooy *et al.* 2015; Latif, 2015; Ahmad *et al.* 2023). In this paper, the primary method for estimating long-term relationships is the Dynamic Ordinary Least Squares (DOLS) method, introduced by Stock and Watson (1993). This method was chosen for its effectiveness with small panel datasets and its ability to address endogeneity bias among regressors (Kao and Chiang, 2000; Hooy *et al.* 2015;

[17] Life expectancy at birth indicates the number of years a newborn would live if the prevailing mortality patterns at the time of birth remained the same throughout their life.

[18] The mortality rate among adult women corresponds to the probability that a young woman aged 15 will die before reaching the age of 60.

Álvarez-Ayuso *et al.* 2018). To ensure the robustness of the results, the Fully Modified OLS (FMOLS) method, developed by Phillips and Hansen (1990), is used as an alternative.

3. Results

3.1 Descriptive Statistics

Table 1 presents the descriptive statistics for the series included in our model. The average remittances per capita received in the North African countries is 120 USD. This figure fluctuated between 38 and 288 USD during the period, highlighting the disparities among the four countries. Additionally, the average annual remittance inflow for these countries is 10.9 billion USD, with Egypt being the primary contributor. This table also highlights the results achieved through public health policies. In this context, the average life expectancy at birth for women in these countries is 70.89 years, showing an increase of over thirty years, rising from 65.9 years to nearly 74 years. The improvement in life expectancy has been accompanied by a notable reduction in the adult female mortality rate, which averaged 116 deaths per 1,000 women annually. North African countries have invested a significant portion of their GDP in education and health. Between 1990 and 2021, these countries allocated nearly 5% of their GDP annually to the health sector and 4% to the education sector. Additionally, these countries have undergone a moderate demographic transition. During the period studied, the total fertility rate averaged 2.99 births per woman. This decline in fertility, along with other factors, has led to an increase in the proportion of the population aged over 65, which averaged 4.66% during this period. North African countries have also experienced a significant wave of urbanization, with just over half of the population living in cities between 1990 and 2021.

Table 1. Description and Descriptive Statistics of Variables

Variable	Description	N	Mean	Std. Dev.	Min	Max	Source
REM-CAPI	Remittances per capita	128	120.18	80.83	38.89	288.18	Calculated
REMIT	Annual amount of remittances received	128	1.09E+10	9.12E+09	2.85E+09	3.15E+10	WDI
GDP-CAPI	*GDP per capita expressed in current international dollars converted by the purchasing power parity*	128	7523.31	2849.87	3639.37	12706.40	WDI
EDUC-EXPE	The share of government expenditure on education in GDP (as % of GDP)	80	3.98	0.66	2.48	4.95	WDI
HEAL-EXPE	*The share of health expenditure in GDP (as % of GDP)*	*80*	*4.91*	*0.41*	*4.15*	*5.63*	*WDI*
LE	*Life expectancy at birth for females*	*128*	*70.89*	*2.33*	*65.97*	*73.97*	*WDI*
MORTALITÉ	*Adult female mortality rate (per 1000 deaths)*	*128*	*116.15*	*38.75*	*61.94*	*214.70*	*WDI*
URBAN-POPU	*Rate of urban population in total population*	*91*	*54.79*	*8.50*	*42.66*	*68.35*	*WDI*
TFR	*Total fertility rate*	*91*	*2.99*	*0.66*	*1.96*	*4.56*	*WDI*
OVER-65	*The share of people over 65 in the total population*	*91*	*4.66*	*0.96*	*3.03*	*7.68*	*WDI*
WDI : World Development Indicator							

Source: developed by the authors

3.2 Unit Root Tests

To analyze the impact of migrants' remittances on women's empowerment in North African countries, we first assess the stationarity properties using the Im *et al.* (2003) and Augmented Dickey-Fuller (ADF) panel unit root tests. Table 2 presents the results of the unit root tests for all the variables included in our models. The table shows that all variables are integrated of order I(1), and none display I(2) characteristics.

Table 2. Unit root test

		At level		1st difference		
Variable	Test	Statistic	Prob.	Statistic	Prob.	Conclusion
REM_CAPI	Im, Pesaran and Shin W-stat	2.341	0.9904	-3.815	0.0001	I(1)
	ADF - Fisher Chi-square	4.581	0.8013	31.484	0.0001	I(1)
REMIT	Im, Pesaran and Shin W-stat	3.577	0.9998	-3.216	0.0007	I(1)
	ADF - Fisher Chi-square	3.133	0.9258	27.344	0.0006	I(1)
GDP-CAPI	Im, Pesaran and Shin W-stat	3.025	0.9988	-3.623	0.0001	I(1)
	ADF - Fisher Chi-square	1.855	0.9851	28.878	0.0003	I(1)
HEAL_EXPE	Im, Pesaran and Shin W-stat	0.491	0.6882	-4.168	0.0000	I(1)
	ADF - Fisher Chi-square	5.648	0.6866	30.739	0.0002	I(1)
EDUC_EXPE	Im, Pesaran and Shin W-stat	1.018	0.8457	-2.578	0.0050	I(1)
	ADF - Fisher Chi-square	6.989	0.5378	26.458	0.0002	I(1)
LE	Im, Pesaran and Shin W-stat	0.106	0.5422	-3.463	0.0003	I(1)
	ADF - Fisher Chi-square	5.574	0.6948	38.179	0.0000	I(1)
OVER_65	Im, Pesaran and Shin W-stat	2.824	0.9976	-2.17783	0.0147	I(1)
	ADF - Fisher Chi-square	12.012	0.1507	18.1287	0.0203	I(1)
Individual intercept included in unit root test equation Lag length on automatic selection and Swartz info criterion (SIC)						

Source: developed by the authors

3.3 Panel Cointegration Test

Before estimating equations (eq.1) and (eq.2), it is essential to conduct panel cointegration tests to examine the presence of long-term relationships and avoid the risk of spurious results. As mentioned earlier, we employ the Pedroni and Kao cointegration tests. Table 3 shows that both the Pedroni and Kao cointegration tests confirm the existence of cointegration among the variables in both models.

Table 3. Cointegration tests

Test	Variable	Model 1	Model 2
Pederoni	Panel v-Statistic	5.479***	-1.657
	Panel rho-Statistic	1.599	2.789
	Panel PP-Statistic	-4.623***	-5.829***
	Panel ADF-Statistic	-3.245***	-3.304***
	Group rho-Statistic	2.619	3.372
	Group PP-Statistic	-3.613***	-8.920***
	Group ADF-Statistic	-2.609***	-3.279***
Kao	ADF	-3.640***	-1.782**
***** significance at 1%, ** significance at 5%, * significance at 10% Note: The results of the Pedroni test for both models are with constant and trend.**			

Source: developed by the authors

3.4 Results of the Cointegrated Panel Estimator

In this paper, we estimate the impact of remittances on women's living conditions in North African countries. As mentioned earlier, living conditions are measured using two proxies: the first is women's life expectancy at birth, and the second is the women's mortality rate. To this end, we estimate the two models using the Dynamic OLS method. As noted above, the main variable of interest is the number of remittances per capita (Rem-capi). To test the robustness of the results, we use the annual amount of remittances received by each country (Remit) as an alternative variable of interest, and the Fully Modified OLS method as an alternative estimator

Evaluating the impact of remittances on women's life expectancy in North African countries requires estimating equation (eq.1). The results of this estimation are presented in Table 4.

Table 4. Estimated impact of remittances on female life expectancy at birth

Model 1				
Dependent variable: LE				
	DOLS	**FMOLS**	**DOLS**	**FMOLS**
LREM_CAPI	0.010*** (0.003)	0.013*** (0.002)		
LREMIT			0.010*** (0.002)	0.013*** (0.002)
LGDP_CAPI	0.034*** (0.012)	0.038*** (0.009)	0.032*** (0.011)	0.036*** (0.009)
LHEAL_EXPE	0.014 (0.022)	-0.0001 (0.024)	0.011 (0.022)	-0.002 (0.023)
LEDUC_EXPE	0.014 (0.015)	0.0166 (0.014)	0.016 (0.015)	0.018 (0.013)
OVER_65	0.012*** (0.004)	0.009*** (0.003)	0.012*** (0.004)	0.009*** (0.003)
TFR	-0.032* (0.018)	-0.038** (0.018)	-0.032* (0.017)	-0.039** (0.017)
Values in brackets denote standard error. * significance at 1%, ** significance at 5%, * significance at 10%. Dols made for a constant trend.**				

Source: developed by the authors

Table 4 shows that remittances are positively and significantly associated with an increase in life expectancy in North African countries. The DOLS method reveals that a 10% increase in remittances per capita results in a 0.10% increase in women's life expectancy in these countries. This finding suggests that migrant remittances have a positive impact on life expectancy at birth in the home countries. This result aligns with the findings of Azizi (2018) in his study of 122 developing countries, Omon (2021) in the West African Monetary Zone (WAMZ) countries, Zhunio *et al.* (2012) in their survey of 69 low- and middle-income countries, and Naatus (2013) in El Salvador. For robustness, the same results are obtained using the alternative variable of interest and alternative estimator.

Table 5. Estimated impact of remittances on adult female mortality

Model 2				
Dependent variable: Mortality				
	DOLS	**FMOLS**	**DOLS**	**FMOLS**
LREM_CAPI	-0.030** (0.014)	-0.029*** (0.009)		
LREMIT			-0.032** (0.013)	-0.031*** (0.009)
LGDP_CAPI	-0.243*** (0.062)	-0.298*** (0.045)	-0.231*** (0.061)	-0.286*** (0.045)
LHEAL_EXPE	-0.109 (0.115)	-0.090 (0.085)	-0.101 (0.113)	-0.083 (0.084)
OVER_65	0.150 (0.182)	0.402*** (0.135)	0.149 (0.178)	0.397*** (0.133)
TFR	0.109 (0.089)	0.173** (0.068)	0.109 (0.087)	0.174** (0.067)
LURBA_POPU	-2.611*** (0.526)	-3.086*** (0.383)	-2.615*** (0.515)	-3.097*** (0.377)
Values in brackets denote standard error. * significance at 1%, ** significance at 5%, * significance at 10%. Dols made for a constant trend.**				

Source: developed by the authors

The country-specific results are shown in Table 6 in the appendix. We observe that, with the exception of Tunisia, remittances have a positive effect on female life expectancy. A 10% increase in remittances per capita

corresponds to a 0.02% increase in female life expectancy in Algeria, 0.17% in Egypt, and 0.007% in Morocco.[10] This finding aligns with the studies by Naatus (2013), Zhunio *et al.* (2012), Amakom and Iheoma (2014), Azizi (2018), Amega (2018), and Bare *et al.* (2021). Some researchers suggest that this positive impact is due to remittances improving recipients' access to healthcare and increasing their healthcare spending (Nathaniel, 2019; Omon, 2021). For robustness, the same results were obtained using an alternative interest variable and estimator.

Model 2 is estimated to assess the impact of remittances on the mortality rate of adult women. The results in Table 5 indicate that remittances are negatively and significantly correlated with adult female mortality in North African countries. A 10% increase in per capita remittances would lead to an approximate 0.3% reduction in female mortality in these countries. Previous research has shown that remittances not only alleviate economic hardship but also increase the share of household income allocated to health expenditures. Furthermore, remittances enhance household food security and encourage greater use of healthcare services (Kuhn, 2006; Valdero-Gil, 2009; Ponce *et al.* 2011; Adams and Cuecuecha, 2013; Azizi, 2018; Agadjanian *et al.* 2021). These improvements in living conditions positively affect the health of women left behind, thereby contributing to a decrease in their mortality rate. This result aligns with previous findings that remittances contribute to an increase in female life expectancy in these countries. In fact, it has been demonstrated that the reduction in adult mortality is linked to an increase in life expectancy at birth (among others: Vaupel, 1986; Crimmins and Zhang, 2019; Marshall *et al.* 2019; Woolf and Schoomaker, 2019).

Our findings further suggest that an increase in income, as measured by GDP per capita, significantly reduces mortality rates among adult women. Specifically, higher income improves individuals' access to healthcare services, which in turn has a positive effect on lowering mortality during adulthood. Additionally, higher income may contribute to a decrease in the fertility rate, resulting in better overall health conditions. As a result, the mortality rate among adult women decreases. In line with our expectations, the increase in the proportion of individuals over 65 and the total fertility rate positively affects the mortality rate of adult women in North African countries. Moreover, urbanization plays a key role in reducing female mortality in these countries. Urban women are more likely to benefit from healthcare services, medical monitoring of pregnancies, improved housing conditions, and other factors. It is important to note, however, that the proportion of health expenditure in GDP does not have a significant impact on female mortality in North African countries.

This broad analysis seems to overlook certain nuances. As a result, a country-specific analysis was carried out. The findings, presented in Table 7 of the appendix, show a negative and significant relationship between remittances and adult female mortality in Egypt and Morocco. Specifically, a 10% increase in per capita remittances would lead to a reduction in the mortality rate for adult women by 0.8% in Egypt and 0.24% in Morocco. In contrast, remittances are positively correlated with an increase in female mortality in Algeria and Tunisia. For robustness, the same results were obtained using an alternative interest variable and estimator

The positive impact of remittances on life expectancy and the reduction in mortality among adult women in Morocco and Egypt can be attributed to the significant portion of remittances spent on healthcare and medicines. This expenditure represents the third-largest allocation of remittances, accounting for 18% in Morocco and 11.8% in Egypt, respectively (Jureidini *et al.* 2010; Farid *et al.* 2013; HCP, 2022). Although Tunisian households receiving remittances allocate more than 15% of these funds to medical expenses and medicines (Kriaa and Ben Youssef, 2022), our findings indicate that these transfers have a negative effect on life expectancy and mortality among adult women.

Several researchers have highlighted significant challenges in financing Tunisia's healthcare system (Abu-Zaineh *et al.* 2013; Abdelaziz *et al.* 2018; Ismaïl, 2021). Abu-Zaineh *et al.* (2013) note that the system remains heavily dependent on direct out-of-pocket payments, which can constitute up to 40.5% of healthcare expenses, despite the availability of medical coverage. While remittances could provide a financial solution to this issue, the amounts sent by households appear insufficient to meet the growing demand. A second explanation is that male migration may have a negative impact on the health of women left behind in Tunisia. This decline in health could be partly attributed to the limited funds remitted, the increased responsibilities placed on women, feelings of loneliness and abandonment, and greater experiences of oppression and control (McEvoy, 2008; Kadi, 2020; Lei and Desai, 2021). The situation in Algeria is linked to the lack of public policies aimed at better utilizing remittances (Mohamed, 2024) and the relatively low volume of remittances compared to the substantial influx of oil revenues (Johansson, 2012)

Conclusion

This paper aims to estimate the impact of remittances on female life expectancy and mortality in North African countries from 1990 to 2021. Considering the size of our panel and to address potential endogeneity bias of remittances, we have employed the Dynamic Ordinary Least Squares (DOLS) method as proposed by Stock and Watson (1993). To verify the robustness of the findings, we employ the Fully Modified Ordinary Least Squares (FMOLS) method, developed by Phillips and Hansen (1990), as an alternative estimator method. our findings indicate that remittances exert a positive and statistically significant impact on the living conditions of women in North African countries. A 10% rise in remittance inflows would lead to a 0.3% reduction in the morality rate of adult women and a 0.1% increase in life expectancy. This result can be attributed to the fact that remittances enhance access to health care and preventive health measures for those left behind, particularly women and girls. Remittances also alleviate the budgetary constraints of households in home countries, thereby improving their access to quality food.

Although the countries in this subregion share certain similarities, they also exhibit points of divergence. In this regard, a more detailed country-by-country analysis reveals disparities in the effects of remittances on longevity of North African women. Indeed, while remittances benefit of Egyptian and Moroccan women, they exacerbate the living conditions of Tunisian women. It appears that in Algeria, which differs structurally from other countries in the sub-region, remittances have a limited impact on the situation of women. These differences can be attributed to several factors. Such as the volume of remittances received and the share that these remittances represent in each country's GDP. In addition, these differences can be attributed to the public policies of these countries towards their diasporas. The economic choices of each country and the allocation of remittances. However, more in-depth analyses are needed to better interpret the existing differences. These results indicate that remittances have significant potential to enhance human development indicators for women in North African countries. Remittances could also serve as an effective strategy for reducing gender inequalities in these nations and advancing their progress towards achieving the Sustainable Development Goals (SDGs). This study, on the other hand, highlights that remittances may pose a risk to the sustainability of social protection systems in these countries.

This study makes several contributions to existing literature. Firstly, it utilizes data from North African countries spanning the period from 1990 to 2021. To our knowledge, no prior papers have explored the impact of remittances on women's living conditions in the countries of this sub-region, which are geographically situated near Europe and therefore possess strategic significance. Secondly, this study surpasses the limitations of previous work that estimated the impact of remittances on women's access to fundamental rights. However, this work allows for the measurement of the effects induced and changes brought by the receipt of remittances on women's situation.

While previous studies have focused on analysing the impact of remittances on women's access to healthcare, this article examines the broader societal changes brought about by these remittances. This approach will provide a deeper understanding of the demographic transition in these countries. Additionally, it will help inform policymakers and international cooperation organizations, enabling them to anticipate potential societal challenges that could worsen the economic and social situation of this segment of the population.

In terms of policy recommendations, the countries in the sub-region are encouraged to maximize and sustain the positive effects of remittances. They are also invited to set up appropriate pension plans for women to prevent them from falling into poverty at retirement age. These countries will also benefit from directing a part of remittances towards health insurance, ensuring that older women can access healthcare services. These countries should enhance the gender dimension in the expansion of their national social protection programs. Additionally, health studies should evolve to include considerations for women's geriatric health. These countries also need to promote research in gerontology and gender-specific health issues.

Credit Authorship Contribution Statement

Aomar Ibourk: Conceptualization, Methodology, Formal analysis, Writing – original draft, Supervision, Validation, review.

Oussama Zennati: Investigation, Formal analysis, Writing – original draft, Data curation, Visualization, 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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Appendix

Table 6. Impact of remittances on women's life expectancy in North African countries

	Algeria				Egypt				Morocco		Tunisia			
Dependent variable: LE														
	DOLS	**FMOLS**	**DOLS**	**FMOLS**	**DOLS**	**FMOLS**	**DOLS**	**FMOLS**	**DOLS**	**DOLS**	**DOLS**	**FMOLS**	**DOLS**	**FMOLS**
LREM_CAPI	0.002** (0.0006)	0.002** (0.0005)			0.017* (0.007)	0.017*** (0.003)			0.0007 (0.027)		-0.016* (0.008)	-0.016** (0.006)		
LREMIT			0.002** (0.0006)	0.002** (0.0006)			0.019** (0.006)	0.018*** (0.003)		0.006 (0.027)			-0.015 (0.008)	-0.015** (0.006)
LGDP_CAPI	0.024 (0.012)	0.029* (0.011)	0.024 (0.012)	0.028* (0.010)	0.023 (0.023)	0.023 (0.011)	0.008 (0.022)	0.011 (0.011)	0.169 (0.093)	0.179 (0.087)	0.068*** (0.018)	0.067*** (0.013)	0.066*** (0.018)	0.064*** (0.013)
LHEAL_EXPE	0.039*** (0.009)	0.034** (0.008)	0.040*** (0.009)	0.034** (0.008)	0.015 (0.019)	-0.019 (0.015)	0.018 (0.017)	-0.015 (0.014)	-0.001 (0.059)	0.008 (0.059)	0.057** (0.024)	0.067*** (0.019)	0.056** (0.025)	0.065*** (0.019)
LEDUC_EXPE	0.006 (0.005)	0.009 (0.005)	0.006 (0.005)	0.009 (0.005)	0.012 (0.010)	0.0004 (0.006)	0.010 (0.009)	-0.0002 (0.005)	0.017 (0.014)	0.015 (0.015)	0.002 (0.005)	0.001 (0.004)	0.002 (0.005)	0.001 (0.004)
OVER_65	0.027*** (0.002)	0.028*** (0.002)	0.027*** (0.002)	0.028*** (0.002)	0.007 (0.008)	0.051** (0.011)	0.003 (0.007)	0.043*** (0.011)	0.0006 (0.024)	-0.002 (0.024)	1.94E-05 (0.004)	0.0002 (0.003)	0.002 (0.003)	0.002 (0.003)
TFR	-0.013 (0.013)	-0.009 (0.011)	-0.014 (0.013)	-0.011 (0.011)	-0.018** (0.007)	-0.023*** (0.004)	-0.017** (0.006)	-0.021*** (0.004)	0.004) (0.081)	-0.007 (0.082)	-0.035** (0.014)	-0.042*** (0.013)	-0.035** (0.014)	-0.042** (0.014)
C	3.916*** (0.123)	3.861*** (0.109)	3.883*** (0.13)	3.827*** (0.110)	3.982*** (0.162)	3.871*** (0.084)	3.775*** (0.067)	3.659*** (0.049)	2.763* (0.696)	2.569 (1.038)	3.79*** (0.114)	3.796*** (0.083)	4.040*** (0.058)	4.049*** (0.043)
Values in brackets denote standard error. ***** significance at 1%, ** significance at 5%, * significance at 10%.** **Dols made for a constant trend.** **Results for Morocco using the FMOLS model are not available**														

Source: developed by the authors

Table 7. Impact of remittances on female mortality in North African countries

	Algeria				Egypt				Morocco				Tunisia			
Dependent variable: Mortality																
	DOLS	**FMOLS**	**DOLS**	**FMOLS**	**DOLS**	**FMOLS**	**DOLS**	**FMOLS**	**DOLS**	**FMOLS**	**DOLS**	**FMOLS**	**DOLS**	**FMOLS**	**DOLS**	**FMOLS**
LREM-CAPI	0.0003 (0.006)	0.00027 (0.006)			-0.080*** (0.017)	-0.079*** (0.015)			-0.024** (0.011)	-0.027** (0.009)			0.099** (0.040)	0.104** (0.039)		
LREMIT			0.00027 (0.006)	0.0012 (0.0099)			-0.083*** (0.016)	-0.082*** (0.014)			-0.024** (0.010)	-0.028** (0.009)			0.098** (0.039)	0.103** (0.039)
LGDP_CAPI	-0.031 (0.130)	-0.001 (0.128)	-0.031 (0.131)	0.026 (0.192)	-0.142** (0.047)	-0.141*** (0.045)	-0.097* (0.049)	-0.095* (0.046)	0.141** (0.053)	0.147*** (0.047)	0.142** (0.052)	0.149*** (0.047)	-0.034 (0.096)	-0.047 (0.095)	-0.026 (0.093)	-0.039 (0.092)
LHEAL_EXPE	-0.203*** (0.064)	-0.188** (0.066)	-0.203*** (0.064)	-0.182 (0.084*	-0.118** (0.042)	-0.113** (0.047)	-0.111** (0.039)	-0.100** (0.044)	0.050** (0.018)	0.052*** (0.016)	0.051** (0.018)	0.052*** (0.016)	0.013 (0.108)	0.00068 (0.106)	0.017 (0.107)	0.005 (0.105)
OVER_65	-0.798 (0.461)	-0.704 (0.495)	-0.799 (0.461)	-0.647 (0.592)	0.208 (0.187)	0.241 (0.169)	0.218 (0.176)	0.256 (0.158)	-0.314*** (0.088)	-0.303*** (0.077)	-0.317*** (0.087)	-0.306*** (0.077)	-0.158 (0.278)	-0.045 (0.279)	-0.182 (0.270)	-0.069 (0.272)
TFR	-0.122 (0.125)	-0.106 (0.199)	-0.122 (0.125)	-0.083 (0.171)	0.183*** (0.021)	0.177*** (0.019)	0.172*** (0.019)	0.167*** (0.018)	0.009 (0.033)	0.022 (0.0299)	0.008 (0.032)	0.020 (0.029)	0.012 (0.046)	0.016 (0.048)	0.008 (0.045)	0.012 (0.048)
LURBA_POPU	-0.789 (1.236)	-1.067 (1.446)	-0.787 (1.239)	-1.297 (1.612)	16.446*** (2.334)	16.838*** (2.468)	15.913 (2.206)	16.544*** (2.329)	-3.844*** (0.337)	-3.878** (0.295)	-3.809*** (0.329)	-3.841*** (0.291)	-2.415* (1.123)	-2.913** (1.167)	-2.578** (1.146)	-3.089** (1.188)
C	10.046*** (3.071)	10.715** (3.832)	10.037*** (3.046)	11.246** (3.721)	-56.030*** (9.111)	-57.556*** (9.651)	-52.89 (8.651)	-55.367*** (9.124)	19.718*** (0.838)	19.769*** (0.731)	19.998*** (0.845)	20.095*** (0.747)	14.453*** (4.397)	16.426*** (4.536)	13.529*** (4.216)	15.469*** (4.401)
Values in brackets denote standard error. ***** significance at 1%, ** significance at 5%, * significance at 10%.** **Dols made for a constant trend.**																

Source: developed by the authors

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Prevention of Tax Criminal Offences as a Factor in the Financial Stability of the State

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Abstract: Effective counteraction to tax offences strengthens the financial stability of the state and ensures the filling of the state budget. The aim of the research is to compare the effectiveness of measures to prevent tax offences, applied separately and in combination, using the example of developed economies and developing countries. The research employed correlation, regression analyses, and mediation testing. The study found that the introduction of innovative technologies in the tax sphere can increase the efficiency of detecting tax offences and reduce tax evasion. The effectiveness of the use of Artificial Intelligence (AI), electronic invoice mechanisms, Robotic process automation (RPA), Application programming interfaces (API), Cloud computing was confirmed. The impact of AI and electronic invoice mechanisms is mediated by the efficiency of tax audits, where these technologies can be useful for automation, increasing accuracy and scalability. It is proven that the effective implementation of technologies also depends on the amount of expenses incurred, as well as investment in infrastructure and human resources (HR). The findings may be useful for government officials in the development of tax policy and determining the most effective measures to combat tax evasion.

Keywords: tax offences; tax evasion; new technologies; artificial intelligence; electronic taxation systems; tax audits.

JEL Classification: G10; G18; G28; H21; H26; C10; A12.

Introduction

Prevention of tax criminal offences is one of the key factors in the financial stability of the state (Ozili, 2020; Rieznik *et al.* 2020). Failure to fulfil tax obligations, violation of tax legislation and tax evasion using various fraudulent schemes significantly reduce the revenue part of the state budget (Pițu *et al.* 2021; Abdulaziz *et al.* 2022). This weakens the country's economic capabilities and prevents it from performing its functions properly.

The ways to prevent criminal tax offences are a relevant topic and have been considered in numerous studies from different perspectives (Smiesova *et al.* 2019). Apriwarto (2024) states that the fulfilment of tax obligations depends on numerous economic, demographic, social and psychological factors. This necessitates a comprehensive approach to solving the problem of tax evasion, incorporating social and educational initiatives, economic incentives, etc. (van Brederode, 2020; Okeke *et al.* 2024). Furthermore, a set of measures to prevent tax evasion may include the use of new technologies (Bolifaar & Sinaga, 2020; Atayah & Alshater, 2021), as well as effective tax enforcement (Araújo Marques *et al.* 2020; Widuri *et al.* 2023).

What is new in the work is the assessment of the simultaneous impact of regulatory, technological, social, financial and punitive measures to prevent tax crimes on reducing tax losses and corporate tax abuse. An important aspect of the study is the analysis of how these measures interact with each other, in particular, what is their cumulative impact on reducing tax losses and corporate tax abuse, and whether this impact is mediated by certain additional factors.

The aim of the research is to compare the effectiveness of tax fraud prevention measures applied separately and in combination, using the example of developed economies and developing countries. The aim involves the fulfilment of the following research objectives:

- Conduct a correlation analysis between the tax loss of countries and indicators that quantitatively characterize the measures taken to prevent tax offences;
- Conduct a regression analysis to identify the impact of tax offence prevention measures on the amount of tax losses of countries;
- Conduct mediation testing to assess the mediating role of the amount of assessments that rely on the results of tax audits.

1. Literature Review

A large number of studies focus on the impact of new technologies on the tax offence rates. The authors of these studies mostly argue that technological changes will contribute to the reduction of tax evasion, as Belahouaoui & Attak (2024) stated. The increased information flow to governments is one of the main advantages of using new technologies to reduce tax evasion. El-Manaseer *et al.* (2023) added that access to accurate and immediate information by governments will contribute to the expansion of the tax base and the reduction of tax fraud. According to Oduro *et al.* (2024), the acceptance of information technologies by taxpayers will encourage them to evade taxes less in order to avoid tax audits and fines. Yamen *et al.* (2023) are sure that digitalization contributes to the reduction of tax evasion but is much more effective in countries with low corruption rates. These views can be agreed with, but it should be considered that the development of technology can also have negative consequences because of the emergence of new criminal schemes that involves technology.

Rahayu (2024) focused on the AI use in the tax system. The researcher determined that AI improves the quality of tax services and facilitates tax compliance, also helping to detect tax fraud. Saragih *et al.* (2023) also believe that AI will promote tax compliance and improve fairness for taxpayers. According to Nuryani *et al.* (2024), AI has great potential for detecting tax evasion schemes. The researchers proposed their own approach to developing an AI model that can be used by tax authorities to improve the detection of tax evasion. This model uses Machine Learning (ML) technology and considers the taxpayers' individual and network characteristics. Xavier *et al.* (2022) developed AI-based models that can identify the profile of potential tax evaders. The proposed models enable predicting tax evasion companies with an accuracy of up to 98%. So, the effectiveness of using AI to detect tax evasion is a generally recognized fact, but its impact on the amount of tax losses remains poorly studied.

A number of studies have assessed the potential of e-taxation systems to reduce tax fraud. Do *et al.* (2022) found that attitudes towards and implementation of e-taxation systems are positively and strongly correlated with tax compliance. Similar conclusions are reached by Nguyen *et al.* (2024) and Saptono *et al.* (2023). The researchers emphasize that e-taxation systems have a positive impact on tax compliance and taxpayers' intentions to comply with their tax obligations. Zamani *et al.* (2024) noted that aligning the e-services system with taxpayers' information needs will foster a culture of creating and sharing information. This will reduce the number of offences and reduce tax evasion. As with other technologies, the researchers have tended to focus

on the positive aspects of implementing e-taxation. At the same time, the possible negative consequences and side effects of using e-taxation systems should be assessed.

Some studies examined other factors that affect tax offences that are not related to technological change. In particular, an appropriate system of deterrence and punishment plays an important role in tax compliance. According to Suriyadi & Hani (2024), tax audits, fines, and taxpayer awareness reduce tax evasion. In contrast, Yan & Wangdra (2024) found that tax fines do not significantly affect tax compliance. The differences in the researchers' findings can be explained by the differences in the studied regions and the socio-economic factors that affect them. Therefore, it is appropriate to test the effectiveness of deterrence and punishment systems in a larger sample of countries, which will ensure a wider coverage and increase the representativeness of the results. Farrar & King (2023) argue that tax compliance improves when tax fraud is punished only when the offenders perceive that they deserve to be punished. Accordingly, the effectiveness of certain sanctions for violation of tax laws is closely related to people's behavioural and psychological characteristics. Esmaeil Darjani *et al.* (2023) and Utama *et al.* (2024) analysed behavioural factors that influence tax compliance intentions. The study show that various external and internal factors can significantly influence people's dishonest tax behaviour.

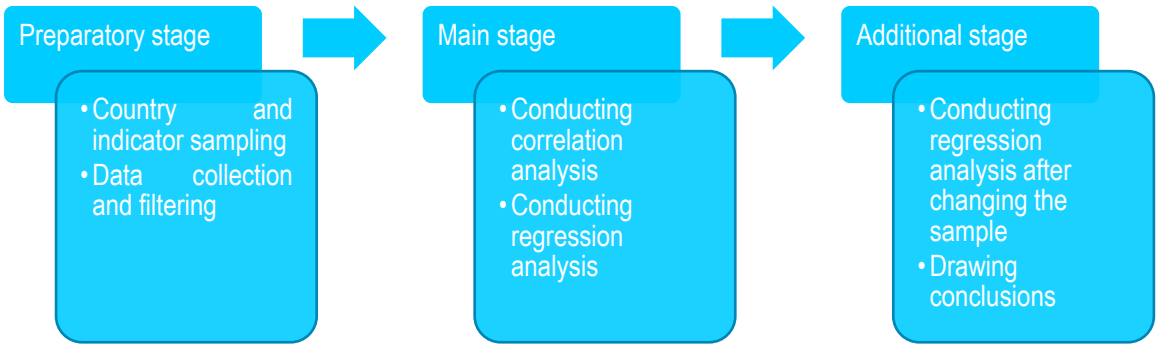
So, the approach to preventing tax crime can encompass regulatory, technological, social, financial, punitive and other measures. At the same time, the comprehensive impact of these measures remains understudied. This study seeks to fill the gap in comparing the effectiveness of various preventive measures applied separately and in combination.

2. Method also Called Materials and Methods or Experimental Methods

Research Design

The research design is divided into preparatory, main, and additional stages. All stages are logically interconnected and follow from each other. The main content of the stages is presented in Figure 1.

Figure 1. Research design



Source: developed by the authors

Sample

The sample of countries for the study is formed by 57 countries, including: Argentina, Australia, Austria, Belgium, Brazil, Bulgaria, Canada, Chile, China, Colombia, Costa Rica, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Georgia, Germany, Greece, Hungary, Iceland, India, Indonesia, Ireland, Israel, Italy, Japan, Kenya, Korea, Latvia, Lithuania, Luxembourg, Malaysia, Malta, Mexico, Morocco, Netherlands, New Zealand, Norway, Peru, Poland, Portugal, Romania, Saudi Arabia, Singapore, Slovak Republic, Slovenia, South Africa, Spain, Sweden, Switzerland, Thailand, Türkiye, United Kingdom, and United States. The sample was formed based on the data provided by the Organization for Economic Cooperation and Development (OECD) and available in open access on the OECD iLibrary (2023). The approach to forming the sample is determined by the availability of qualitative and standardized data from countries with different levels of development and different features of their tax systems. Accordingly, the formed sample provides sufficient diversification and variety of data for the purposes of the study, which makes it representative for the purposes of in-depth analysis.

The sample of indicators for the study is divided into two groups for analysis, the first of which consists of indicators of tax losses of countries. It includes Total annual tax loss (USD million), Total annual tax loss (% of GDP), Corporate tax abuse (USD million), and offshore wealth (USD million). These indicators reflect various

aspects of tax losses and violations, as well as their interrelationships. Total annual tax loss is a basic indicator for assessing the impact of factors causing tax losses. Corporate tax abuse and Offshore wealth are included in Total annual tax loss, but reflect different areas of tax losses. Corporate tax abuse is of particular importance, because corporate tax is quite vulnerable to abuse, and the corporate sector is a key source of tax revenues. The second group contains indicators that quantitatively characterize the measures taken to prevent tax violations. In turn, such indicators are divided into subgroups that provide for the use of technological, regulatory and control, financial, and penalty instruments (Table 1).

Table 1. Selection of indicators for the study

Indicator	Possible impact on the tax system
Indicators of the use of innovative technologies	
Data science / analytics tools	Capabilities for detecting anomalies indicating tax evasion and predicting risks
Robotics Process Automation (RPA)	Increasing transparency and minimizing errors through automation
Application programming interfaces (APIs)	Integrating different systems in real time, which allows for broader possibilities of checking data for compliance with legal requirements
Distributed ledger technology / Block chain	Increasing transparency and immutability of data, which allows for increased efficiency of checks
Artificial intelligence (AI), including machine learning	Automation and expanding possibilities for detecting anomalies
Cloud computing	Allows storage of large volumes of data and access to them at any time for checks and audits
Indicators related to control and regulatory initiatives taken	
Administration uses behavioural insight methodologies or techniques	Such methodologies involve studying taxpayer behaviour to identify motives for tax evasion, which enables adjusting approaches to preventing abuse
All or certain taxpayers are required to use an electronic invoice mechanism for tax purposes	Electronic invoices enable automating the process of recording tax transactions, reducing the scope for manipulation
Certain taxpayers are required to use electronic fiscal devices / cash registers	Reducing opportunities for manipulation and falsification
Percentage of payments received electronically by number of payments	The increase in the number of taxpayers using electronic means of payment may contribute to improving control over tax revenues
Percentage of payments received electronically by value of payments	Indicates the effectiveness of tracking large financial flows by tax authorities
Financial indicators relating to expenses incurred and the amount of additional charges	
Operating expenditure	Reduction or increase in expenditures indicates the efficiency of resource use to prevent abuse in different areas (expenditures on technology, infrastructure, human capital, etc.)
Salary expenditure	
Information and communications technology expenditure	
Capital expenditure	
Value of additional assessments raised from audits and verification actions (including penalties and interest)	Indicates the amounts of funds additionally accrued based on the results of tax audits, which may indicate the efficiency of carried out tax audits

Source: developed by the authors based on (OECD iLibrary, 2023)

Note: the indicators for which categorical data were presented were coded as 1 or 0 for analytical purposes. 1 indicates that a particular technology or methodology is used by the jurisdiction, 0 indicates that the methodology is not used or is in the implementation phase

Methods

The research employed correlation analysis using the Pearson correlation coefficient to identify linear correlations between the groups of studied indicators. The first group was represented by tax loss indicators, the second — by indicators that quantitatively characterize the measures taken to prevent tax offences. Regression analysis using the linear regression method was applied to assess the cumulative impact of tax offence prevention measures on tax losses in the countries that were dependent variables. Mediation testing was additionally conducted by repeating the regression analysis with the exception of the variable Value of Additional Assessments Raised from

Audits and Verification Actions. It was assumed that the effectiveness of inspections can explain the positive impact of AI and electronic taxation on the volume of tax losses, which explains the use of the indicator as a mediator. The greater the volume of assessments after tax audits, the greater the documented losses, which indicates the effectiveness of using the latest technologies in detecting violations. The direct impact of AI and e-taxation could have been interpreted in a contradictory manner without an additional stage of analysis. In particular, it could be assumed that new criminal schemes using these technologies would emerge.

3. Research Results

The results of the correlation analysis conducted at the initial stage of the study provided a preliminary idea of the existing relationships between the studied indicators. The results of the analysis were visualized through a rectangular matrix containing correlations between two groups of indicators. The first group consisted of indicators of tax losses of countries, the second - of indicators that quantitatively characterize the measures taken to prevent tax offences (Table 2).

Table 2. Results of the correlation analysis between indicators of tax losses and indicators that quantitatively characterize the measures taken to prevent tax offences

		Data science / analytics tools	Robotics Process Automation (RPA)	Application programming interfaces (APIs)	Distributed ledger technology / Blockchain	Artificial intelligence (AI), including machine learning	Cloud computing	Administration uses behavioural insight methodologies or techniques	All or certain taxpayers are required to use an electronic invoice mechanism for tax purposes	Certain taxpayers are required to use electronic fiscal devices / cash registers	Operating expenditure	Salary expenditure	Information and communications technology expenditure	Capital expenditure	Percentage of payments received electronically by number of payments	Percentage of payments received electronically by number of payments	Value of additional assessments raised from audits and verification actions (including penalties and interest)
Total annual tax loss (USD million)		0.170183	0.428846	0.127052	-0.096592	0.363325	-0.003747	0.412914	-0.198409	-0.279516	0.494445	0.472882	0.494442	0.337549	0.096544	0.124988	0.461516
Total annual tax loss (% of GDP)		0.116985	0.300403	0.066332	-0.116985	0.228842	0.071621	0.118228	-0.300323	-0.235103	-0.061078	-0.063522	-0.035939	-0.184911	0.134926	0.046426	-0.097713
of which:	Corporate tax abuse (USD million)	0.195277	0.211323	0.094884	-0.042599	0.298195	-0.177329	0.391822	0.166909	-0.226542	0.624892	0.637798	0.547186	0.500856	0.012154	0.025211	0.799401
	offshore wealth (USD million)	0.110755	0.394739	0.103654	-0.090971	0.285345	0.068839	0.302490	-0.291665	-0.220705	0.298078	0.266536	0.330083	0.172905	0.103456	0.130031	0.189196

Source: calculated by the authors based on Tax Justice Network, 2021 and OECD iLibrary, 2023

There is a moderate direct relationship between the Total Annual Tax Loss in absolute terms and some indicators that quantitatively characterize the measures taken to prevent tax offences. This applies to the following indicators: Operating Expenditure, Salary Expenditure, Information and Communications Technology Expenditure, and Value of Additional Assessments Raised from Audits and Verification Actions. Corporate Tax Abuse is part of the Total Annual Tax Loss and demonstrates a stronger relationship with the observed indicators of tax system expenditures and, additionally, Capital Expenditure. In this case, the strength of the relationship is direct and noticeable (0.5-0.7) or strong (0.7-0.9). On the one hand, the detected trend may indicate insufficiently efficient use of resources, because the volume of losses from tax abuse increases with increasing expenditures. On the other hand, it can be assumed that the increase in expenditure contributes to the detection of a greater number of abuses, which increases documented losses from tax abuse. The assumptions made are mutually exclusive in a sense, which necessitates further analysis. Linear regression analysis was chosen for this purpose, which will provide more information for interpreting the interaction of the studied indicators. This is possible by assessing the impact of several indicators on the amount of tax losses.

Regression analysis was conducted using the Total Annual Tax Loss and Corporate Tax Abuse as dependent variables. During the correlation analysis, these indicators demonstrated a statistically significant relationship with some indicators of the quantitative characteristics of measures to prevent tax abuse. However, , the regression analysis did not reveal statistically significant results for the Total Annual Tax Loss, so further research is focused on Corporate Tax Abuse. As the regression analysis showed, the values of the indicator are under a statistically significant influence of several indicators of the quantitative characteristics of measures to prevent tax abuse (Table 3). The resulting model demonstrated a strong correlation between the dependent and independent indicators for the correlation coefficient, which was 0.98485531. Besides, the model was characterized by high explanatory power, as the coefficient of determination reached 0.98485531, the adjusted coefficient of determination – 0.87374789. So, changes in the selected independent variables can explain about 87.37% of the variation in Corporate Tax Abuse.

Table 3. Results of regression analysis between indicators that quantitatively characterize measures taken to prevent tax offences and Corporate Tax Abuse as a dependent variable

	Regression coefficient	Standard error	t(5)	p-value
Intercept	-1,150.96	1,290.331	-0.89199	0.413262
Data science / analytics tools	-0.00989	0.116273	-0.08506	0.935512
Robotics Process Automation (RPA)	-0.52305	0.192732	-2.71388	0.042081
Application programming interfaces (APIs)	-0.46787	0.132453	-3.53235	0.016698
Distributed ledger technology / Blockchain	-0.23978	0.184934	-1.29656	0.251393
Artificial intelligence (AI), including machine learning	0.63190	0.182564	3.46126	0.018018
Cloud computing	-0.59188	0.139689	-4.23709	0.008192
Administration uses behavioural insight methodologies or techniques	0.14648	0.132108	1.10879	0.317983
All or certain taxpayers are required to use an electronic invoice mechanism for tax purposes	0.39144	0.124353	3.14785	0.025440
Certain taxpayers are required to use electronic fiscal devices / cash registers	-0.19914	0.102635	-1.94027	0.110033
Operating expenditure	2.95162	1.382340	2.13524	0.085833
Salary expenditure	-1.32435	1.097891	-1.20627	0.281672
Information and communications technology expenditure	-0.57741	0.467116	-1.23611	0.271317
Capital expenditure	-0.90574	0.271338	-3.33807	0.020596
Percentage of payments received electronically by number of payments	0.43602	0.197263	2.21034	0.078071
Percentage of payments received electronically by value of payments	-0.05797	0.220430	-0.26297	0.803065
Value of additional assessments raised from audits and verification actions (including penalties and interest)	0.52353	0.172517	3.03465	0.028927

Source: calculated by the authors based on (Tax Justice Network, 2021; OECD iLibrary, 2023)

The regression results show that Corporate Tax Abuse is directly affected by whether the tax system uses AI, including ML. The indicator is also directly affected by whether taxpayers are required to use the electronic invoicing mechanism for tax purposes. Another indicator that is positively correlated with the dependent variable is the value of additional assessments based on the results of audits and inspections. RPA, APIs, Cloud Computing and Capital Expenditure are inversely correlated with Corporate Tax Abuse.

Table 4. Interpretation of the obtained results of the regression analysis from the pessimistic and optimistic perspectives

Interpretation of the results from a pessimistic perspective	Optimistic interpretation of the results
The direct relationship between the amount of tax losses from corporate tax abuse and AI may indicate the emergence of new opportunities for the realization of criminal schemes with the introduction of this technology. Hypothetically, AI can be used to facilitate data manipulation, for example, by generating false information, hiding anomalies or automating fraudulent schemes.	The introduction of AI and the use of electronic invoicing mechanisms may contribute to the detection of fraudulent schemes, with an increase in the volume of documented losses.
The direct impact of the use of electronic invoicing mechanisms on Corporate Tax Abuse may indicate the emergence of new fraudulent schemes through the use of innovative technologies.	
The positive correlation of Corporate Tax Abuse with Value of Additional Assessments Raised from Audits and Verification Actions indicates a direct relationship between the amount of additional funds charged and tax losses. On this grounds, it can be assumed that inspections and penalties do not contribute to the reduction of tax losses, and therefore the amount of abuse.	The identified impact may indicate intensified activity of tax authorities in conducting inspections and greater efficiency in detecting offences committed in previous periods.

Source: developed by the authors based on (Tax Justice Network, 2021; OECD iLibrary, 2023)

It is appropriate to explain the results obtained from an economic perspective. Regarding indicators that are inversely correlated with Corporate Tax Abuse, it can be assumed that the use of appropriate technologies and methods reduces the volume of tax abuse. For example, the inverse relationship with the implementation of cloud computing may indicate increased transparency and monitoring capabilities, resulting in a decrease in the abuse level. RPA expands the possibilities of automation, thereby reducing the chances of manual intervention in the system and the realization of fraudulent schemes.

Table 5. Results of the regression analysis after excluding the variable Value of Additional Assessments Raised from Audits and Verification Actions

	Regression coefficient	Standard error	t(5)	p-value
Intercept	1,626.78	5,927.908	0.27443	0.786104
Data science / analytics tools	-0.05620	0.104873	-0.53591	0.596956
Robotics Process Automation (RPA)	-0.09478	0.118064	-0.80280	0.429972
Application programming interfaces (APIs)	0.03304	0.094593	0.34926	0.729940
Distributed ledger technology / Blockchain	-0.09887	0.093641	-1.05586	0.301547
Artificial intelligence (AI), including machine learning	0.09519	0.121336	0.78455	0.440392
Cloud computing	-0.13119	0.100527	-1.30507	0.204244
Administration uses behavioural insight methodologies or techniques	0.07420	0.090832	0.81686	0.422044
All or certain taxpayers are required to use an electronic invoice mechanism for tax purposes	0.06488	0.096399	0.67305	0.507348
Certain taxpayers are required to use electronic fiscal devices / cash registers	-0.08211	0.092697	-0.88577	0.384533
Operating expenditure	-6.21570	1.958182	-3.17422	0.004088
Salary expenditure	6.06207	1.919399	3.15832	0.004248
Information and communications technology expenditure	0.32996	0.154504	2.13559	0.043120
Capital expenditure	0.80537	0.187882	4.28658	0.000255
By number of payments	-0.13072	0.145340	-0.89943	0.377362
By value of payments	0.14850	0.142713	1.04055	0.308454

Source: calculated by the authors based on (Tax Justice Network, 2021; OECD iLibrary, 2023)

APIs are used to integrate data from different sources, which also improve monitoring and allows them to detect anomalies. Capital expenditure can also contribute to reducing losses from tax abuse using funds for the development of infrastructure and equipment.

The interpretation of indicators that directly affect the dependent indicator is more difficult. This is determined by the fact that the regression results obtained can indicate both positive and negative trends. Table 4 presents the interpretation of the results obtained from the pessimistic and optimistic perspectives.

The Value of Additional Assessments Raised from Audits and Verification Actions (including penalties and interest) shows the amounts of funds additionally assessed as a result of tax audits. These assessments may include amounts of unpaid taxes identified during the audit, penalties, and interest. For the purposes of further analysis, it was assumed that this indicator acts as a mediator, mediating the relationship between other variables. Therefore, this indicator was excluded from the analysis to check which of the hypotheses noted in Table 4 are more realistic. Table 5 contains the results of the regression analysis without considering Corporate Tax Abuse with Value of Additional Assessments Raised from Audits and Verification Actions.

The results presented in Table 5 give grounds to draw several important conclusions. After excluding the variable Value of Additional Assessments Raised from Audits and Verification Actions, several other independent variables lost their statistically significant effect on Corporate Tax Abuse. Instead, the variables related to costs became statistically significant. This suggests that the excluded variable is the main mediator. In other words, the volume of additional assessments, which may indicate an increase in the efficiency of tax audits, mediates the relationship between the other variables. It is most likely that new technologies by themselves do not significantly affect the volume of tax losses, either positively or negatively. However, they increase the efficiency of tax audits due to increased accuracy, scalability, automation, and other advantages. This can be represented as a scheme: *Use of electronic invoices, implementation of AI technologies → Increase in the efficiency of tax audits → Detection of new fraud schemes*. Accordingly, the results of the additional stage of regression analysis suggest that the interpretation of the analysis results from an optimistic perspective in Table 4 is closer to reality. The increasing impact of costs at this stage of analysis can be explained by the fact that they are the initial condition for the effective implementation of technologies.

4. Discussion

The obtained results demonstrate that the introduction of new technologies in the tax sphere (AI, electronic invoice mechanisms, RPA, APIs, Cloud computing) can increase the efficiency of tax fraud detection. However, their impact is mediated by the efficiency of tax audits, during which the technologies observed can be useful for automation, increasing accuracy and scalability. The effective implementation of technologies depends on the amount of expenses incurred.

The conclusions of the study coincide with the views of Alm (2021), who argues that new technologies can both reduce tax evasion and open new opportunities for fraudsters. Ultimately, the researcher is inclined to believe that technological progress will complicate tax evasion in the future. Similar conclusions are reached by Paoki *et al.* (2021), noting that optimizing the use of information technologies in the tax sphere minimizes tax evasion. Yamen *et al.* (2023) also found a negative and strong relationship between digitalization and tax evasion. Moreover, the researchers emphasized the importance of investment in technology, as in our study.

Saragih *et al.* (2023) and Rahayu (2024), as well as the author of this work, demonstrated the positive impact of AI on tax fraud detection and tax compliance. Nuryani *et al.* (2024) emphasized the effectiveness of implementing big data analytics technologies in addition to AI. Xavier *et al.* (2022) demonstrated that using AI with open data can effectively predict tax evasion companies. Saptono *et al.* (2023), Nguyen *et al.* (2024) and Zamani *et al.* (2024) also confirm the direct impact of implementing e-taxation on reducing tax offences. However, our study emphasizes that new technologies and the implementation of e-taxation systems do not significantly reduce tax losses caused by fraud by themselves. The positive effect of technology implementation is mediated by the effectiveness of tax audits.

Some studies noted the role of socio-psychological factors in tax compliance. Apriwarto (2024) states that an anti-tax evasion strategy should be comprehensive, combining social influence, educational initiatives, and economic incentives. Pereira & Silva (2020) and Esmaeil Darjani *et al.* (2023) showed that the use of behavioural analysis results can help to identify approaches to improving tax compliance. However, our study did not reveal a statistically significant impact of the administration's use of behavioural analysis methodologies or techniques. It can be assumed that these technologies are undervalued and require further development and improvement.

So, the author found that the effectiveness of tax audits and the volume of additional assessments are the main mediators mediating the relationship between the use of technology and the detection of fraudulent

schemes. Increasing the effectiveness of detecting fraudulent schemes can help to reduce their scale and consequences. Such findings coincide with the views of Rahmayanti & Prihatainingtias (2020) and Farrar & King (2023), who determined that sanctions and appropriate punishment improve tax compliance. At the same time, Yan & Wangdra (2024) did not find a significant impact of tax fines on taxpayers' compliance with tax legislation. The practical contribution of the study is to substantiate the identified relationships, which can be useful for preventing criminal tax offences. Therefore, an important conclusion of the research is that technological changes and optimization of regulation may not have the desired effect without appropriate control and financial measures.

Limitations

The limitations of the study relate to the lack of data for certain country indicators, which necessitated the recoding of data as "missing data." However, this did not significantly affect the quality of the results because of the sufficient sample size, which compensated for the lack of data.

Recommendations

The results of the study give grounds to provide several key recommendations:

- The introduction of new technologies is effective in combating tax evasion, but it should be accompanied by adequate funding and infrastructure development. It is also advisable to ensure an appropriate level of transparency and control over the development and use of technologies to minimize the possibility of their use for criminal purposes;
- The introduction of technologies in itself may not have the expected effect, as it depends on the effectiveness of tax audits. Increasing such effectiveness involves adequate funding and training of personnel, improving awareness and social consciousness;
- The approach to preventing tax offences should be comprehensive, as the measures analysed in the study demonstrated the highest effectiveness when applied in combination.

Conclusions

Tax crimes are a widespread and significant problem for many countries, as they negatively affect their financial sustainability and the performance of state functions. Effective prevention of tax crimes allows solving the problem of insufficient filling of the state budget, promotes economic growth, increases welfare, and consolidates trust in state authorities.

In the first stage of the regression analysis, several variables had a statistically significant impact on the amount of tax losses of countries. RPA, APIs, Cloud computing and Capital expenditure had an inverse effect, therefore their use contributes to the reduction of tax losses. AI and the use of electronic invoice mechanisms demonstrated a direct effect. On the one hand, this could be explained by the emergence of new fraudulent schemes using these technologies. On the other hand, the relationship can be explained by the increase in documented tax losses because of the effectiveness of technologies in detecting offences.

An additional stage of regression analysis was conducted to check which of the assumptions is closer to reality. At this stage, the variable Value of Additional Assessments Raised from Audits and Verification Actions was excluded, which also demonstrated a direct effect on the increase in tax losses. It was assumed that this variable acts as a mediator, mediating the relationship between other variables. The effect of technology turned out to be statistically insignificant, while the effect of costs increased after excluding the variable. Therefore, it was assumed that the variables that demonstrated a direct effect on Corporate Tax Abuse in the first stage of regression analysis contribute to the detection of fraudulent schemes. The direct effect in this case can be explained by the increase in the volume of documented losses.

It is also worth noting that if the impact of tax audits is excluded, costs come to the fore, which also have a linear impact on Corporate Tax Abuse according to the results of the correlation analysis. Costs can be an initial condition for the effective implementation of technologies. Tax audits could also mediate these relationships, so their exclusion demonstrated that without the corresponding costs, technologies do not have the proper effect. The conclusions obtained have scientific and practical value and can be used by government officials in the process of developing tax policy and determining effective measures to prevent tax criminal offenses. Further research may concern assessing the effectiveness of the implementation of international standards, in particular, the Common Reporting Standard (CRS) and Base Erosion and Profit Shifting (BEPS).

Credit Authorship Contribution Statement

Vasyl Topchii: Conceptualization, Investigation, Writing – original draft;
Yuliia Moroz: Methodology, Project administration, Writing – review and editing;
Natalia Karpenko: Software, Formal analysis, Writing – original draft;
Oleg Khoronovskyi: Supervision, Data curation, Validation, Writing – review and editing;
Volodymyr Tarashchenko: Methodology, Writing – original draft, Supervision, Data curation, Validation.

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/ or 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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Non-Accounting Drivers of Forensic Accounting Techniques: Insights from PLS-SEM Analysis

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Abstract: Forensic accounting techniques are pivotal in combating financial fraud and enhancing corporate governance. According to Forensic Accounting Theory, both accounting and non-accounting factors influence the intention to adopt these techniques. This study explores the impact of key non-accounting factors *i.e.* Bonus Contract, Anonymity, and Collapse Avoidance on adoption of forensic accounting techniques by the practitioners, employing Partial Least Squares Structural Equation Modeling (PLS-SEM) and SmartPLS software. Data was collected from professionals across diverse industries utilising forensic accounting services. The results reveal that these non-accounting factors exert varying levels of influence on adoption intentions. This research enriches the existing body of knowledge by offering new perspectives on the role of non-accounting drivers in forensic accounting adoption, providing actionable insights for policy-makers, regulators, and corporate leaders.

Keywords: forensic accounting; forensic accounting theory; non-accounting drivers; bonus contract; anonymity; collapse avoidance; PLS-SEM.

JEL Classification: K13; M41; C01.

Introduction

Forensic accounting integrates accounting, auditing, and investigative expertise to identify, investigate, and prevent fraud and other financial crimes. It involves scrutinizing financial records to uncover inconsistencies, fraudulent activities, or violations of regulatory and ethical standards. Forensic accountants are commonly involved in fraud detection, litigation support, and providing expert testimony, playing a crucial role in uncovering and addressing corporate misconduct (Ellili *et al.* 2024). By providing insights into financial practices, forensic accountants contribute to a culture of accountability and transparency within organizations. Forensic accounting has demonstrated its effectiveness in mitigating financial fraud and improving corporate governance, however, companies all around the globe are still reluctant to use the forensic accounting techniques (Alabdullah *et al.* 2013; Guellim *et al.* n.d.). There is a limited understanding of the factors that hinder its adoption across different industries. To comprehend this, the Forensic Accounting Theory was developed by P.K. Ozili in 2020. This theory suggests that a variety of both accounting and non-accounting factors affect the decisions made by practitioners in the use of forensic accounting methods (Ozili 2020).

This study focuses on the impact that the non-accounting elements, namely bonus contract, anonymity and collapse avoidance have on the adoption of forensic accounting. The primary aim of the study is to explore how these non-accounting factors influence practitioners' intention to adopt forensic accounting techniques. In order to achieve the stated objective, the study will explore the following research questions:

1.Does Bonus Contract influence the intentions of practitioners to adopt forensic accounting techniques?

2.Does Anonymity in fraud detection/reporting impact the intentions of practitioners to adopt forensic accounting techniques?

3.Does Collapse Avoidance impact the intentions of practitioners to adopt forensic accounting techniques?

Earlier studies have recognised certain behavioural factors in the adoption of forensic accounting. However, no study till date studied the influence of non-accounting factors on the adoption of forensic accounting techniques (Alshurafat, Shbail, and Almuiet 2024; Azman and Vaicondam 2020; Ng *et al.* 2017). There is absolute dearth of empirical studies on non-accounting factors affecting the adoption of forensic accounting. Therefore, this study is an attempt to understand the different influence of the non-accounting factors, namely, bonus contract, anonymity and collapse avoidance on the adoption of forensic accounting techniques. This paper will focus on overcoming this research gap by thoroughly examining the non-accounting drivers.

The study intends to make the following addition to the literature. The research aims to broaden the scope and provide insights into non-accounting drivers of forensic accounting adoption. The understanding of these factors will have important implications not only for the practitioners but also policymakers and corporate governance point of view. It will provide valuable information about the factors that motivate the adoption of fraud detection techniques and factors that hinder it. The findings of the study will help foster a culture of accountability and transparency along with proactive fraud prevention by focusing not only on financial and accounting factors. The subsequent sections of the paper include literature review, formulation of hypothesis, research methodology, results, analysis, and conclusion.

1. Literature Review and Hypotheses Formulation

The literature provides multiple definitions of forensic accounting. Forensic accounting is described as the use of financial expertise and investigative thinking to address unresolved matters within the framework of evidence rules (Botes and Saadeh 2018). Additionally, forensic accounting is defined as the application of accounting, auditing, financial, and investigative skills to address unresolved issues within the context of evidence rules (Bhasin 2015; Felix 2022). It can also be defined as the use of auditing methods, techniques, or procedures to resolve legal issues that necessitate the integration of investigative, accounting, and auditing (Aksoy and Uzay 2021; Emmanuel, Enyi, and Olajide 2018). Another definition of forensic accounting is the process of collecting, interpreting, summarizing, and presenting complex financial matters in a clear, concise, and factual manner, often as an expert in a court of law (AlGhunaimi 2023; Chukwu *et al.* 2019; Felix 2022)

Experts agree that forensic accounting can be instrumental in uncovering fraudulent (Afriyie *et al.* 2023). Research provides various definitions of fraud and explores the various motivations of driving fraud. Fraud, as a concept, does not have a universally recognized definition, as it includes a broad range of misleading actions that differ in depending on context, legal framework, and sector. Fraud is characterized as a purposeful act of deception aimed at obtaining a financial or personal advantage while inflicting harm on another individual (Reurink 2018). Fraud in financial reporting involves deliberate inaccuracies in financial statements, intended tp deceive stakeholders like investors, creditors and regulatory authorities (Rezaee 2005; Roszkowska 2021). Fraud

is organisational context is characterised as misappropriation or theft of organisations' assets for individual benefit. This included embezzlement of funds, insider trading or manipulation of financial records to exaggerate a company's financial performance (Young 2020).

Reasons that lead individuals or groups to engage in fraudulent activities have been thoroughly examined and explained through the model of Fraud Triangle. The three components of fraud triangle are namely Pressure, Opportunity, and Rationalisation (Maulidi 2020). According to the fraud triangle, individuals who commit fraud go through a sequence involving a need that must be met, the opportunity to fulfill that need through illegal means, and the ability to rationalize the fraudulent actions. Studies have expanded the fraud triangle to include additional motivators for fraud by comprehensively bringing together most commonly used theories in fraud research (Rasheed, Said, and Ismail Khan 2023).

Forensic accounting utilises unique methods and analytical tools to uncover fraudulent activities that standard auditing practices may fail to detect (Akwa Ibom State University *et al.* 2023). Forensic accountants apply data analytics to uncover unusual trends, patterns and insistence in financial documents that may indicate discrepancies in financial records. Methods such as ratio analysis, data mining, and predictive modelling assist in identifying irregularities (Jain and Lamba 2020). According to (Ozili 2020), Forensic Accounting Theory suggests that the use of forensic accounting methods is affected by both accounting decisions and non-accounting decisions. The variables that make up accounting decisions include materiality and ability signaling, while the variables that pertain to non-accounting choices encompass bonus contracts, anonymity, and collapse avoidance.

2. Hypotheses Formulation

The *bonus contract* hypothesis suggests that when the compensation or bonus of a forensic investigator is tied to their effectiveness in uncovering unresolved issues related to suspected financial misstatements or financial frauds, it is in the best interest of the investigator to employ forensic detection methods (Koppl and Sacks 2013). Forensic investigators with bonus contracts are more inclined to use detection methods or procedures that enhance the likelihood of uncovering unresolved issues. Additionally, if the detection of actual fraud is the yardstick for evaluating the investigator's performance, there will be stronger incentives for the investigator to utilize forensic methods, procedures, and decisions that raise the probability of receiving the promised compensation, which is contingent on the successful detection of actual fraud (Ozili 2020). Thus, the bonus contract hypothesis can be formulated as follows:

H1: Presence of Bonus Contract positively influences the adoption of forensic accounting techniques

The *anonymity* hypothesis argues that the personal security of the forensic investigator is more important than successfully resolving the case. This is a valid argument considering the history of attacks on both whistleblowers and investigators by associates of convicted fraudsters (Armstrong and Francis 2015; Ozili 2020) . For example, in the past two decades, individuals were assassinated by the mafia and cartels, including whistleblowers and investigators of criminal cases. In some instances, political elites have chosen not to prosecute lawbreakers and criminal organizations, instead resorting to secret assassinations and unjust imprisonments of whistleblowers (Onyango 2024). As a result, civilian forensic investigators are unwilling to risk their lives due to fear of reprisal. Forensic investigators who believe that their personal security may be at risk but still wish to continue with the case are more likely to pursue the investigation by choosing forensic detection methods or procedures that conceal their identity (Ozili 2020). Hence, the second hypothesis has been framed as follows:

H2: Anonymity in the investigation procedure positively influences the adoption of forensic accounting techniques

In forensic practice, the objective of forensic investigations is not to bring about the downfall of an accused individual or corporation. Instead, the role is to uncover unresolved cases, with the ultimate decision regarding the fate of the firm or the punishment of the accused individual lying with the courts and the law (Oni, and Oyedokun 2023). If the purpose of the investigation is conveyed as uncovering unresolved issues for corrective actions, the firm's management is likely to cooperate during the investigation. Therefore, it is crucial for forensic investigators to assure the firm's management that the investigation aims to correct wrongdoings, not to wind up the company. The argument for avoiding collapse states that forensic investigators with access to multiple methods should understand that their objective is not to shut down the company if it's found guilty, but to provide evidence for the legal process and promote corrective action in the future (Ozili 2020). Hence, the third hypothesis has been framed as follows:

H3: Assurance of collapse avoidance positively influences the adoption of forensic accounting techniques

3. Research Methodology

3.1 Data Collection and Sample Design

The study employs a quantitative method to assess the influence of non-accounting factors on adoption forensic accounting techniques, so it is entirely based on primary data. Data has been collected from geographically scattered population using a structured questionnaire (Robson and McCartan 2016). Data has been collected from forensic accounting practitioners from different regions of India including Delhi, Noida, Gurugram, Faridabad, Patna, Meerut, Chennai, Mumbai, Ahmedabad and Chandigarh. Responses were collected through digital platforms using purposive sampling. The minimum sample size was determined using G*Power software (Faul *et al.* 2009). The estimated sample size was 77, calculated at 0.80 power and a 95% confidence level. Out of the 240 questionnaires distributed, responses were received from 191 respondents. A total of 179 responses were accepted for the final analysis, while the other responses were discarded due to missing data and outliers. The response rate is deemed satisfactory, as suggested by (Nulty 2008).

3.2 Measurement of Variables

The proposed model consists of four variables adopted from the Forensic Accounting Theory. The items were selected according to the objective of the study. A structured questionnaire was developed using a five-point Likert scale, and the responses were analysed using partial least square-structure equation modelling (PLS-SEM). The relationship between the variables were examined using smartPLSv4 software. PLS-SEM serves as an advanced exploratory method to assess the influence of exogenous variables on the endogenous variable (Hult *et al.* 2018; Reinartz, Haenlein, and Henseler 2009)

The survey was developed through an extensive review of existing literature on forensic accounting. Bonus contract and Anonymity were adopted as it is from the Forensic Accounting Theory given (Ozili 2020). Whereas collapse avoidance was influenced by (Ozili 2020) and (Azman 2021). The dependant variable, *i.e.* Adoption of Forensic Accounting Techniques has been influenced and adapted from the work of (Ozili 2020) and (Muthuswamy 2011) (see Table 1).

Table 1

Constructs	No. of Items	Source
Bonus Contract	3	(Ozili 2020)
Anonymity	4	(Ozili 2020)
Collapse Avoidance	3	(Azman 2021) and (Ozili 2020)
Adoption of Forensic Accounting	4	(Muthuswamy 2011) and (Ozili 2020)

Source: Compiled by Author

4. Results

4.1 Demographic Profile

Table 2 gives an overview of the demographic characteristics of the respondents of the survey.

Table 2. Demographic Information

Characteristics	Frequency	Percentage
Gender		
Male	113	63.13
Female	66	36.87
Age		
18-25 years	5	2.80
25-35 years	53	29.61
35-45 years	68	37.99
45-55 years	42	23.46
Above 55 years	11	6.15
Educational Qualification		
Graduation	78	43.58

Characteristics	Frequency	Percentage
Post Graduation	29	16.20
Diploma	49	27.37
PhD	23	12.85
Years of Experience		
1-5 years	31	17.32
5-10 years	67	37.43
10-15 years	54	30.17
Above 15 years	27	15.08

Source: Compiled by Author

Among the respondents, 113 *i.e.* 63.13% were males, and 66 *i.e.* 36.87% were females. Most of the respondents' ages varied between 35 and 45 years, constituting 37.99%, followed by 25-35 years with 29.61%. The others constituted 23.46% (45-55 years), 6.15% (Above 55 years) and 2.80% (18-25 years). 43.58% of the respondents *i.e.* were graduates, 27.37% held a diploma degree, 16.20 % and 12.85% were Postgraduates and Doctorates respectively. Most of the respondents had work experience of 5-10 years (37.43%), followed by work experience of 10-15 years (30.17%), 1-5 years (17.32%) and above 15 years (15.08%).

Initially, the data were examined for missing values and any outliers using SPSSv29. The data analysis was carried out through both the measurement model and structural equation model using SmartPLSv4.0 The measurement model represents the connections between the latent variables and their associated variables, while the structural model is used to identify the cause-and-effect relationships among the dependent and independent variables. SmartPLS was selected for its suitability in hypothesis testing and in clarifying the relationships among the variables (Chin 1998).

4.2 Measurement Model

The measurement model was initially assessed for multivariate normality. Web-based software was utilized to evaluate the data's normality by examining multivariate kurtosis and skewness (Cain, Zhang, and Yuan 2017; Mardia 1970). The outcomes indicated that the data did not meet the requirements for multivariate normality, as the p-value was less than 0.05 for both kurtosis and skewness. Consequently, PLS-SEM was selected for data analysis (Joseph F. Hair *et al.* 2019). Additionally, the data were scrutinized for common method bias. According to (Podsakoff *et al.* 2003), a single factor should not explain over 50% of the variance for the model evaluation. Concerns regarding common method bias were dismissed since its value for the current analysis was found to be below 50%.

Three criteria for validity and reliability were selected to evaluate the reflective measurement model, namely, indicator reliability, convergent validity, and discriminant validity (Coltman *et al.* 2008; Joe F. Hair, Ringle, and Sarstedt 2011). The outer loadings were greater than 0.7 as shown in Table 3. Hence, the reliability of the indicators is validated. Additionally, the model's convergent validity was assessed using internal consistency measures such as Cronbach's Alpha, rho Alpha, Composite Reliability (CR), and Average Variance Extracted (AVE) (Thompson, Barclay, and Higgins 1995). The internal consistency was assessed using the values of Cronbach Alpha and rho alpha, which were all greater than 0.7, indicating that the data is trustworthy (Gellman 2020; Henson 2001). Additionally, the AVE surpassed the 0.5 threshold confirming the data's convergent validity (Bagozzi and Yi 1988).

Table 3. Indicator reliability, internal consistency and convergent validity of measurement model

Constructs	Items	Outer Loading	Cronbach Alpha	rho Alpha	CR	AVE
BC	BC1	0.95	0.926	0.938	0.953	0.871
	BC2	0.92				
	BC3	0.93				
AN	AN1	0.91	0.905	0.908	0.94	0.84
	AN2	0.93				
	AN3	0.91				
	AN4	0.90				
CA	CA1	0.94	0.909	0.909	0.943	0.847

	CA2	0.90				
	CA3	0.93				
AFA	AFA1	0.94	0.901	0.901	0.938	0.835
	AFA2	0.92				
	AFA3	0.89				
	AFA4	0.90				

Source: Compiled by Author

The discriminant validity was confirmed by analyzing the square root of AVE and comparing it to the intercorrelation of constructs with alternative measures (Fornell and Larcker 1981). The diagonal entries in Table 4 indicated the square root of the Average Variance Extracted (AVE), while the entries outside the diagonal reflected the correlations among the constructs. As the square root of AVE exceeded the inter-construct correlations, this confirmed the presence of discriminant validity; however, it was argued that the criteria set forth by (Fornell and Larcker 1981) are insufficient for establishing discriminant validity. Thus, the discriminant validity was assessed using the Heterotrait-Monotrait ratio (HTMT) values. All observed values remained below the threshold of 0.85, as indicated in Table 5 (Henseler, Ringle, and Sarstedt 2015).

Table 4. Discriminant Validity

	AFA	BC	AN	CA
AFA	**0.93**			
BC	-0.57	**0.92**		
AN	0.48	-0.46	**0.92**	
CA	0.51	0.83	0.6	**0.91**

Source: Compiled by Author

Table 5. HTMT Ratio

	BC	AN	CA	AFA
BC				
AN	0.622			
CA	0.684	0.523		
AFA	0.543	0.554	0.512	

Source: Compiled by Author

4.3 Structural Model

The structural model was evaluated by collinearity examination, testing the significance of the structural model, (Hair *et al.* 2012; Henseler *et al.* 2009) and calculating R^2 *i.e.* coefficient if determination (Cohen 1988). Variance Inflation Factors (VIF) were utilized to assess the multicollinearity among the constructs (Joseph F. Hair *et al.* 2012; Henseler, Ringle, and Sinkovics 2009). The VIF values calculated using SPSSv29 with latent variable scores were all below the threshold of 5, as illustrated in Table 6. Consequently, it is ensured that there is an absence of multicollinearity (Joseph F. Hair *et al.* 2012). Given that the values for collinearity have been justified, we can conclude that there is a significant relationship among the constructs. The significance testing of the constructs in the model was done using the bootstrapping algorithm in PLS-SEM. A random sample of 5000 cases were created from the original dataset to assess the significance of relationship between the constructs (Joseph F. Hair *et al.* 2012; Henseler, Ringle, and Sinkovics 2009). The findings are represented in Table 7.

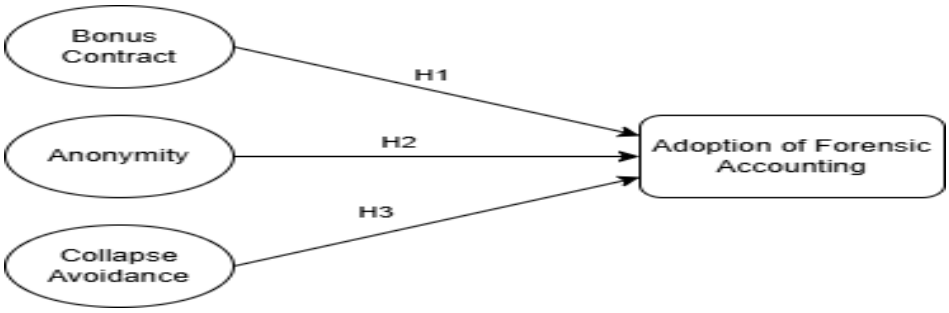
Table 6. Hypothesis Testing

Hypothesis	Path co-efficients	T Statistics	*P*-value	Decision
BC → AFA	0.09	0.71	0.05	Not Supported
AN → AFA	0.4	3.90	0.05	Supported
CA → AFA	0.27	2.21	0.05	Supported

Source: Compiled by Author

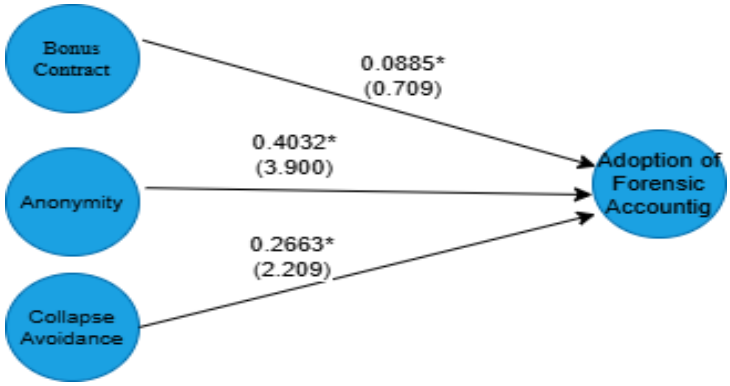
Figures 1 and 2 illustrate hypothesis testing. Following the hypothesis testing, the coefficient of determination (R^2) was calculated and was found to be 0.74 which is deemed satisfactory as suggested by (Cohen 1988).

Figure 1. Research Model



The model was also assessed for a good fit using the standardized root mean square residual (SRMR), Normal fir index (NFI), and RMS theta. The recommended SRMR value is below the critical threshold of 0.80 (Henseler *et al.* 2014; Joe F. Hair, Howard, and Nitzl 2020) The obtained value was 0.071, suggesting that the model is a good fit. The NFI reported is 0.844, and the RMS theta is 0.133.

Figure 2. Results



5. Discussion and Implications

5.1 Discussion

The bootstrap algorithm of PLS-SEM was utilized to analyse the relationships between the constructions. These findings provide valuable insights into the non-accounting factors influencing the adoption of forensic accounting techniques. It indicated that the presence of bonus contract did not influence the adoption of forensic accounting techniques, whereas anonymity and collapse avoidance positively influenced the adoption of forensic accounting techniques.

H1 evaluates whether presence of bonus contract significantly and positively affects adoption of forensic accounting techniques. The results revealed that the presence of bonus contracts has an insignificant impact on adoption of forensic accounting techniques (t=0.71, *P <0.05).* Hence H1 was not supported. This outcome suggests that financial and non-financial incentives linked to performance and result of an investigation done by accounting professionals, may not serve as a compelling motivator for adopting forensic accounting techniques.

H2 evaluates whether anonymity significantly and positively affects the adoption of forensic accounting techniques. The results revealed that anonymity has a significant impact on adoption of forensic accounting techniques (t=3.90, *P*<0.05). Hence H2 was supported. Anonymity likely fosters a sense of security, encouraging practitioners to participate actively in fraud detection without fear. Organizations that prioritize anonymous reporting mechanisms may be in a better position to allow their professionals to uncover frauds using forensic accounting measures.

Similarly, H3 evaluated whether collapse avoidance significantly and positively affects the adoption of forensic accounting techniques. The results revealed that it has impact (t= 2.21, *P*<0.05). Thus, H3 is supported. This highlights that organisations are likely to adopt forensic accounting practices when they recognize the

consequence of such investigative tools is not the winding up of the organization resulting in complete collapse. It may also reflect a proactive approach to mitigate the risk of operational disruption and reputational damage.

The research confirms the role of anonymity and collapse avoidance assurance in adoption of forensic accounting. The weak association between bonus contracts and adoption of forensic accounting techniques contradicts the hypothesis given by (Ozili 2020).

5.2 Theoretical Implications

Theoretically, the study highlights the nuanced roles of non-accounting factors such organisational incentives, *i.e.* bonus contract, anonymity and risk of collapse of the entity. First, the study shifts discourse beyond traditional accounting measures which focused on accounting measures, financial metrics, and compliance with regulatory framework. It broadens the lens by introducing cultural and psychological dimensions that are critical drivers of forensic accounting practices. Second, the study challenges the existing notion that financial incentives such as bonus contracts are sufficient to drive ethical practices and fraud prevention mechanisms within the organisation. Third, the significant impact of anonymity and collapse avoidance on the adoption of forensic accounting techniques highlights the importance of organizational culture and risk perception in prevention of fraud. This emphasizes that beyond the technical measures and financial incentives, the intangible aspects like the organisational culture, sense of security and perception of threat profoundly influence the ability of an organisation to combat frauds.

5.3 Practical implications

From a practical standpoint, the study highlights that the companies ought to focus on building an ethical culture and effective reporting system instead of solely relying on financial incentives. Such strategies not only foster a conducive environment for fraud detection and prevention but also create a culture of integrity and responsibility within an organisation. The positive impact of anonymity on forensic accounting adoption highlights the critical role of secure reporting system. Organisations are recommended to integrate forensic accounting methods into their risk management plans to proactively spot and address potential operational disruptions. The corporate policymakers are suggested to focus on raising awareness of the impacts of fraud among stakeholders. The awareness of the impact of fraud on the overall well-being of the organisation should be used as an encouragement for whistleblowing initiatives. Policies should support such initiatives, leveraging on the expertise of forensic accountants to investigate the reported misconduct.

Conclusion

The corporate world is always at the risk of both financial and non-financial misconduct. Forensic accounting techniques over the years have proved to significantly impact the effectiveness of financial fraud detection and prevention. Thus, the relevance of the sophisticated measures employed by forensic accountants to detect fraud is ever growing. Organisations must understand the vitality of forensic accounting in establishing a fraud-resistant atmosphere to thrive and develop in the current compliance-oriented environment.

This research underscores the importance of non-financial factors in the adoption of forensic accounting practices. In particular, anonymity was identified as a key facilitator, creating a safe space for practitioners to identify and report fraudulent activities. Additionally, the acknowledgment of collapse avoidance emphasizes the necessity of proactive strategies to reduce operational and reputational hazards. On the other hand, the minimal impact of bonus contracts indicates that financial incentives alone do not effectively encourage the integration of forensic accounting practices. The study broadens the understanding of how cultural, psychological and organisational elements can significantly influence the implementation of forensic accounting practices.

The present study can act as a basis for future research in the field of forensic accounting. Though this study concentrated particularly on non-accounting variables such as bonus contract, anonymity and collapse avoidance, further research could explore the role of additional variables to develop a deeper understanding of the factors affecting the adoption of forensic accounting. Additionally, studies that compare different industries or explore varying cultural and regulatory environments could yield important insights into how various factors impact successful implementation of forensic accounting practices.

The Forensic Accounting Theory formulated by P.K. Ozili in 2020 states how selected accounting and non-accounting factors affect the choice of forensic accounting techniques adopted by the practioners. This study is the first to conduct empirical research on the non-accounting factors that affect the adoption of forensic accounting techniques. This novelty contributes significantly to both industry and academics.

Limitations

The present study has provided valuable contribution to literature; however, there are certain limitations that provide scope for future research. First, the study predominantly employed a quantitative method using the PLS-SEM, which, although useful for analysing relationships between constructs, fails to address the intricacies of organisational behaviours. A qualitative approach, such as case study and interviews, could offer deeper insights into how these non-accounting factors offer a more comprehensive understanding about organisational decision-making in regard to forensic accounting. Second, the study emphasised only on the non-accounting factors of Forensic Accounting Theory, accounting variables have not been examined. Factors such as regulatory changes, leadership commitment or even the role of technology have not been examined in the study which may have significant influence on adoption of forensic accounting. Finally, the sample of the study may not represent all industries or geographical location. Organisation from different sectors of the economy may have different levels of awareness, resources and regulatory pressures influencing their decision to adopt forensic accounting measures.

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Credit Authorship Contribution Statement

Richa Diwakar: The framework and idea of the study was conceptualised and curated by the first author, after thorough research of the existing literature. Based on this the questionnaire was developed to justify the objectives with the data.

Ritu Wadhwa: The author worked and analysed the data collected. She not only worked on removing outliers from the data but also used SmartPLS software to analyse the data. Based on the results of PLS-SEM analysis she concluded the findings and discussions of the study.

T.V. Raman: The author gave his contribution in designing the structure of the paper. He worked on the introduction and conclusion sections of the paper to make it a meaningful article. He kept a track of our work and synchronised the efforts of all the author.

Anubha Srivastava: The expertise of the author helped in materialising the idea of this study. She suggested the correct way to approach the objective of the study, worked on literature review to develop the hypothesis and finalised the methodology of the study.

R. Gowri Shankar: The author has made the final contribution in the paper by bringing together the essence of the study. His expertise in finance contributed to the understanding of the concept of forensic accounting.

Piyush Kumar Jain: The contribution of the author has been in conceptualization of the research model and correcting the methodology of the study in order to achieve the objectives. The language of the paper has been corrected by him to match the standards of academic publications.

Declaration of Competing Interest

No known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper have been declared by the authors of this study.

Declaration of Use of Generative AI and AI-Assisted Technologies

To the best of authors' knowledge, the use of artificial intelligence has been limited to improving only the quality of the study in terms of this fluency and readability. The originality of the idea is purely the authors', and due reference has been given to the studies referred to.

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Exploring the Link between Corporate Governance and Financial Information Quality: A Comprehensive Bibliometric Analysis

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Abstract: The quality of financial information is crucial for establishing a company's transparency and integrity, which, in turn, affects its reputation and ability to attract investors. The effective application of corporate governance is expected to improve the quality of financial reporting by ensuring that financial data accurately reflects a company's performance and financial position. This paper aims to conduct a bibliometric analysis of corporate governance literature, providing an overview of current trends in publications and their impact on the quality of financial information, using data from the Scopus and Web of Science databases. The analysis employs bibliometric software, VOSviewer, to evaluate various metrics. The study examines a sample of 670 articles published between 2018 and 2024 in the Scopus and Web of Science databases. The findings show a significant upward trend in the volume of corporate governance literature, characterized by increased collaboration among authors. The results of this study, which explores how corporate governance influences financial reporting, will offer valuable insights for researchers, regulators, corporations, and investors.

Keywords: corporate governance; quality of financial information; bibliometric analysis; Scopus database; Web of Science database.

JEL Classification: G34; G00; O30; A12.

Introduction

Corporate governance plays a crucial role in helping companies reduce mismanagement, address potential gaps in governance mechanisms to prevent abuses of power, and manage risks. Adhering to governance recommendations forms the essential foundation for evaluating the quality of the governance system and, consequently, protecting the company's reputation. In this context, the quality of corporate governance is a necessary condition to ensure and maintain stakeholder trust. Indeed, stakeholders perceive companies with strong governance practices as less risky, which is likely to contribute to an increase in stock prices. Governance codes place significant importance on the quality of financial information provided by companies.

Financial reports are critical tools used by investors to make economic and investment decisions. The preparation of these reports largely depends on the governance structure prevailing within the organization preparing them. The content of these reports must, as a policy, convey vital information about the organization's true financial condition, faithfully representing each accounting value contained in the reports. The corporate governance structure must ensure that high-quality financial reports are prepared and used by stakeholders to make informed economic and investment decisions. Financial reports have become essential tools for users of financial statement information, as their decisions are based on the content of these reports. The governance system is greatly influenced by certain mechanisms that determine whether the quality of this information will be

high or low. Corporate governance issues gained prominence after the collapse of Enron and WorldCom in the United States, leading to the adoption of the Sarbanes-Oxley Act in 2002.

The communication of financial information is a key means of communication between businesses and their stakeholders. It allows the public, government, shareholders, employees, bankers, suppliers, creditors, and other stakeholders to stay informed about the financial situation and other activities of the company (Johnson, Khurana, & Reynolds, 2002; Kantudu & Samaila, 2015). Therefore, good quality of financial information facilitates decision-making by investors and other stakeholders (Kamaruzaman, Mazlifa, & Maisarah, 2009). The quality of financial reporting is considered high when the information reported is reliable, relevant, meaningful, comparable, and consistent. Compliance with accounting and regulatory standards, the absence of errors, and timely dissemination are other characteristics that contribute to the quality of financial reporting (Bushman, Chen, Engel, & Smith, 2004). However, guaranteeing error-free financial reporting is challenging, as certain information in financial statements relies on assumptions that affect the quality of the reported information. The International Accounting Standards Board (IASB) also recognizes this by requiring a certain level of precision, rather than complete accuracy in financial information (IASB, 2008). The quality of financial reporting became a subject of significant interest when the public questioned the transparency, integrity, and reliability of financial information, particularly after fraudulent transactions scandals involving Enron, WorldCom, Marconi, Parmalat, and others (Hashim & Devi, 2007).

This study employs bibliometric analysis to assess the existing literature on the influence of corporate governance on financial information. The aim is to identify trends, key authors, and research clusters related to the connection between corporate governance mechanisms and the quality of financial information. By compiling and analyzing a broad dataset of scholarly publications, the study seeks to provide insights into the current state of knowledge, highlight emerging research topics, and offer recommendations for future research. The study aims to address the following questions:

RQ1: What are the impactful authors in corporate governance and financial information quality?

RQ2: What are the most frequently used keywords in the research on corporate governance and financial information quality?

RQ3: Which studies or publications have been most frequently cited in the field of corporate governance and financial information quality?

RQ4: Which journals have published the most influential articles on corporate governance and financial information quality?

The structure of this study is as follows: Section 2 provides the literature review, while Section 3 outlines the methodology used. The results of the comprehensive bibliometric analysis, along with the discussion, are presented in Section 4. Finally, Section 5 concludes the study, highlighting the key findings and Future Research Directions.

1. Literature Review

1.1 Corporate Governance

Corporate governance has emerged as a critical concept in modern corporations due to the separation between management and ownership control. This separation creates inherent conflicts between shareholder and manager interests, manifesting in the principal-agent problem that affects various stakeholders' interests in organizational direction and management. The concept of corporate governance has evolved significantly since its early discussions by Smith (1776) and Berle and Means (1932), leading to various interpretations and definitions from different perspectives.

Scholars and institutions have provided diverse definitions of corporate governance. Zingales (1998) presents it as a comprehensive framework encompassing ownership allocation, capital structure, managerial incentives, and institutional pressures. Shleifer and Vishny (1997) focus on the financial aspect, defining it as the mechanisms ensuring investment returns for corporate financiers. The OECD offers a broader perspective, describing corporate governance as the system directing and controlling business corporations, specifying rights and responsibilities among participants, and establishing decision-making procedures. This definition aligns with Oman's (2001) view of corporate governance as encompassing both private and public institutions that govern relationships between corporate managers and stakeholders.

The importance of corporate governance has intensified due to global corporate scandals, leading organizations and countries to establish protective policies through either principle-based or rule-based approaches. As Arjoon (2006) and Nakpodia *et al.* (2018) note, while rule-based approaches enforce compliance through penalties, principle-based approaches focus on adhering to the spirit of governance codes. This

distinction is particularly relevant in different societal contexts, with bureaucratic settings favoring rule-based approaches and societies with strong social controls preferring principle-based systems.

Research shows that effective corporate governance practices significantly impact organizational performance and stakeholder relationships. Claessens and Yurtoglu (2012) demonstrate that enhanced governance practices can increase share prices and reduce capital costs. Bae *et al.* (2018) highlight how strong corporate governance elements reduce information asymmetry and send positive market signals. Orazalin (2019) emphasizes the relationship between good governance practices and disclosure transparency. These findings underscore corporate governance's crucial role in organizational success and growth, particularly in managing agency costs and strengthening organizational mechanisms amid business uncertainties.

Corporate governance mechanisms are essential for balancing management and shareholder interests, as emphasized by Kose and Lemma (1998). They note that these mechanisms emerge primarily from the separation of ownership and control, aiming to oversee corporate insiders and protect corporate interests. Freeman and David (1983) stress the importance of rationalizing management actions to advance both company and shareholder interests, highlighting the need for structured governance frameworks that satisfy multiple stakeholders' needs while ensuring effective organizational control and management.

1.2 Quality of Financial Information

The quality of financial information is a multidimensional concept that has been the subject of numerous academic studies. It can be defined as the ability of financial statements to provide relevant and faithful information about a company's economic performance and financial position (Beest *et al.* 2009). According to the IASB conceptual framework (2018), the quality of information is based on fundamental qualitative characteristics such as relevance and faithful representation, complemented by auxiliary characteristics such as comparability, verifiability, timeliness, and understandability. Relevance refers to the ability of the information to influence users' decisions, while faithful representation requires that the information be complete, neutral, and free from significant errors (IASB, 2018).

Dechow *et al.* (2010) highlight that the quality of financial information is often assessed through various measures of earnings quality, such as persistence, accounting adjustments, earnings smoothing, and timeliness of publication. They also note that this concept of quality is contextual and depends on the decisions to be made. Furthermore, Van Beest *et al.* (2009) developed more comprehensive measurement tools, considering both financial and non-financial aspects.

The importance of financial information quality is reflected in its influence on investor confidence, market liquidity, capital cost, and the efficiency of financial markets (Kothari, 2000). Additionally, it helps reduce information asymmetry between managers and external stakeholders (Healy & Palepu, 2001). Thus, information quality goes beyond mere compliance with accounting standards; it encompasses the ability of financial statements to faithfully reflect the economic reality of the company and provide useful information for decision-making.

The quality of financial information can be assessed through several key criteria. Reliability is crucial, as information is considered reliable when it is free from significant errors and biases, thereby providing users with a faithful representation of the economic realities it aims to describe (Beest *et al.* 2009). The IASB (2018) specifies that this reliability is based on the completeness, neutrality, and absence of errors in the information. Moreover, relevance plays a major role in enabling information to influence users' economic decisions, whether by offering insights into past, present, or future events, or by confirming or correcting their prior assessments (IASB, 2018). According to Dechow *et al.* (2010), it is often measured by indicators such as earnings persistence or the timeliness of financial reporting.

Another important criterion is comparability, which allows users to compare a company's financial statements over time to identify trends in its performance and financial position, while also facilitating comparisons with other companies (Beest *et al.* 2009). This characteristic significantly contributes to investors' analysis and decision-making. Although not explicitly mentioned in the IASB conceptual framework, transparency also plays a major role. It requires full and clear disclosure of relevant information, allowing users to fully understand a company's financial position (Healy & Palepu, 2001).

The quality of financial information is essential for effective corporate governance and informed decision-making. Beyond comparability and reliability, it relies on qualitative characteristics such as relevance and transparency, which are often integrated into the IASB conceptual framework. Executives, particularly CEOs, have a strong influence on this quality through their choices of accounting policies, especially in measurement decisions. In an increasingly digital world, evaluating the quality of information has become a growing challenge,

requiring the development of critical judgment skills. Finally, the interaction between normative and positive accounting theories contributes to a better understanding and improvement of the relevance of financial information.

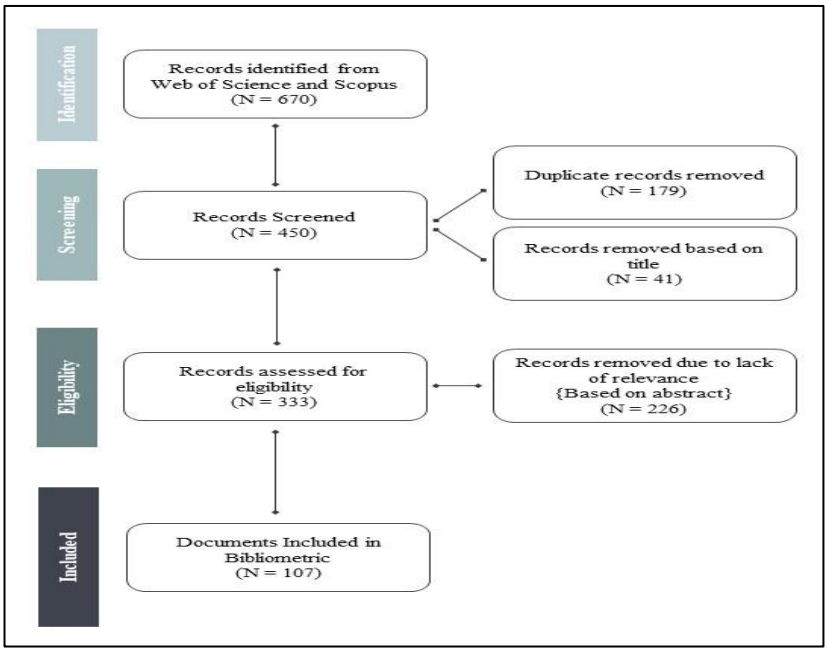
2. Methodology

This research employs a bibliometric methodology to evaluate the relationship between corporate governance and financial information quality. This approach, similar to that used by Cullen (2017), Ezenwoke and Tion (2020), and Nicolas *et al.* (2020), is a powerful tool for mapping research patterns through influential publications. The bibliometric method enables the identification of research trends and literature gaps through comprehensive mapping. Unlike traditional systematic reviews, which typically rely on evidence-based experiential analysis (Inamdar *et al.* 2020), bibliometric evaluation provides sophisticated network analysis, examining factors such as co-authorship patterns, citation metrics, and research collaborations - crucial elements for understanding a field's current state. This approach also plays a vital role in evaluating research performance at both departmental and institutional levels. As noted by Ellegaard and Wallin (2015), bibliometric analysis primarily focuses on quantitative statistical data and is rarely combined with bibliographic analysis in a given field.

This study analyzed articles published between 2018 and 2024, collected from Scopus and Web of Science databases, to assess recent research over a significant period. The Scopus database stands out for its comprehensive nature, gathering a rich collection of academic data and scientific literature across numerous disciplines. With over 17,000 titles and more than 5,000 indexed publishers, it enables international multidisciplinary integration. Similarly, Web of Science is renowned as one of the most trusted citation indexing platforms, providing access to multiple databases that reference cross-disciplinary research. Since corporate governance issues span multiple fields, our Scopus search focused on articles published in Business Management and Accounting, Economics, Econometrics and Finance, Social Sciences, and Decision Sciences. For Web of Science, we concentrated on articles in Business Economics and General Social Sciences.

Figure 1 outlines our methodological framework and the systematic process used to determine the final publication sample. To visualize the relationships between researchers and their publications, we employed the VOSviewer software (Van Eck and Waltman, 2010; Nicolas *et al.* 2020). According to Liu (2013), VOSviewer positions items in a dimensional space where the distance between elements represents their similarity or relationship. This visualization tool effectively illustrates the evolution and structure of research within a field over time. VOSviewer's capabilities allow for the identification of emerging patterns and provide deeper insights into the nature of a specific research domain. As noted by Vallaster *et al.* (2019), the software excels at comparing historical and current research activities, revealing the evolution of particular research areas. Through this bibliometric analysis approach, we were able to identify key authors, relevant keywords, citation and co-citation patterns, publication sources, and geographical distribution of research contributions.

Figure 1. Flow diagram of the searching process.



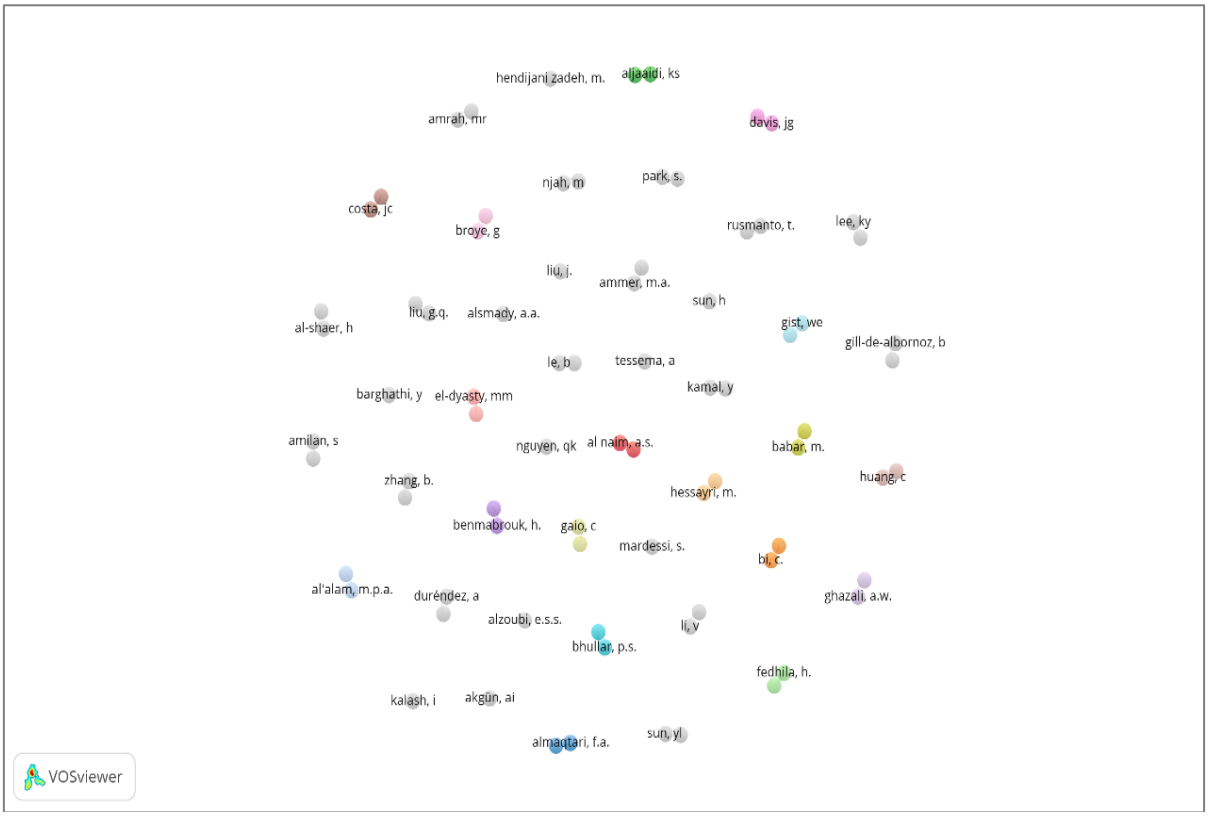
Source: compiled by the authors.

3. Results and Discussion

3.1 Authorship Analysis

Consistent with previous bibliometric studies (Ferreira *et al.* 2014; Øyna & Alon, 2018), an authorship analysis is conducted using VOSviewer to identify the leading contributors in corporate governance and disclosure research. This analysis classifies authors based on their publication frequency in the sample. Authors with high productivity on the topic are highlighted according to the selection criteria established by Waltman *et al.* (2010). From the 304 authors in our sample, the top 15 who have published at least two articles are shown on the first map in Figure 2. Additionally, the map illustrates the strength of co-authorship links among these 15 authors.

Figure 2. Dominant authors network visualization map



Source: compiled by the authors.

The strength of authorship links (co-authorship) is calculated to identify authors who have collaborated frequently. A stronger link indicates a higher frequency of co-occurrence between two authors. However, as shown in the first map in Figure 2, the strongest co-authorship links analysis shows that we have multiple clusters of two authors such as Ahsan Habib and Dinithi Ranasinghe, Abdulaziz Saud Al Naim and Abdulrahman Alomair. These authors form clusters with the highest link strength.

3.2 Keywords Analysis

In addition to the keyword search that generated documents for the study's analysis, the distribution of other keywords is further explored. Co-occurrences of two or more keywords refer to the number of publications in which the keywords appear together in the title, abstract, or keyword list (van Eck & Waltman, 2010). In the keyword analysis, larger nodes or keywords on the bibliometric map indicate higher weight and frequency in the sample. The proximity between two nodes reflects the strength of their association, with shorter distances suggesting a stronger connection between the keywords (Liao *et al.* 2018). The lines connecting the keywords also represent their co-occurrence. Li *et al.* (2016) explains that keyword co-occurrence is an effective method for identifying central research areas within a field and can support further research.

In this study, 1,223 author keywords were collected. By setting a minimum occurrence threshold of 5, the analysis resulted in 47 keywords (see Figure 3), which were used to determine the total strength of co-occurrence links. The top 15 keywords, along with their frequency and total link strengths, are shown in Table 1.

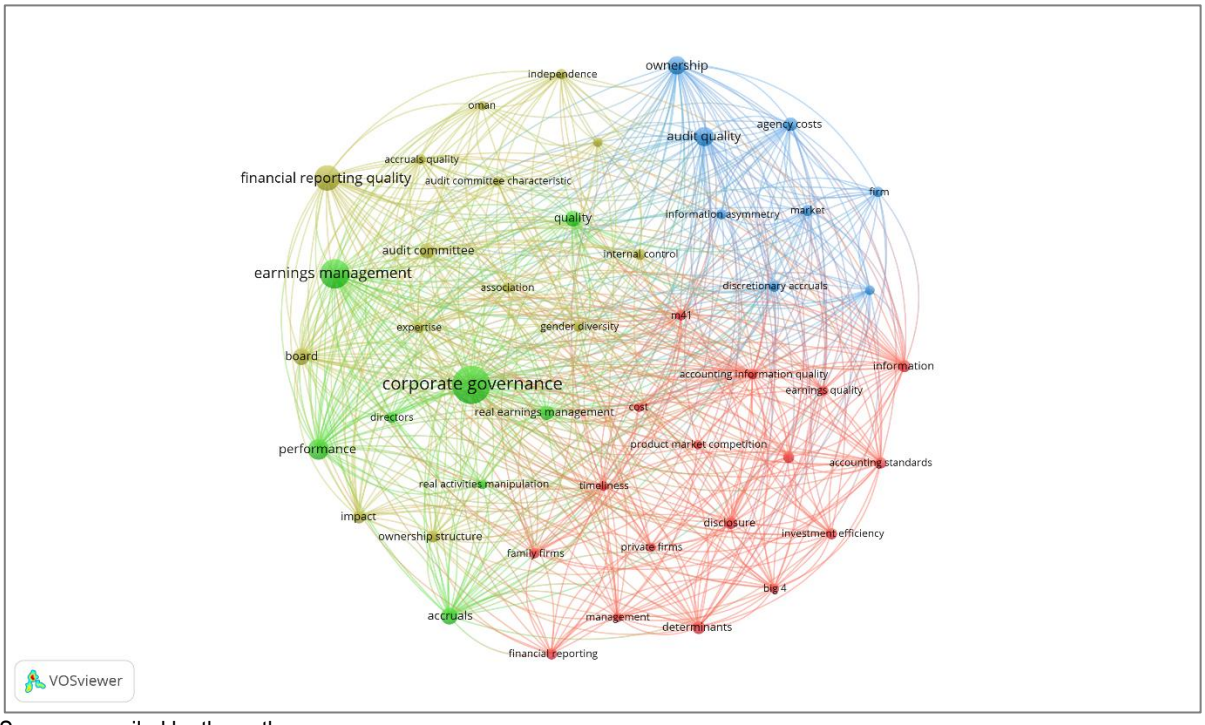
Table 1. Top 15 keywords of corporate governance and financial information quality

Rank	Keyword	Occurrences	Total Link Strength
1	Corporate governance	76	357
2	Earnings management	45	252
3	Performance	22	168
4	Financial reporting quality	34	158
5	Ownership	18	150
6	Board	15	135
7	Audit quality	19	132
8	Accruals	15	118
9	Quality	13	109
10	Agency costs	10	98
11	Impact	9	98
12	Information	8	96
13	Audit committee	12	93
14	Expertise	7	93
15	Discretionary accruals	7	89

Source: compiled by the authors.

The keyword co-occurrence map (Figure 3) revealed four clusters with total link strength of 2,274. "Corporate governance", "Earnings management", "Performance" and "Financial Reporting Quality" emerged as the keywords with the largest nodes and the shortest connections, indicating the high frequency with which these terms are used together in scholarly work. This was followed by the co-occurrence of "Ownership" and "Board". This pattern aligns with the evolution of corporate governance research, which has grown to incorporate multiple business administration and disclosure aspects, including Audit Quality, Accruals, and various external factors. Therefore, the frequent appearance of "Corporate Governance," "Earnings Management," and "Performance" as key terms across numerous studies reflects the integrated nature of modern corporate governance research.

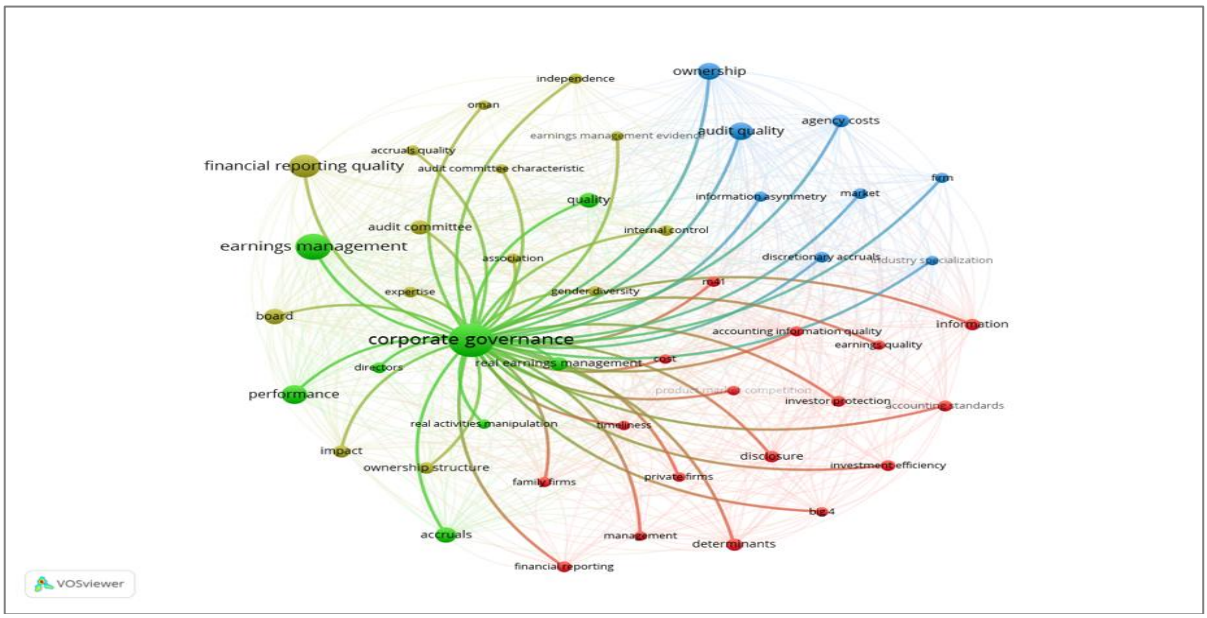
Figure 3. Keyword co-occurrence network visualization map



Source: compiled by the authors.

Following the analysis of the network visualization, and focusing on the most frequent keyword, "Corporate governance", Figure 3 shows its relationship with the four clusters in our visualization becomes evident. This analysis highlights the strong and visually prominent links between this keyword and the associated keywords in the top 15, as reflected by the significant links.

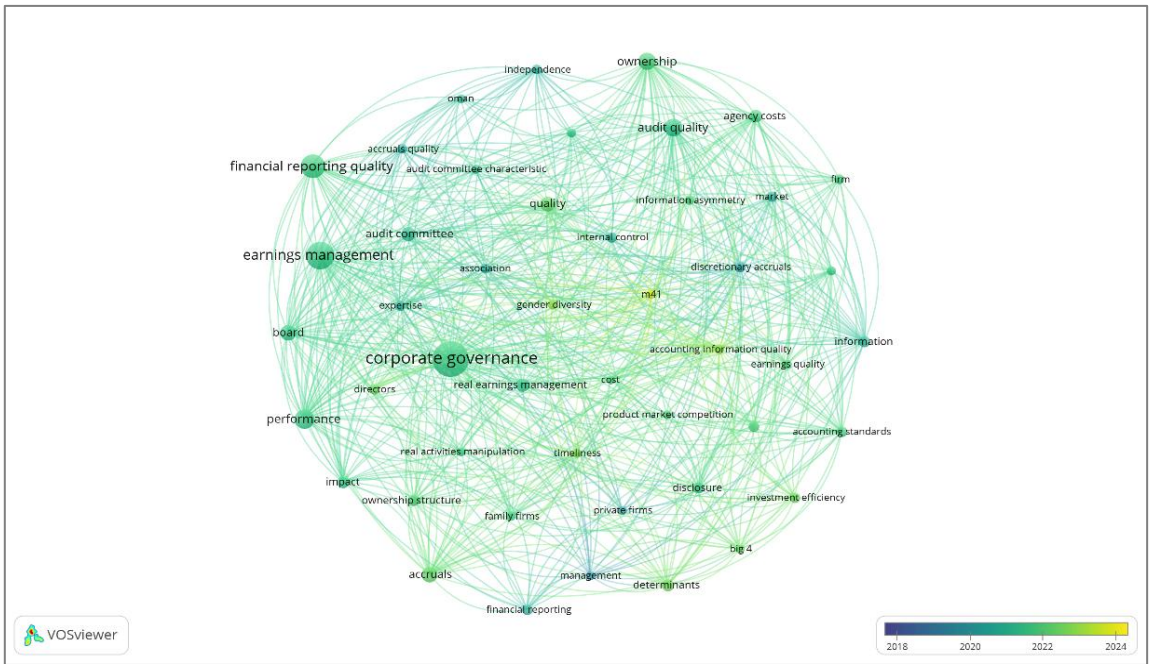
Figure 4. Focus on “Corporate governance” relation with other clusters.



Source: compiled by the authors.

In addition to the previous maps, the overlay visualization map is important because it provides a clear and intuitive representation of how different keywords are related within a dataset, typically in citation or keyword analysis. By using color coding based on time or a specific metric, it helps to highlight trends, shifts, and emerging topics over time. This feature allows researchers to visually track the evolution of research keywords, identify clusters of related topics, and discern patterns that may not be easily apparent through traditional methods. It is especially useful for understanding how certain areas of research are gaining prominence or fading away.

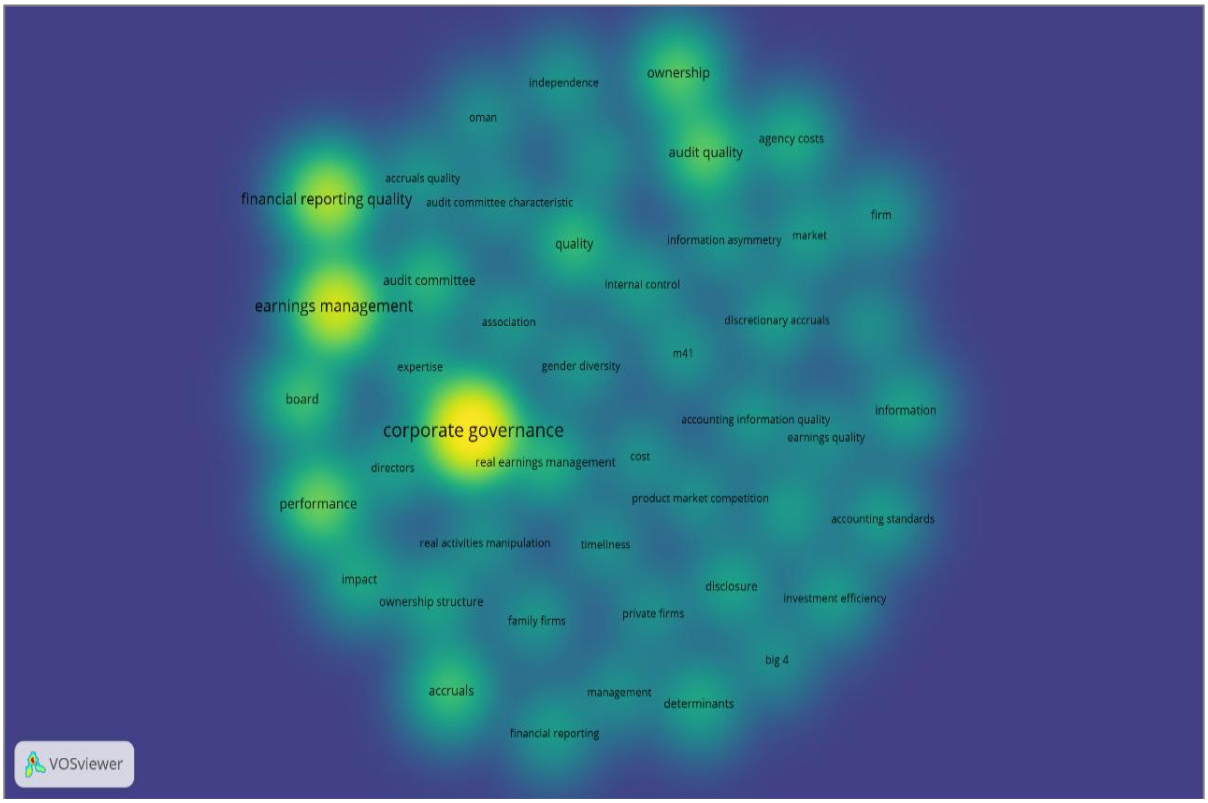
Figure 5. Keyword co-occurrence overlap visualization map



Source: compiled by the authors.

Additionally, the density visualization map (Figure 6) was used to show the extent of co-occurrence, with each keyword color-coded to represent its density on the map. The map highlights higher weights among neighboring items based on their colors. Specifically, the color of a keyword corresponds to its frequency of occurrence in the sample. According to Van Eck and Waltman (2010), the larger the items in a particular region on the map and the higher the weights of surrounding items, the closer the point is too yellow. The density visualization map reveals that "corporate governance" and "disclosure" are central and key keywords, widely featured in the existing literature.

Figure 6. Keyword co-occurrence density visualization map



Source: compiled by the authors.

3.3 Citation Analysis

Citation analysis is a widely used method in bibliometric research. It provides a way to assess scholarly work through the citation of other authors. This technique involves examining the reference lists of documents to identify the most influential articles, based on the frequency with which they are cited by other researchers within specific topics or fields. According to Liao *et al.* (2018), citation analysis is a quantitative approach that evaluates the quality of subjects, such as authors or journals, by counting the number of citations they generate. When researchers cite articles, they consider essential for their work, the most frequently cited articles are those that have had a significant impact on their respective areas.

In this study, citation analysis was performed on articles with at least 7 citations. To highlight the most cited works, the top 12 articles with the highest citation counts were selected and are presented in Table 2.

Of the twelve most cited papers listed in Table 2, nine were published between 2020 and 2024, with the remaining one from the 2018–2024. This indicates that articles from 2020 become more cited in articles due to the impact of corporate governance in improvement of financial information quality and organizational performance. All the selected papers were co-authored by no more than five authors, emphasizing the importance of co-authorship in building key relationships and enhancing subsequent citation analysis.

The most cited paper, by Habib, A; Ranasinghe, D; Liu, Y (2024) made a significant contribution to labor investment efficiency and corporate governance literature by demonstrating how financial reporting quality have profound implications for labor investment efficiency.

Table 2. Top 12 most cited articles

Rank	Authors	Articles	Sources	Citations
1	Habib, A; Ranasinghe, D; Liu, Y (2024)	Labor investment efficiency: a review of the international literature	Journal Of Accounting Literature	216
2	Almaqtari, FA; Hashed, AA; Shamim, M (2021)	Impact of corporate governance mechanism on IFRS adoption: A comparative study of Saudi Arabia, Oman, and the United Arab Emirates	Heliyon	185
3	Rahaman, MM; Hossain, MM; Bhuiyan, MBU (2023)	Disclosure of key audit matters (kams) in financial reporting: evidence from an emerging economy	Journal Of Accounting In Emerging Economies	159
4	Calabrò, A; Cameran, M; Campa, D; Pettinicchio, A (2022)	Financial reporting in family firms: a socioemotional wealth approach toward information quality	Journal Of Small Business Management	126
5	Mayberry, M; Park, HJ; Xu, T (2021)	Risk-Taking Incentives and Earnings Management: New Evidence	Contemporary Accounting Research	116
6	Amrah, MR; Obaid, MM (2019)	Effective corporate governance mechanisms, ownership structure and financial reporting quality: evidence from oman	Asia-Pacific Management Accounting Journal	113
7	Ismail, I; How, J; Shafie, R; Ismail, KNIK; Wahab, EAA (2024)	Female leadership and earnings management in politically connected and family firms	Accounting Forum	110
8	Gill-de-Albornoz, B; Rusanescu, S (2018)	Foreign ownership and financial reporting quality in private subsidiaries	Spanish Journal Of Finance And Accounting-Revista Espanola De Financiacion Y Contabilida	108
9	Tessema, A (2020)	Audit quality, political connections and information asymmetry: evidence from banks in gulf co-operation council countries	International Journal Of Managerial Finance	107
10	Celik, B; Ozer, G; Merter, AK (2023)	The Effect of Ownership Structure on Financial Reporting Timeliness: An Implementation on Borsa Istanbul	Sage Open	104
11	Al-Sayani, YM; Nor, MNM; Amran, NA (2020)	The influence of audit committee characteristics on impression management in chairman statement: Evidence from Malaysia	Cogent Business & Management	103
12	Alzoubi, E.S.S. (2018)	Audit quality, debt financing, and earnings management: Evidence from Jordan	Journal Of International Accounting, Auditing And Taxation	103

Source: compiled by the authors.

3.4 Most Cited Journals

The most cited journals in scientific research play a pivotal role in shaping the direction of academic discourse and advancing knowledge within various fields. Once research articles are cited, the journals in which they are

published also receive citations. The study resulted in a selection of 81 journals, based on a minimum of 3 articles per journal, with the top 15 listed in Table 3.

Table 3. Top 15 most cited journals

Rank	Journals	Citations
1	Journal Of Accounting Literature	358
2	Journal Of Applied Accounting Research	257
3	Journal Of Financial Reporting And Accounting	253
4	Journal Of Accounting In Emerging Economies	237
5	Managerial Auditing Journal	226
6	Cogent Business & Management	199
7	Heliyon	185
8	Accounting Forum	169
9	International Review Of Financial Analysis	165
10	Accounting And Finance	158
11	Journal Of Corporate Finance	156
12	Auditing-A Journal Of Practice & Theory	135
13	Contabilidade Gestao E Governanca	128
14	Journal Of Small Business Management	126
15	Contemporary Accounting Research	116

Source: compiled by the authors.

The three most-cited journals are: the *Journal of Accounting Literature* with 358 citations, the *Journal of Applied Accounting Research* with 257 citations, and the *Journal of Financial Reporting and Accounting* with 253 citations. It can be noted that, except for the first journal, the next five journals are closely aligned in terms of citation count.

Conclusions and Further Research

This study provides a comprehensive bibliometric analysis of the literature on corporate governance and its influence on the quality of financial information. The findings reveal a significant upward trend in the volume of publications in this field, highlighting the growing importance of corporate governance in improving transparency and the quality of financial reporting. The authorship analysis identifies key contributors to the field, while the keyword co-occurrence analysis uncovers central research areas, including "corporate governance," "earnings management," "performance," and "financial reporting quality." These insights reflect the evolving and multifaceted nature of corporate governance research, which increasingly integrates various dimensions of business administration and disclosure practices.

The citation analysis confirms that several seminal works have had a profound impact on the research agenda, further underscoring the relevance of corporate governance mechanisms in enhancing financial transparency. The clustering of terms such as "ownership" and "board" alongside financial reporting topics suggests a deepening exploration of governance structures and their implications for financial outcomes.

Despite these valuable contributions, several avenues remain open for future research. First, future studies could examine the long-term effects of corporate governance reforms on financial reporting quality across different industries and regions. This would provide a more nuanced understanding of how governance structures influence transparency in diverse contexts. Second, while this study highlights the major research trends, it is important to explore under-researched areas, such as the role of technology and digital transformation in corporate governance and financial reporting. Emerging trends like artificial intelligence, blockchain, and big data may have significant implications for governance practices and the quality of financial information.

Furthermore, the increasing collaboration among authors suggests that interdisciplinary approaches could offer new perspectives on the relationship between governance and financial transparency. Future research could leverage cross-disciplinary methodologies to further explore how corporate governance intersects with fields such as law, ethics, and information technology.

In conclusion, this study offers valuable insights into the current state of corporate governance research and its implications for financial reporting. It also lays the groundwork for future investigations that can refine and

expand our understanding of how corporate governance affects the accuracy, reliability, and transparency of financial information.

Credit Authorship Contribution Statement

The authors 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 during the preparation of this work.

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Green Banking in Albania: Examining Its Impact on Environmental Performance, Financing, and Corporate Image

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Abstract: In recent years, the banking sector has increasingly embraced eco-friendly practices to address environmental, social, and governance (ESG) challenges while promoting environmental preservation. In Albania, banks have begun implementing green banking strategies; however, limited empirical research exists on the measurement and impact of these initiatives. This study examines the effects of green banking practices on environmental sustainability, green financing, and the green image of banks in Albania. Data were gathered through self-administered and online surveys targeting employees in the Albanian banking sector, and regression analysis was conducted using the Statistical Package for the Social Sciences (SPSS). The findings indicate a significant positive relationship between green banking practices and improvements in environmental sustainability, green financing activities, and the overall corporate image of banks. The results underscore the importance of adopting green banking practices to enhance sustainability efforts, expand green financing opportunities, and strengthen banks' reputations. The study recommends that banks prioritize environmental education and training for employees, introduce incentive programs for green initiatives, and integrate sustainable practices into daily operations, such as reducing paper consumption, utilizing energy-efficient technologies like Smart BanKomaT (ATM), and expanding online banking platforms. Additionally, the Bank of Albania and the government should establish targeted regulations and facilitate awareness-raising events, such as seminars and training sessions, to engage customers and the public in green banking initiatives. These actions are expected to enhance environmental sustainability while supporting Albania's sustainable economic growth.

Keywords: green banking practices; environmental sustainability outcomes; green financing; green image.

JEL Classification: G21; G32; M14; Q56; C12.

Introduction

Banks play a critical role in promoting sustainable environmental practices and driving the economic growth of nations. As primary economic agents, they influence the industrial sector through lending and project financing, shaping the trajectory of sustainable development (Alshebami, 2021). Due to their intermediary role between economies and investment industries, financial institutions significantly contribute to economic development and sustainability. To fulfill their corporate social responsibility and support sustainable development, many banks are transitioning toward paperless, technology-driven services for both existing and prospective customers (Fernando & Fernando, 2017). These dual objectives of ethical and socially responsible operations align with the principles of green banking (Tara *et al.* 2015), further encourage banks to adopt eco-friendly initiatives.

Internationally, environmental concerns have led to an increased focus on green banking practices. Regulatory bodies and stakeholders are urging financial institutions to embrace pro-environmental initiatives to address environmental, social, and governance (ESG) challenges (Sarma & Roy, 2020). Banks, both individually

and collectively, are responding by launching green financial products to enhance economic value while improving their reputation as responsible corporate citizens (Park & Kim, 2020).

Numerous studies over the last ten years have highlighted the positive effects of green banking practices on environmental sustainability (Shaumya *et al.* 2017; Rehman *et al.* 2021; Chen *et al.* 2022), green financing (Rehman *et al.* 2021; Zheng *et al.* 2021), and the enhancement of a bank's corporate reputation (Alshebami, 2021). There is a consensus in the literature that the adoption of these eco-friendly banking initiatives is strongly associated with better environmental outcomes, greater opportunities for green financing, and a stronger green image for financial institutions. Building on existing literature, this research explores the link between green banking practices and their effects on environmental sustainability, green financing, and the corporate image of banks in Albania's financial sector.

In recent years, the concept of green banking has gained traction in Albania. The country's banking sector includes 11 licensed commercial banks, comprising eight foreign-owned and three domestically-owned institutions. Collaboration between these foreign and domestic banks has laid a foundation for future stability and greener financial operations. However, only a handful of banks have officially embraced green banking practices. Early efforts include reducing carbon emissions, minimizing paper usage, and investing in digital banking solutions to reduce the environmental impact of daily operations. Digital banking initiatives, such as mobile banking, e-banking, and Smart BanKomaT (ATM), encourage customers to use online channels, which consume less energy, reduce transportation needs, and lower paper use and carbon emissions. Most Albanian banks now offer these digital services, which, as Ayinaddis *et al.* (2023) suggest, are transforming the financial industry by fostering growth, promoting green innovation, and enhancing competitiveness.

Additionally, Albanian banks have improved energy efficiency in internal operations, such as lighting, heating, and insulation. Some banks have installed solar panels at selected ATMs and office buildings, while others plan similar upgrades. Banks are also financing energy efficiency projects for businesses and individuals in collaboration with the Green Growth Fund (GGF). These initiatives aim to reduce environmental harm, improve energy efficiency, and lower carbon footprints, demonstrating a commitment to eco-friendly banking.

Despite these efforts, the adoption of green banking in Albania faces challenges. There is a lack of government incentives, insufficient legislation mandating environmental practices, and limited awareness and expertise among managers and employees. These barriers hinder broader implementation and monitoring of green practices. Furthermore, empirical studies on green banking in Albania remain scarce, highlighting the need for in-depth research.

This study addresses these gaps by examining the impact of green banking practices on banks' Environmental sustainability outcomes, green financing, and green image. Using data collected through self-administered surveys of employees from Albanian banks in the Vlore region, the study employs regression analysis via the Statistical Package for the Social Sciences (SPSS). The findings aim to provide insights into how green banking practices can enhance sustainability in Albania's banking sector.

1. Literature Review

1.1 Green Banking

Green banking is a dynamic concept that intersects environmental policy, financial institution operations, and socioeconomic growth (Khairunnessa *et al.* 2021). It aims to promote environmental sustainability by integrating green policies and practices into banking operations. The origins of green banking trace back to 1980, when "Triodos Bank" in the Netherlands pioneered the concept. A decade later, the bank established a "green fund" to finance environmentally friendly projects, inspiring financial institutions worldwide to adopt similar green banking policies (Khairunnessa *et al.* 2021; Yadav *et al.* 2013). Today, banks are increasingly aware of the need to address environmental challenges and are implementing green strategies to reduce carbon emissions.

Sharma and Choubey (2022) describe green banking as a socially responsible banking approach that incorporates sustainability into daily operations. These practices transform banks into "green banks" or "ethical banks," institutions that integrate green technologies and minimize their carbon footprint while fostering environmental management (Hossain *et al.* 2020; Zhixia *et al.* 2018). According to Bose *et al.* (2017), green banks achieve this by adopting paperless operations, energy-efficient technologies, and eco-friendly initiatives.

Banks are also under growing pressure to redirect investments away from fossil fuels and toward green technologies. By financing renewable energy projects and refinancing sustainable assets, financial institutions can play a pivotal role in promoting environmental sustainability (Park & Kim, 2020). Green banking thus reduces both the internal carbon footprint of banking operations and external emissions by influencing industries.

Although banking is not traditionally viewed as a polluting industry, its significant reliance on energy, paper, and non-sustainable infrastructure has contributed to an increased carbon footprint. For instance, Scholtens (2009) highlights that green banks can address this by offering savings accounts that ensure investments are directed toward sustainable projects. Similarly, banks can finance green technology initiatives that mitigate air pollution and promote eco-friendly practices.

Empirical studies have also demonstrated the broader benefits of green banking. Lymperopoulos *et al.* (2012) and Alshebami (2021) found that green banking initiatives not only reduce environmental impacts but also enhance a bank's green image, fostering customer trust and loyalty. In countries like Albania, where the banking sector is growing, green banking can increase environmental awareness and encourage compliance with sustainability practices. However, as Shaumya and Arulrajah (2017) note, while green banking practices have been studied extensively in various countries, their application and impact in contexts like Albania warrant further investigation. This growing emphasis on green banking highlights its potential as a transformative approach for achieving environmental sustainability and driving economic development.

1.2 Green Banking Initiatives in Albania

The financial risks associated with climate change are becoming increasingly evident, prompting the banking sector, central banks, and financial regulators to address these challenges more seriously (Monnin, 2018). Banks play a pivotal role in managing climate-related risks and supporting the transition to a low-carbon economy by promoting investments in environmentally friendly and green projects. In line with the Sustainable Development Goals (SDGs), Albanian banks are developing green products and prioritizing environmental and social responsibility as integral components of their mission.

Banks have both direct and indirect environmental impacts. Direct impacts stem from their internal operations, such as carbon emissions, water and energy consumption, and paper usage. Indirect impacts arise from the products and services they offer to customers, which influence environmental sustainability. Recognizing this dual impact, Albanian banks are incorporating environmental objectives into their strategic development missions.

The Albanian authorities have taken significant steps toward fostering a sustainable economy. These include adopting the 2030 Agenda for Sustainable Development Goals, the Green Agenda for the Western Balkans outlined at the Sofia Summit in 2020, and the commitments under the Paris Agreement. Additionally, Albania has developed a National Energy and Climate Plan and other frameworks to facilitate the transition to a green economy.

While the Albanian banking sector has started supporting this transition by financing green projects, further actions are needed to ensure stability and resilience against climate-related risks. The sector's efforts are bolstered by the presence of European banks in Albania, which adhere to the Environmental, Social, and Governance (ESG) guidelines set by the European Banking Authority. Collaboration between foreign and domestic banks has laid a foundation for a more sustainable and greener banking system.

Despite this progress, only a few banks in Albania have fully embraced the concept of green banking. Some steps taken include reducing carbon emissions, minimizing paper usage in internal operations, and investing in digital banking to reduce the environmental impact of daily banking activities. Digital banking solutions, such as mobile banking, e-banking, and Smart BanKomaT, encourage customers to adopt digital channels, which reduce energy consumption, transportation needs, paper usage, and carbon emissions.

Currently, most banks in Albania offer e-banking and mobile banking services, signaling an ongoing transition toward greener practices. However, there is still a need for stronger commitments and more widespread adoption of green banking practices to achieve greater sustainability and resilience to climate risks (Topalli & Monnin, 2023).

1.3 Green Banking Practices and Banks' Environmental Sustainability Outcomes

Green banking practices, particularly through green project financing, are increasingly emphasized as critical tools for promoting environmental sustainability at both the corporate and policy levels (Rehman *et al.* 2021). While banks are not traditionally considered polluting industries, they indirectly contribute to environmental degradation as key financiers for businesses that may harm the environment. Moreover, the growing scale of banking operations has significantly elevated banks' carbon footprint due to excessive energy consumption, paper waste, and insufficient adoption of eco-friendly infrastructure, such as green buildings (Shaumya *et al.* 2017). Thus, despite environmental preservation not being their primary objective, banks must actively contribute to improving the climate, quality of life, and the efficient use of materials and energy.

Over the past decade, several studies have explored the relationship between green banking practices and banks' Environmental sustainability outcomes (Shaumya *et al.* 2017; Rehman *et al.* 2021; Chen *et al.* 2022). These studies commonly conclude that green banking practices reduce environmental harm and enhance Environmental sustainability outcomes.

For example, Shaumya *et al.* (2017) analyzed the impact of green banking practices on the Environmental sustainability outcomes of banks in Sri Lanka. Their findings revealed a statistically significant and positive effect of green banking practices on banks' Environmental sustainability outcomes. Specifically, Policy-driven green strategies, Employee environmental contributions, and daily operation-related practices were identified as strong predictors of improved Environmental sustainability outcomes. However, Client-focused green initiatives did not exhibit a significant impact. Similarly, Rehman *et al.* (2021) examined the relationship between green banking practices and Environmental sustainability outcomes in Pakistan. Their results indicated a strong positive correlation, particularly emphasizing the role of Policy-driven green strategies, daily operations, and green investments in driving Environmental sustainability outcomes improvements.

More recently, Chen *et al.* (2022) studied the impact of green banking practices on banks' Environmental sustainability outcomes in Bangladesh. Their findings confirmed that green banking policies and operational practices positively influenced Environmental sustainability outcomes. However, employee-related and Client-focused green initiatives did not show significant effects. The study highlighted a gap in awareness and knowledge among employees and customers regarding green banking practices. Chen *et al.* (2022) suggested that providing environmental training and education to bank employees and customers could bridge this knowledge gap and enhance the Environmental sustainability outcomes of banks.

In conclusion, green banking serves as a crucial mechanism for reducing emissions, protecting the environment, and enhancing banks' environmental efficiency. By adopting green practices, banks can position themselves as responsible corporate citizens, contributing to sustainable economic development.

Based on the discussion above, the following research hypotheses are proposed:

H1a: Employee environmental contributions in Albania positively influence banks' environmental awareness but may have limited direct impact on overall Environmental sustainability outcomes due to low employee engagement.
H1b: Daily operation-related green banking practices, such as energy-efficient technologies and digital banking solutions, significantly enhance Environmental sustainability outcomes in the Albanian banking sector.
H1c: Client-focused green initiatives, including green product offerings and digital service adoption, moderately influence Environmental sustainability outcomes due to limited customer awareness.
H1d: Policy-driven green strategies, such as regulatory alignment and green financing policies, are critical drivers of improved Environmental sustainability outcomes in Albanian banks.

1.4 Green Banking Practices and Green Financing

Green banking plays a crucial role in encouraging industries to adopt environmentally friendly practices (Bhardwaj & Maholtra, 2013). It refers to banking systems that aim to minimize environmental degradation and foster sustainable development (Shershneva & Kondyukova, 2020). Today, financial institutions prioritize financing industries and projects that promote environmental conservation. As part of green banking initiatives, banks implement eco-friendly financing mechanisms and integrate green policies into their operations to drive sustainable change (Park & Kim, 2020).

Green finance, a core component of green banking, is a vital financial tool for achieving sustainable economic growth (Zhang *et al.* 2019). It involves investments in environmentally friendly projects such as solar panels, organic fertilizers, biogas plants, recyclable products, alternative energy sources, and green security initiatives (Khatun *et al.* 2021). Green security encompasses the tools, methods, and practices employed by industries to reduce their environmental footprint. By supporting such initiatives, green financing seeks to harmonize economic progress with environmental stability and ecological security, thus contributing to sustainable national development (Zhou *et al.* 2020).

Research demonstrates a strong link between green banking practices and green financing. Rehman *et al.* (2021) found that policy-driven green banking operations positively influence the funding of eco-friendly projects. Similarly, Chen *et al.* (2022) highlighted that green banking practices—spanning employee engagement, daily operations, and policy implementation—significantly boost green financing in Bangladesh. However, the same study revealed that customer-related green banking practices did not have a measurable impact on green financing. This underscores the need for increased customer awareness and participation in green initiatives to

maximize their potential contribution. Based on the existing literature, this study proposes the following hypotheses to explore the relationship between green banking practices and green financing:

H2a: Employee environmental contributions, such as green training programs and employee participation in eco-friendly initiatives, moderately support green financing opportunities in Albania.
H2b: Daily operation-related practices, particularly those minimizing energy and paper use, significantly contribute to the growth of green financing initiatives.
H2c: Client-focused green initiatives, including promoting green loans and renewable energy project financing, have limited impact on green financing due to weak customer demand in Albania.
H2d: Policy-driven green strategies, including partnerships with international green funds, play a pivotal role in expanding green financing options.

This study aims to empirically validate these hypotheses, shedding light on the role of green banking practices in advancing green financing initiatives in the context of Albania.

1.5 Green Banking Practices and Banks' Green Image

Corporate image refers to the perception customers form about a business, shaped by its physical and behavioral attributes (Hatch *et al.* 2003). In service industries like banking, corporate image plays a pivotal role in influencing customer satisfaction and loyalty. It is largely determined by customers' evaluations of the services they receive (Nguyen & LeBlanc, 1998). As highlighted by Sharma and Choubey (2022), green banking initiatives significantly contribute to restoring customer trust by enhancing a bank's green brand image. Within the banking sector, corporate image is a critical variable due to its influence on customer perceptions and market competitiveness. A strong corporate image helps organizations gain a competitive edge by building trust and fostering customer loyalty (Gong & Yin, 2018; Richard & Zhang, 2012). Over recent years, researchers have explored the relationship between green banking practices and the corporate image of banks, with evidence pointing to a strong positive association (Ibe-enwo *et al.* 2019; Alshebami, 2021; Deepthi & Munuswamy, 2022).

For instance, Ibe-enwo *et al.* (2019) investigated the links between green banking practices, green imagination, and customer loyalty. Their study confirmed that green banking practices significantly enhance banks' green image and build trust with customers. Banks that prioritize eco-friendly initiatives not only protect the environment but also create a positive brand image, which encourages greater customer loyalty. Similarly, Alshebami (2021) demonstrated a significant positive relationship between green banking practices and the green image of Saudi banks, concluding that as banks adopt more green practices, their corporate image improves.

Deepthi and Munuswamy (2022) further reinforced this notion, asserting that green banking practices foster a green image in customers' minds. This enhanced image increases the bank's perceived credibility, trustworthiness, and appeal among environmentally conscious consumers. In light of these findings, this study aims to empirically evaluate the impact of green banking practices on banks' green image within the Albanian context. Based on the existing literature, the following research hypotheses are proposed:

H3a: Employee environmental contributions, such as environmental advocacy and customer communication, enhance the green image of Albanian banks.
H3b: Daily operation-related practices, such as the implementation of digital and energy-efficient services, positively influence the public perception of banks as environmentally responsible.
H3c: Client-focused green initiatives, such as offering tailored green products, significantly impact the green image by creating stronger brand trust among environmentally conscious consumers.
H3d: Policy-driven green strategies, such as corporate sustainability goals and eco-friendly partnerships, are the strongest predictors of a bank's green image in Albania.

2. Method

2.1 Sampling and Data Collection

Data for this study were collected through surveys targeting employees in Albanian banks. The sample was selected using a non-probability convenience sampling method, based on the criterion that respondents must be employees within the Albanian banking sector. To enhance the response rate, both self-administered and online-based surveys were employed.

According to the 2023 Annual Supervisory Report (Bank of Albania), the banking sector in Albania employs approximately 6,500 individuals. The sample size for this study was determined to be 360, and a total of 240 questionnaires were distributed (120 self-administered and 120 online). Out of these, 192 completed and

usable responses were collected, yielding a response rate of 53.3%. This response rate is statistically acceptable and indicates that the sample is representative of the target population.

Data collection took place between April and November 2023. The collected data were analyzed using the Statistical Package for Social Sciences (SPSS), and the research model was tested through regression analysis to assess the relationships between green banking practices and their outcomes

2.2 Measurements

To ensure the validity and reliability of the survey instrument, several measures were undertaken. First, the questionnaire items were adapted from well-established studies, including those by Shaumya *et al.* (2017) and Chen *et al.* (2022), which have been validated in prior research. Second, the survey underwent expert review by academics and practitioners in the fields of banking and environmental sustainability to confirm content relevance and clarity. Third, a pilot study was conducted with a small group of 20 banking employees to test the questionnaire's comprehensibility, flow, and timing. Feedback from the pilot study led to minor revisions, such as simplifying language and refining ambiguous questions. Additionally, reliability was assessed using Cronbach's alpha, with all constructs exceeding the accepted threshold of 0.70, indicating strong internal consistency.

3. Research Results

The empirical findings section covers the demographic data of respondents, factorial analysis, reliability and validity, structural equation modelling, and research hypothesis results.

3.1 Demographic Data

The findings of the general demographic information of the respondents were analyzed and divided into five categories: gender, age, educational level and working experience. The findings of the study indicated that 41.2% of the respondents were male, while 58.8% were female. Among the respondents, 30.8% were aged 18 to 28 years; 45.6%, 29 to 39 years; 18.6%, 40 to 50 years; and 5%, over 50 years. In terms of educational level, 72% had a master's degree, 23.1% had postgraduate qualifications, 3.3% had completed an undergraduate degree and 1.6% had PhD degrees. Therefore, it can be concluded that the majority of respondents were well educated. The empirical findings revealed that 30.2% of the respondents had worked 1–4 years, 30.2% for more than 4 years and 19.8%. Table 1shows the demographic information of the respondents.

Table 1: Demographic data of the sample (N 192)

Variable	Items	Frequency (N)	Percent %
Gender	Female	107	58.8
	Male	75	41.2
Age	18-28 year	56	30.8
	29-39 year	83	45.6
	40-50 year	34	18.6
	Over 50 year	9	5.0
Education qualification	undergraduate	6	3.3
	postgraduate	42	23.1
	Master's	131	72.0
	PhD	3	1.6
Working experience	less than 1 year	36	19.8
	1 to 4 years	91	50.0
	above to 4 years	55	30.2

Source: The author's calculations.

3.2 Factor and Reliability Analysis for Green Banking Practices Variables

To measure green banking practices, four key dimensions were developed. These dimensions are: (1) Employee environmental contributions, (2) Green operational activities, (3) Client-focused green initiatives, and (4) Policy-driven green strategies. All measurements used a 5-point Likert-type scale with 32 question items. First, 12 items for measuring green banking practices were adopted from the study of Shaumya, S. *et al.* 2017 and Chen, J *et al.* 2022.

The measure unit green banking practices was evaluated by a scale developed by Shaumya, S *et al.* (2017) and Chen, J *et al.* (2022). This measure contains four items (Employee environmental contributions, daily operation-related green banking practices, customer-related green banking practices, and Policy-driven green strategies) that were rated on a five-point scale (ranging from 1. strongly disagree, to 5. strongly agree), but a bit modified and adapted to this research. To assess the reliability of the questionnaire, the Cronbach's alpha coefficient was used. According to Hair (2010) reliability is a measurement of the degree of consistency between multiple measurements of variables. This study has used Cronbach's alpha as a diagnostic measure, which assess the consistency of the entire scale, since being the most widely used measure (Sharma, 2000). The lowest limit for Cronbach's alpha is 0.70(Hair 2010, Roberts 1980). The results of the reliability analysis summarized in Table 2 confirm that all scales display satisfactory levels. As a conclusion, the measures which were used have an acceptable level of reliability. From the table generated through the SPSS data processing program, it can be seen that the Cronbach's alpha coefficient for the green banking practices variables is 0.743, and the number of measurement units is 13, namely, 3 units of Employee environmental contributions, Green operational activities, Policy-driven green strategies and 4 units for Client focused green initiatives (Table 2).

Table 2. Cronbach's alpha coefficient results for green banking variables

Green banking factors	Nr	Cronbach's Alpha	Evaluation questions
Green banking practices	192	.743	13
employees related green banking practice	192	.752	3
Green operational activities	192	.875	3
Client-focused green initiatives	192	.767	4
Policy-driven green strategies	192	.835	3

3.3. Factorial and Reliability Analysis for the Dependent Variable

This study focuses on three dependent variables: banks' Environmental sustainability outcomes, green financing, and green image. The measurement scales for these variables were adapted from prior studies to ensure validity and reliability. Four items measuring banks' Environmental sustainability outcomes were adopted from the works of Shaumya *et al.* (2017) and Chen *et al.* (2022). Six items assessing green financing were also drawn from these studies. Finally, banks' green image was evaluated using a four-item scale adapted from the studies of Alshebami (2021) and Nguyen *et al.* (2018).

All measurements utilized a 5-point Likert-type scale, ranging from "strongly disagree" to "strongly agree." To assess the reliability of the questionnaire, Cronbach's alpha coefficient was calculated. The results indicated satisfactory reliability, with Cronbach's alpha values of 0.755 for banks' Environmental sustainability outcomes, 0.777 for green financing, and 0.787 for banks' green image. These values exceed the recommended threshold of 0.7, confirming the internal consistency of the scales and their suitability for further analysis.

3.4 Regression Analysis of Green Banking Practices on Banks' Environmental Sustainability Outcomes

To determine which of the green banking practices influence banks' Environmental sustainability outcomes, we performed a multiple regression analysis, where in this case, we have banks' Environmental sustainability outcomes as a dependent variable and employee-related green banking practices, daily operation-related green banking practices, customer-related green and Policy-driven green strategies independent variables. Before we develop the regression model, which explains the relationship between the variables taken in the study, we see that there is a significant relationship between them for the 0.01 error level. Only Employee environmental contributions are significant at the 0.05 level. As Table 3 shows, the correlation between the independent variables "Employee environmental contributions", "Green operational activities", "Client-focused green initiatives" and "Policy-driven green strategies" and the dependent variable "banks' environmental sustainability outcomes" is. 284*,.542*,.478*,.567*.

We note that the relationship between the independent and dependent variables is positive. This shows the positive impact that Green banking practices factors have on banks' Environmental sustainability outcomes. ANOVA was performed to assess whether the multiple regression model was valid.

Table 3. The correlation between Green Banking Practices* and "Banks' Environmental sustainability outcomes"

	Banks' Environmental sustainability outcomes
Employee environmental contributions	r=.284*, Sig=.016; p< .05
Green operational activities	r=.542** Sig.=.000, p< .01
Client-focused green initiatives	r=.478*, Sig=.000, p< .01
Policy-driven green strategies	r=.567** , Sig=.000, p< .01

* " Green banking practices", "Employee environmental contributions", " Green operational activities", " Client-focused green initiatives" and "Policy-driven green strategies"
**. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).

The research model used for the analysis is valid, and the variables taken in the study explain 49.9% (adjusted R2=0.499) of the influence on the dependent variable job performance (table 5).

Table 4. Coefficients of Green Banking Practices on "Banks' Environmental sustainability outcomes"

		Unstandardized Coefficients		Standardized Coefficients				
	Model	B	Std. Error	Beta	t	Sig.	F	R2
1	(Constant)	10.434	.455		1.237	.173	16.345	.499
	employee related green practice	**-.481**	**.298**	**-.169**	**-1.535**	**.118**		
	daily operation related green practice	1.149	.304	.408	3.799	.000		
	customer related green practice	**.414**	**.199**	**.189**	**1.721**	**.098**		
	policy-driven green strategies	1.198	.288	.438	4.398	.000		

Note: a. Dependent Variable: Banks' Environmental sustainability outcomes.

The constructed regression model is valid. In our model, the value F=16.345 was significant at the 0.05 control level (because p=0.000 is less than 0.05). In the table of regression coefficients (table 4), we see that the banks' daily operation and Policy-driven green strategies have acceptable p-values (p< 0.05).
Based on the model data shown in Table 4, the regression equation can be expressed as:

Y Environmental sustainability outcomes =β0 +β1 (Daily Operations)+ β2 (Policy Practices)+ϵ

$$Y= 10.434 +0.408(\text{daily operation}) + 0.438 (\text{Policy Practices}) +\epsilon$$

This means that banks' daily operation and Policy-driven green strategies of green banking were noticed to have significant impacts on banks' Environmental sustainability outcomes. The dimension bank's policy-related green banking has a greater impact on banks' Environmental sustainability outcomes than banks' daily operation because the beta coefficient is larger (.438).

3.5 Regression Analysis of Green Banking Practices on Green Financing

To determine which of the impacts of green banking practices on green financing, we also performed a multiple regression analysis. Before we develop the regression model, which explains the relationship between the variables taken in the study, we see that there is a significant relationship between them for the 0.01 error level. Only customer-related green banking practices are significant at the 0.05 level. As Table 5 shows, the correlation between the independent "Employee environmental contributions", "daily operation-related green banking practices", "customer-related green banking practices" and "bank policy-related green banking" and the dependent variable "green financing" is respectively .584**,.573*,.267*,.594*.

We noticed that the relationship between independent and dependent variables is positive. This shows the positive impact that Green banking practices factors have on green financing. The hypothesized relationships among the constructions were checked using a regression model. The research model used for the analysis is valid, and the variables taken in the study explain 54.9% (adjusted R2=0.549) of the influence on the dependent variable of green financing (table 6).

Table 5. The correlation between the independent variables* and the dependent variable "green financing"

	Green financing
employee related green banking practice	r=.584** , Sig=.000, p< .01
Green operational activities	r=.573**, Sig.=.000, p< .01
Client-focused green initiatives	r=.267*, Sig=.000, p< .05
Policy-driven green strategies	r=.594**, Sig=.000, p< .01

*. "employee-related green banking practice", "daily operation-related green banking practice", "customer-related green banking practice" and "bank policy-related green banking"
**. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).

The constructed regression model is valid. In our model, the value F=24.345 was significant at the 0.05 control level (because p=0.000 is less than 0.05).

Table 6. Coefficients of Green banking practices variables and the impact on the variable "Green Financing"

		Unstandardized Coefficients		Standardized Coefficients				
	Model	B	Std. Error	Beta	T	Sig.	F	R2
1	(Constant)	10.731	7.475		1.437	.157	26.365	.549
	Employee related practice	1.149	.304	.408	3.799	.000		
	Green operational activities	1.381	.398	.398	3.535	.000		
	Client focused green initiatives	**-.481**	**.298**	**-.169**	**-1.535**	**.118**		
	Policy-driven green strategies	1.198	.288	.438	4.398	.000		

Note: a. Dependent Variable: Green Financing

In the table of regression coefficients, we see that "Employee environmental contributions", "daily operation-related practices" and "Policy-driven green strategies" have acceptable p-values (p< 0.05). This means that customer-related green practices do not have a significant positive effect on green financing. The factors "Employee environmental contributions", "daily operation-related practices" and Policy-driven green strategies" have a significant positive effect on green financing. Based on the model data shown in Table 6, the regression equation can be expressed as:

Y Green Financing =β0 +β1 (Employee Practices) + β2 (Daily Operations) + β3 (Policy Practices) +ϵ

Y (Green Financing) = 10.731 +.408 (Employee Practice) +.398 (Daily Operational) +.438 (Policy Practice)

3.6 Regression Analysis of Green Banking Practices on Banks' Green Image

Additionally, to determine which of the green banking practices influence banks' green image, we performed a multiple regression analysis, where in this case, we have banks' Environmental sustainability outcomes as a dependent variable and Employee environmental contributions, daily operation-related green banking practices, customer-related green banking practices and Policy-driven green strategies as independent variables. Before we develop the regression model, which explains the relationship between the variables taken in the study, we see that there is a significant relationship between them for the 0.01 error level. Only Employee environmental contributions are significant at the 0.05 level. As Table 7 shows, the correlation between the independent variables "Employee environmental contributions", "daily operation-related green banking practices", "customer-related green banking practices" and "banks 'policy-related green banking" and the dependent variable "banks' green imagine" is. 521**,.528**,.467*,.537**.

Table 7. The correlation between the independent variables* and the dependent variable "banks' green image"

	Banks' Green Image
employee related practice	r=.521** Sig=.000 p< .01
Green operational activities	r=.528** Sig.=.000 p< .01
customer related practice	r=.467* Sig=.000 p< .01
bank's policy related practice	r=.537** Sig=.000 p< .01

*. "employee-related practice", "daily operation – related practice", "customer-related practice" and "bank's policy-related practice"
**. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).

Table 8 shows that green banking practices have a positive impact on banks' green image. ANOVA was performed to assess whether the multiple regression model was valid. The research model used for the analysis is valid and the variables taken in the study explain 67.9% (adjusted R2=0.679) of the influence on the dependent green image. In the constructed regression model, the value F=19.375 was significant at the 0.05 control level (because p=0.000 is less than 0.05). In the table of regression coefficients, we see that all variables have acceptable p-values (p< 0.05).

Table 8. Coefficients of Green banking practices and the impact on the "banks' green image"

		Unstandardized Coefficients		Standardized Coefficients				
	Model	B	Std. Error	Beta	t	Sig.	F	R2
1	(Constant)	.632	.275		.437	.057	19.375	.679
	employee related practice	0.249	.034	.334	.709	.000		
	Green operational activities	0.225	.049	.318	.519	.000		
	customer related practice	0.198	.088	.278	.398	.001		
	bank's policy related practice	0.314	.099	.409	.721	.000		
Note: a. Dependent Variable: Banks' green image.								

Based on Table 8, the following equation is used in the model to calculate the impact of banks' green image from the predictor variable:

$$Y \text{ Green Image } = \beta 0 + \beta 1 \text{ (Employee Practices)} + \beta 2 \text{ (Daily Operations)} + \beta 3 \text{ (Customer Practices)} + \beta 4 \text{ (Policy Practices)} + \epsilon$$

$$Y \text{ Green Image} = 0.0632 + 0.334 \text{ (Employee Practice)} + 0.318 \text{ (Daily Operation)} + 0.278 \text{ (Customer Practice)} + .409 \text{ (Policy Practice)}.$$

4. The Summary of Results

This study aims to examine the impact of green banking practices on sustainable Environmental sustainability outcomes, green financing and banks' green image in the banking sector in the Albanian context. From the current analysis, it is noted that green banking practices have a positive effect on the Environmental sustainability outcomes: Daily operation-related practices and Banks' policy-related have a positive impact on their Environmental sustainability outcomess (H1b and H1d supported) contrary to Employee environmental contributions and Client-focused green initiatives which were not statistically significant (H1a dhe H1c not supported). The results of the study show that Daily operation-related practices Employee environmental

contributions and Banks' policy-related have a positive effect on green financing (H2a, H2b and H2d supported) contrary to Client-focused green initiatives which was not statistically significant (H1c not supported). The last result shows that Daily operation-related practices, Employee environmental contributions, Policy-driven green strategies and Client-focused green initiatives have a positive impact on Banks'green image (H3a, H3b, H3c dhe H3d supported). Based on the analysis results, Table 9 shows a summary conclusion of the study.

Table 9. Summary Conclusion

Indipendent Variable	Dependent variable		
Green banking practice	Environmental sustainability outcomes	Green financing	Banks'green image
	Decisions		
Employee environmental contributions	Not supported	Supported	Supported
Green operational activities	Supported	Supported	Supported
Client-focused green initiatives	Not Supported	Not Supported	Supported
Policy-driven green strategies	Supported	Supported	Supported

The results support hypotheses **H1b** and **H1d**, demonstrating that Policy-driven green strategies and Green operational activities have a positive and significant impact on banks' Environmental sustainability outcomes. These findings align with the studies of Shaumya *et al.* (2017) and Chen *et al.* (2022). Specifically, daily operation-related practices—such as reducing paper usage, adopting energy-efficient equipment, and offering eco-friendly banking services—directly contribute to improved Environmental sustainability outcomes. Similarly, Policy-driven green strategies, including establishing green branches, implementing green policies, and fostering partnerships with environmentally responsible suppliers and investors, significantly enhance Environmental sustainability outcomes.

In contrast, hypotheses **H1a** and **H1c**, which posit that employee-related and Client-focused green initiatives influence Environmental sustainability outcomes, are not supported. This conclusion is consistent with Chen *et al.* (2022), who found that employees and customers often lack sufficient knowledge about green banking's role in mitigating negative environmental impacts. To address this gap, it is recommended that the Bank of Albania and relevant institutions provide environmental training and education, such as conferences and symposiums, to improve employees' awareness and skills related to green banking.

Furthermore, the analysis supports hypotheses **H2a**, **H2b**, and **H2d**, indicating that Employee environmental contributions, banks' policies, and Green operational activities significantly contribute to green financing. These findings are validated by the work of Rehman *et al.* (2021) and Chen *et al.* (2022), underscoring the critical role of green banking practices in fostering the growth of green financing in Albania. However, hypothesis **H2c** is not supported, suggesting that Client-focused green initiatives, such as providing loans for eco-friendly projects, offering online banking services (*e.g.*, bill payments and e-statements), and assessing clients' environmental risks, do not significantly influence green financing decisions. This result aligns with studies by Zheng *et al.* (2021) and Chen *et al.* (2022), highlighting the need to better engage customers in green banking initiatives.

Finally, the results confirm that hypotheses **H3a**, **H3b**, **H3c**, and **H3d** are supported, showing that green banking practices positively impact the green image of banks in Vlore, Albania. This finding is consistent with Alshebami (2021), who found a significant positive relationship between green banking practices and the green image of Saudi banks. To leverage these findings for sustainable economic growth, it is recommended that the Bank of Albania and the Albanian government draft specific laws and organize seminars, training programs, conferences, and symposiums to raise awareness among customers and the general public about the benefits of green banking. Such initiatives will help increase engagement with green practices and further enhance the banking sector's contribution to sustainability.

5. Discussions

The results support hypotheses **H1b** and **H1d**, demonstrating that Policy-driven green strategies and Green operational activities have a positive and significant impact on banks' Environmental sustainability outcomes. These findings align with the studies of Shaumya *et al.* (2017) and Chen *et al.* (2022). Specifically, daily

operation-related practices - such as reducing paper usage, adopting energy-efficient equipment, and offering eco-friendly banking services - directly contribute to improved Environmental sustainability outcomes. Similarly, Policy-driven green strategies, including establishing green branches, implementing green policies, and fostering partnerships with environmentally responsible suppliers and investors, significantly enhance Environmental sustainability outcomes.

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Conclusions and Further Research

This study examined the role of green banking practices in enhancing Environmental sustainability outcomes, green financing, and banks' green image, focusing on four key dimensions: Employee environmental contributions, green operational acvtivites, Client-focused green initiatives, and Policy-driven green strategies. Data were collected from employees of private sector banks in Albania to provide empirical insights into the banking sector's progress toward sustainability.

The findings demonstrate that green banking practices positively impact banks' Environmental sustainability outcomes, green financing, and green image. This highlights the growing commitment of banks to environmental protection through eco-friendly operational activities, the promotion of green financing initiatives, and the development of a sustainable corporate image.

The analysis underscores the significant influence of adopting green practices. As banks increase their implementation of employee, operational, customer, and policy-related green practices, they contribute to improved Environmental sustainability outcomes, greater availability of green financing sources, and enhanced brand reputation. This reinforces the notion that green banking practices are not only vital for sustainable development but also integral to building trust and credibility among customers and stakeholders.

Managerial and Policy Implications

The managerial and policy implications of this study are significant and multifaceted. The findings emphasize that the effective implementation of green banking practices can enhance banks' environmental reputation, thereby fostering trust among current and potential customers. Through strategic planning and execution of green practices, banks can create new opportunities to strengthen their market relevance and align with sustainability goals.

Managerial Implications:

Bank managers play a crucial role in integrating green practices into daily operations. Key recommendations include:

- Reducing Resource Usage**:** Minimize paper consumption by promoting digital banking solutions and implementing paperless processes.
- Investing in Energy Efficiency**:** Provide energy-efficient infrastructure, such as environmentally friendly ATMs, digital banking platforms, and renewable energy sources for bank branches.
- Offering Eco-Friendly Services**:** Develop and promote green financial products and services tailored to environmentally conscious customers.
- Establishing Green Policies**:** Adopt and enforce policies that prioritize environmental goals, such as partnering with sustainable suppliers and promoting green financing.

Policy Implications**:**

This study also has critical implications for policymakers and regulatory bodies. It highlights the need for the Bank of Albania and the Albanian government to:

- Draft specific legislation to incentivize the adoption of green banking practices, including tax benefits for green projects and penalties for environmentally harmful practices.
- Organize awareness-raising initiatives, such as seminars, training programs, conferences, and symposiums, to educate the public, bank employees, and customers on the advantages of green banking.
- Establish national frameworks to monitor and evaluate the environmental impact of green banking practices, ensuring alignment with international sustainability standards such as the UN Sustainable Development Goals (SDGs).

By addressing these managerial and policy aspects, this study contributes to the development of effective and efficient green banking strategies. These strategies are vital not only for the banking sector but also for promoting sustainable economic growth and environmental stewardship in Albania.

Limitations and Suggestions for Future Studies

This study focused solely on the banking sector in Albania, limiting the generalizability of its findings to other industries or countries. Additionally, the study's theoretical framework addressed a narrow set of variables, excluding financial performance and potential mediators or moderators that could deepen the analysis.
Future research could expand on this work by:

1. **Incorporating New Variables**: Analyse the impact of green banking practices on financial performance and environmental outcomes while exploring mediating factors such as green financing and green image.
2. **Digital Banking and Sustainability**: Investigate how digital banking contributes to environmental sustainability by reducing resource consumption and promoting green practices.
3. **Regional Comparisons**: Conduct cross-country studies to identify similarities and differences in green banking practices within the Balkan region or other comparable economies.
4. **Long-Term Impacts**: Study the long-term financial effects of green banking, such as profitability, cost savings, and customer loyalty.

These recommendations aim to provide a more comprehensive understanding of green banking and its broader implications for sustainability and financial performance.

Author contributions

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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Audit Quality Model Moderated by Professional Skepticism: Determinants of Professional Ethics and Auditor Experience

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Abstract: This research explores how an auditor's experience and professional ethics influence audit quality, with professional skepticism playing a key moderating role. Experience sharpens an auditor's ability to detect fraud, while strong ethics help them uphold integrity. Together, these factors shape professional skepticism - the cautious, questioning mindset auditors use when reviewing evidence and making decisions. The study was carried out by the South Sulawesi Provincial Audit Board in early 2024, focusing on auditors in Makassar. Rather than selecting a sample, the researchers included all 35 auditors in the city, ensuring comprehensive insights. Using field research methods, the analysis revealed that both experience and ethics significantly improve audit quality. Additionally, professional skepticism was found to positively mediate this relationship, reinforcing how critical a questioning attitude is in high-quality audits. By highlighting these connections, the study contributes to building a clearer model for how experience, ethics, and skepticism work together to enhance audit outcomes.

Keywords: auditor experience; audit quality; moderating variable; professional ethics; professional skepticism.

JEL Classification: M42; M41; D91; C12.

Introduction

With the frequent occurrence of financial scandals, the implementation of audits is very important as a bridge to build public trust and ensure the fairness of financial statements. However, many public accountants have been implicated in financial scandals, often neglecting the quality of their audits (Trihapsari and Anisykurlillah, 2016). Audit quality plays a vital role in fostering trust, maintaining a healthy investment climate, and ensuring transparency across nations (Yunianti *et al.* 2021). Auditors must produce high-quality audit reports that comply with generally accepted accounting principles (Trihapsari and Anisykurlillah, 2016; Rosini and Hakim, 2021).

According to the concept of regional autonomy outlined in Law no.22/1999, there was a fundamental shift in the mechanisms of government administration, leading to significant changes in state financial management. Regional governments are now responsible for managing their own financial resources (Tobing, K.S.L. *et al.* 2022). To achieve good governance, regional financial management must be monitored and audited. This is where the inspectorate plays a critical role in supervising and reviewing the financial management of regional

governments. The regional inspectorate functions similarly to internal auditors in conducting general oversight activities for local governments (Tobing, K.S.L. *et al.* 2022).

According to the Regulation of the Minister for Administrative Reform No. PER/05/M.PAN/03/2008, the measurement of audit quality on financial statements, particularly those conducted by the inspectorate as the internal government auditor, must adhere to the Standards of State Financial Auditing (SPKN). Over time, the scope of auditing has expanded beyond just financial statement audits to include compliance audits, operational audits, and fraud audits. Weaknesses in the Internal Control System (SPI) often arise when responsible officials fail to accurately record transactions and do not follow the established procedures (Susilawati, 2014). This issue is also evident in the performance of the Inspectorate of West Sumatra, where financial management oversight is still considered weak.

This indicates that the audit results used by the local government inspectorate have not yet produced good audit quality, as seen from the findings by the Supreme Audit Agency (BPK) regarding the local government's financial statements. Moreover, there are still lapses in the field that prevent the budget from being aligned with the existing planning. To achieve this expertise, formal education is necessary, supported by practical experience, which is then applied in the audit process. An auditor's maturity in conducting audits depends not only on the knowledge gained during education but also on the experience accumulated during financial examinations. One way to improve audit quality is by ensuring that auditors have sufficient experience. Research conducted by Prasanti, D. H., Ramadhanti, W., and Puspasari, N. (2019) states that experienced auditors have a better understanding of financial statements. This finding aligns with the research by (Dasila and Hajering, 2019), which shows that experience has a direct influence on the quality of audits performed by public accountants. The longer an auditor works, the more experience they gain, which in turn encourages them to broaden their knowledge in the field of auditing. This suggests that the more experience an auditor has, the higher the quality of the audit they produce (Ningrum and Budiartha, 2017).

This study seeks to bridge critical gaps in the existing literature on audit quality by exploring the combined influence of professional skepticism, auditor experience, and ethics on the quality of financial audits. While prior studies (e.g., Nelson, 2009; Glover and Prawitt, 2014) have emphasized the role of skepticism in detecting misstatements, few have integrated these factors into a unified framework to assess their collective impact on audit quality. Moreover, most research has focused on external audits, with limited exploration of internal auditors' roles, particularly within government institutions where regulatory frameworks differ (Tobing, K.S.L. *et al.* 2022). This study addresses the novel research gap by: Examining how skepticism, experience, and ethics interact in shaping audit quality, exploring differences between internal and external auditors in applying professional skepticism, and assessing the moderating role of regulatory environments on audit quality. By addressing these aspects, the study contributes to the field by offering a holistic model that can be used to improve auditing standards and practices across various industries.

The implementation of audits is critical in ensuring transparency and maintaining public trust, particularly in light of recurring financial scandals where auditors have been implicated in fraudulent activities (Trihapsari and Anisykurlillah, 2016). Audit quality plays a significant role in fostering investor confidence and ensuring the reliability of financial statements across different economic sectors (Yunianti *et al.* 2021). However, despite the emphasis on audit quality, prior research has primarily focused on individual factors such as professional skepticism, auditor experience, and ethical compliance in isolation, without integrating these factors into a comprehensive analytical framework (Nelson, 2009; Glover and Prawitt, 2014). The more experience auditors have, the longer they work, which in turn encourages them to expand their knowledge in the audit field. This suggests that the more experience auditors have, the higher the quality of audit results (Ningrum and Budiartha, 2017).

Another factor that affects the quality of audit is professional ethics. Compliance with professional ethics in the audit process is one of the elements that affects the quality of the audit. In the auditing industry, the values and norms that govern professional behaviour are established through a code of ethics that is regulated by a competent authority. According to (Murwanto *et al.* 2008; Mahmud, M. D. B., Quilim, C. A., and Hasan, L. (2024), a code of ethics is a set of values and norms that govern ethical behaviour in a profession through written rules that each member must follow and sanctions imposed on those who violate the rules Mahmud, M. D. B., Quilim, C. A., and Hasan, L. (2024).

The Code of Ethics for Professional Accountants describes several important principles that auditors must follow in addition to the technical standards that guide their work. These principles and standards aim to help auditors perform their duties to the highest possible standards. According to (Najib, 2013), ethical behavior plays a crucial role in enhancing audit quality, emphasizing that the adherence to professional ethics positively impacts

the outcome of audits. Auditors who consistently follow the rules and ethical guidelines significantly contribute to improving audit quality (Lubis and Kuntadi, 2023). Research by (Fransiska, 2014) supports this view, demonstrating that ethics has a significant positive effect on audit quality. However, studies by (Nurjanah and Kartika, 2016; Syafitri, 2014) have found that auditor ethics have no measurable impact on audit quality (Nurjanna, 2016).

On the other hand, scepticism plays a key role in detecting errors or irregularities and ensuring audit quality, especially as financial statements become more complex. Many accounting scandals are linked to the auditor's inability to satisfactorily analyse clients' financial statements. An important factor contributing to this failure is the low level of professional scepticism among auditors, which can undermine the credibility of financial statements. This, in turn, affects public confidence in the quality of financial statements and audit results. High-quality financial statements are crucial for stakeholders as they form the basis for important business decisions (Fatmawati *et al*. 2018).

Professional scepticism, which involves a critical attitude and in-depth evaluation of audit evidence, is recognised as an important factor in improving audit quality. According to Nelson (2009), professional scepticism enables auditors to correctly perceive the standards of evidence and make decisions based on unbiased evaluations. However, it also requires a balance between gathering additional evidence and the effectiveness of the audit process. Furthermore, (Hurtt *et al.* 2013) showed that professional scepticism is influenced by the auditor's personal characteristics, work situation, and pressures from the external environment such as regulations and client expectations. The study confirmed that auditors who consistently apply professional scepticism are better able to detect the risk of material misstatement and avoid audit failures.

In addition, the 'continuum of scepticism' approach proposed by (Glover and Prawitt, 2014) highlights the importance of applying different levels of scepticism depending on the risks identified in the audit. This suggests that applying professional scepticism not only improves audit quality but also provides a basis for auditors to dynamically adjust their strategies in response to changing audit conditions. This study reveals a research gap that supports the importance of professional scepticism as a key factor in building reliable and effective audit quality, given the influence of auditors' experience and professional ethics. This study seeks to fill a gap in existing research by examining how professional scepticism, auditor experience and ethics interact to shape audit quality. Previous studies have focused on professional scepticism in fraud detection and misstatement identification (Hurtt *et al.* 2013) but have largely neglected the influence of experience and ethical standards that strengthen or weaken this relationship. In addition, the role of internal auditors, especially in government entities, has been under-represented, as most studies have focused on external audits (Tobing, K.S.L. *et al.* 2022).

This research improves upon past studies by integrating skepticism, experience, and ethics into a unified framework to assess their combined impact on audit quality. This holistic approach considers how cognitive traits, technical expertise, and ethical commitment interact in audit decision-making. Unlike prior studies that mainly focus on external auditors, this study also examines internal auditors working in government institutions, evaluating whether their regulatory environment affects their levels of skepticism, ethical adherence, and experience.

Furthermore, this research incorporates a cross-country comparison to analyze how differences in audit regulations influence audit quality (Svanberg and Öhman, 2016). By understanding these variations, the study provides insights into how legal frameworks shape audit practices globally. Additionally, an industry-specific analysis explores whether audit quality determinants vary across sectors such as financial services, manufacturing, and government audits. Unlike previous studies that treat audits as uniform across industries, this study examines how different risk environments influence skepticism, experience, and ethics in the auditing process.

1. Literature Review

Attribution Theory

Attribution theory provides a framework for understanding human behaviour and interaction and is therefore highly relevant to psychology, education, management and other fields. Attribution theory is a concept in social psychology that explains how people interpret and attribute the behaviour of themselves and others. This theory was developed by. This theory helps us to understand whether people attribute their behaviour to internal factors (such as personality or effort) or external factors (such as environment or luck). The main components of attribution theory are: (1) Internal attribution (personality): Behaviour is attributed to internal characteristics of the individual, *e.g.* personality, motivation or abilities: 'He was successful because he is clever and works hard'. (2) External attribution (situational): Behaviour is attributed to external factors, *e.g.* environment, social pressure or

opportunities: 'He failed the exam because the questions were too difficult'. (3) Kelley's Covariation Model: (Kelley *et al.* 1967) proposed three dimensions to determine whether a behavior is internally or externally attributed: Consensus: Do others behave the same way in this situation? Consistency: Does this person always behave this way in similar situations? Distinctiveness: Does this person behave differently in other situations? Weiner's Attribution Theory: (Weiner & Kukla, 1970) applied attribution theory to achievement and motivation, focusing on three dimensions: Locus of Causality: Is the cause internal or external?; Stability: Is the cause stable or unstable over time?; Controllability: Can the cause be controlled or not?; Example: A student who fails a test might attribute the failure to "bad luck" (external, unstable, uncontrollable) or "lack of preparation" (internal, unstable, controllable). In the Practical Applications especially on Workplace: Explains employee reactions to feedback, success, or failure, shaping strategies for leadership and management.

(Dayakisni & Hudaniah, 2009) states that attribution is the process of seeking answers to questions such as 'why' or 'what causes' certain behaviors, whether of others or oneself. This process helps us understand the reasons behind behavior, particularly those related to individual attitudes and characteristics. The role of an auditor in providing audit reports is highly influential in shaping decisions made by stakeholders, who expect accurate and high-quality financial statements. Researchers suggest that the quality of audit reports may be influenced by the internal and external characteristics of the auditor. This study applies attribution theory to analyze individual behaviors and better understand how auditors produce high-quality audit reports. Attribution theory is used here to conduct an empirical study of the factors influencing auditors' performance, particularly their personal characteristics.

An auditor's personal characteristics play a crucial role in determining the quality of audit outcomes, as these internal factors drive their actions. One such internal factor is ethics, which guides auditors in fulfilling their responsibilities to society, peers, clients, and professional standards (Zarefar & Zarefar, 2016). Beyond ethics, religiosity also significantly affects an auditor's rationality. A higher level of religiosity, which stems from deeply internalized religious teachings, can positively impact auditors' rational decision-making and behavior in their professional and daily lives (Nainggolan *et al.* 2019).

Audit Quality

Audit quality can be defined as the effectiveness of the audit process in reducing discrepancies between information provided by managers and what shareholders expect, using a third party to verify the financial statements. According to (DeAngelo, 1981), audit quality is the probability that an auditor will detect and report any violations in the client's accounting system. (Arens, 2012) outline five principles that must be upheld by public accountants: integrity, objectivity, professional competence and due care, confidentiality, and professional behavior. Additionally, public accountants must adhere to the Standards of Public Accounting Profession (SPAP), which include general standards, fieldwork standards, and reporting standards (SA Section 150 in SPAP, 2011).

The study by (Munari, 2020) shows that the quality of audits conducted by the inspectorate plays a crucial role in supporting fiscal transparency and local government accountability. The competence of internal auditors, including their experience and educational background, significantly impacts audit quality. For example, a study in Lampung found that a higher level of competence of internal auditors, evidenced by a diploma and professional training, has a positive impact on the quality of audits and accountability of local government financial reporting. In addition, the quality of internal audit is also related to compliance with Government Auditing Standards (GAAS). The implementation of these standards helps to improve the reliability of reporting by ensuring that objective evidence is collected and verified. The study shows that the oversight function of audit is not only aimed at detecting weaknesses but also at improving the efficiency and effectiveness of public financial management.

Interrelationship Between Variables

Auditing Concept

According to Agoes (2018), an audit is a critical and systematic review of an entity's financial statements prepared by management and performed by an independent party. This examination includes the accounting records and other supporting evidence to express an opinion on the fairness of the company's financial statements (Marclanta, 2018). A study published in the International Journal of Auditing found that the adoption of International Financial Reporting Standards (IFRS) is associated with higher audit costs, reflecting the increased complexity of audits and the need for more detailed audits (Kim *et al.* 2010).

Ethics

The Greek word "ethics" consists of two words: ethos, which means habit or habitual, and ethhiokos, which means the inner feelings or moral inclinations that guide human behaviour (Suraida, 2005). Ethics is essentially a

complex process that determines how an individual should act in a given situation; according to Arens et al (2008), ethics is broadly defined as principles or moral values (Zailia, 2013). An analysis of international accounting ethical codes highlights the importance of principles such as honesty, objectivity, professional competence, confidentiality and professional conduct as guidelines for accountants worldwide (Suraida, 2005).

Professional Ethics

Ethics is generally defined as a set of principles or moral values that establish a behavioral standard (Arens *et al.* 2008). Auditors must recognize the importance of ethics as a form of responsibility to society, clients, and fellow practitioners. Professional ethics encompasses commendable behavior, even when it may require personal sacrifice (Fatmawati *et al.* 2017). Research indicates that professional ethics significantly influences audit quality. Auditors who adhere to ethical codes tend to produce higher-quality audits (Fatmawati *et al.* 2017).

Auditor Experience

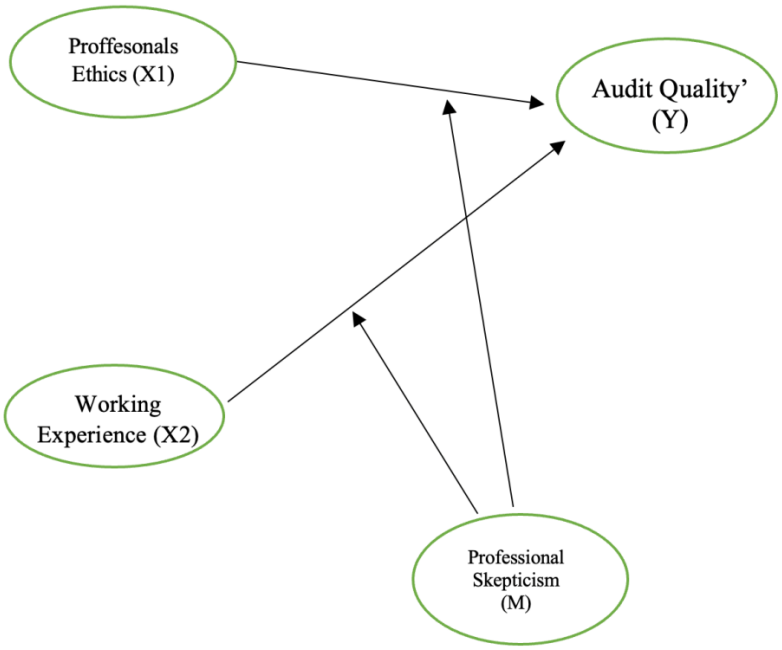
The Indonesian Institute of Accountants states that audits should be conducted by individuals with sufficient technical expertise and training as auditors. According to Konvinna and Betri (2014), experience is a learning process and an enhancement of behavioral potential through both formal and informal education. Experience can also be defined as a process that elevates an individual to a higher behavioral pattern. Hanjani and Rahardja (2014) found that auditors with varying levels of experience will differ in how they perceive, interpret, and respond to information obtained during an audit (Megayani *et al.* 2020). Other studies suggest that auditor experience significantly impacts audit quality, with more experienced auditors being more competent in detecting errors and fraud (Megayani *et al.* 2020).

Professional Skepticism

An auditor with professional skepticism will not immediately accept a client's explanations but will instead ask questions to obtain reasons, evidence, and confirmation regarding the issue in question. Professional skepticism enables auditors to select effective audit procedures to arrive at an accurate audit opinion (Noviyanti, 2008). Professional skepticism is influenced by several factors, including expertise, experience, the audit situation, and ethical considerations (Gusti & Ali, 2008). Research shows that professional scepticism plays an important role in improving audit quality. Auditors who apply professional skepticism are more effective in detecting fraud and errors in financial statements (Gusti & Ali, 2008).

Based on the above explanation, the conceptual framework in our research is presented in the following figure:

Figure 1 Research Framework



Research Hypotheses

H1: Professional ethics have a significant positive effect on audit quality.

Upholding rules and professional ethics in performing audit duties is a crucial factor influencing audit quality. In the public accounting profession, values and norms that serve as guidelines for professional duties have been established by the government in the form of the accountant profession's code of ethics. Oktarini and Ramantha (2016) state that the code of ethics establishes fundamental principles and ethical rules that must be implemented by every individual in their professional duties. Every practitioner is required to adhere to and apply all the fundamental principles and ethical rules stipulated in the professional code of ethics (Accountant Profession Code of Ethics, 2010). A study by Haeridistia and Fadjarenie (2019) found that professional ethics significantly influence audit quality.

H2: Auditor experience has a significant positive effect on audit quality.

An experienced auditor is better equipped to find solutions to problems encountered during audits due to handling numerous cases. The experience of auditors also improves their understanding of national accounting standards, which influences their behaviour in the performance of their duties and is expected to improve the quality of the audit. Putri (2020) argues that auditors with a high level of experience have an advantage when performing audits, which allows them to quickly identify errors made by the audited entity. A study by Kuntari *et al.* (2017) showed that audit experience has a significant impact on audit quality.

H3: Professional skepticism strengthens the positive influence of professional ethics on audit quality.

Professional skepticism is a necessity in every audit assignment. Audits must provide reasonable assurance that audit evidence is sufficient and appropriate to support the auditor's findings and conclusions. An independent mindset, impartiality, and honesty are crucial for auditors to maintain their independence and produce high-quality audits. Theodorus (2013) asserts that a critical assessment mindset that constantly questions and evaluates the validity of audit evidence is essential for detecting fraud. Research by Haeridistia and Fadjarenie (2019) confirmed that professional skepticism has a significant impact on audit quality.

H4: Professional skepticism strengthens the positive influence of auditor experience on audit quality.

Professional scepticism involves constantly asking questions, exercising caution when detecting errors or deliberate mis statements, and making fundamental judgements based on audit evidence. Johari, R. J., Hati, T. M., & Sayed Hussin, S. A. H. (2022) explain that the accountant's professional scepticism is crucial because the public relies on audited financial statements when making decisions. According to Tawakkal (2019), professional scepticism promotes the professional competence of the accountant, which in turn increases the accuracy of judgement and indirectly improves the quality of the audit opinion. A study by Kuntari *et al.* (2017) showed that professional scepticism has a significant effect on the quality of the audit.

2. Method also Called Materials and Methods or Experimental Methods

This study used structural equation modelling (SEM) and partial least squares (PLS) quantitative methods to analyse the relationships between variables. SEM-PLS is a variance-based structural equation modelling technique suitable for small sample sizes and exploration research (Hair *et al.* 2014). This study included 35 respondents from the Makassar City Prosecution Office, and SEM-PLS was an appropriate choice due to its robustness in handling small sample sizes (Henseler *et al.* 2016). The data analysis process begins with data processing, where the dataset is cleaned to remove incomplete responses or outliers, followed by descriptive statistics to summarise demographic trends and respondent characteristics (Sarstedt *et al.* 2017).

Next, the measurement model or external model is evaluated to ensure the reliability and validity of the construction. This includes verifying internal consistency using Cronbach's alpha and composite reliability (CR), both of which should be above 0.7, and ensuring item loadings above 0.7 for indicator reliability. Convergent validity was confirmed when the average variance extracted (AVE) exceeded 0.5, while discriminant validity was assessed using the Fornell-Larcker criterion or the heterotrophic unit ratio (HTMT), which should be less than 0.85 (Hair *et al.* 2019). Following the evaluation of the measurement model, the structural or intrinsic model was examined by analysing the path coefficients, which indicate the strength and direction of the relationships between the components. Hypothetical tests were conducted by bootstrapping 500-5000 subsamples to assess the significance of the relationships, where p-values below 0.05 were considered statistically significant (Chin, 1998). The explanatory power of the model was assessed using the R^2 value, and the predictive relevance was assessed using the Stone-Geisser Q^2 test (Geisser, 1974; Stone, 1974).

The model fit was confirmed using indicators such as standardised root mean square (SRMR), and a good fit should be less than 0.08 (Hu & Bentler, 1999). After the analysis is completed, the results will be presented in the form of tables and graphs, including loadings, path coefficients and indices of model fit. The results are discussed in the context of research hypotheses, focusing on the effect of variables such as professional ethics, auditor experience, scepticism and audit quality etc. SEM-PLS provides insight into quantitative and structural relationships, making it an effective tool for analysing complex models in studies with limited sample size (Henseler *et al.* 2009).

4. Research Results

In this study, descriptive statistical analysis is used to summarise and provide an overview of the research variables, including their central tendencies, spread and distribution. This analysis helps to understand the characteristics of the data and provides valuable insights before proceeding with statistical tests (Hair *et al.* 2014). The descriptive statistics for the research variables are shown in the table below and provide a clear representation of the data used in this study.

Tranche	Spread (basis point) (Gaussian copula)	Spread (basis point) (Student copulas)
0% à 10% (Equity)	2,952.4	3,172.895
10% à 30% (Mezzanine)	779.3024	762.065
30% à 100 % (Senior)	43.4713	30.210

Table 7 Statistics Descriptive Result

Variables	Indicator	Scale	Descriptive Research Variables		
			N	Mean	Std Deviaton
Professional Ethics	1. The personality of an auditor, including traits such as integrity, honesty, and independence, is fundamental to ethical behavior.	ordinal	35	3.80	. 41380
	2. Ethical standards demand that auditors possess the necessary knowledge, skills, and expertise to perform their duties effectively.				
	3. Auditors have a responsibility not only to their clients but also to the public, ensuring that financial information is accurate and fair.				
	4. A formalized code of conduct provides a framework for acceptable auditor behavior.				
Auditor Experience	1. The length of time an auditor has been in practice contributes significantly to their ethical judgment and decision-making abilities.	ordinal	35	3.25	. 46787
	2. The number of tasks or engagements an auditor has undertaken reflects their practical exposure and technical expertise.				
Professional skepticism	1. Personal attributes such as integrity, independence, and diligence are fundamental to professional skepticism.	ordinal	35	4.00	. 51697
	2. A proactive and questioning attitude is critical for fostering				

Variables	Indicator	Scale	Descriptive Research Variables		
	professional skepticism.				
	3. Professional skepticism is enhanced by an auditor's knowledge and experience.				
	4. The ability to critically evaluate evidence and assess its sufficiency and appropriateness is a cornerstone of professional skepticism.				
Audit quality	1. An auditor's ability, encompassing both technical expertise and analytical skills, is fundamental to their effectiveness.	ordinal	35	3.43	. 48765
	2. Professional commitment reflects an auditor's dedication to their profession and ethical principles.				
	3. Motivation plays a critical role in driving auditors to maintain high standards of performance and ethical behavior.				
	4. Job satisfaction is closely linked to an auditor's overall performance and ethical conduct.				

Table 1 presents the descriptive statistical results for the variables in this study, which include the following:

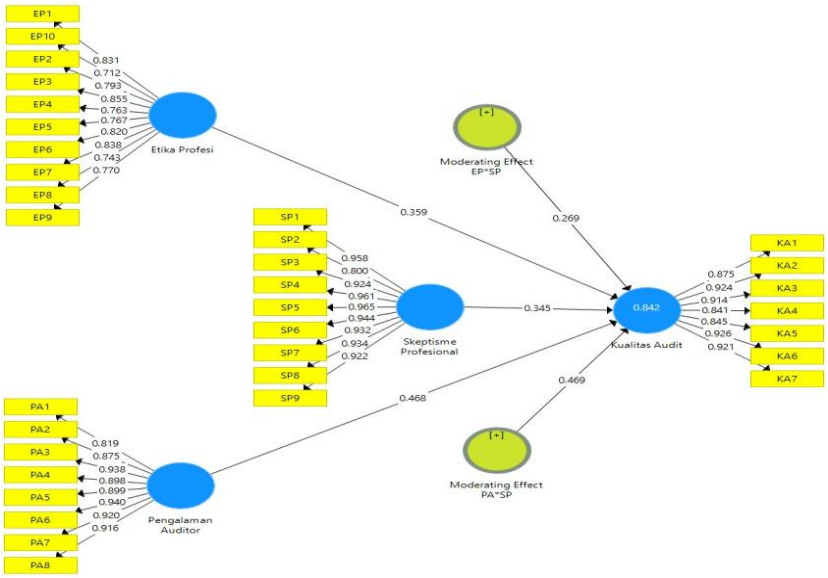
- Auditor Ethics (X1): The data shows that the Auditor Ethics variable has a minimum value of 3.80, a maximum value of 5, and a mean of 4.5771. This mean falls within a scale indicating a response choice of "strongly agree." The standard deviation is 0.41380, suggesting a moderate level of variation from the average responses among respondents.
- Auditor Experience (X2): For Auditor Experience, the variable has a minimum value of 3.25, a maximum value of 5, and a mean of 4.5857. Similar to Auditor Ethics, this means indicates a response choice of "strongly agree." The standard deviation is 0.51697, reflecting a slightly higher variation compared to Auditor Ethics.
- Professional Skepticism (M): The Professional Skepticism variable has a minimum value of 4, a maximum value of 5, and a mean of 4.4603. This means also indicates a response choice of "strongly agree." The standard deviation of 0.46765 signifies a moderate level of deviation from the mean response.
- Audit Quality (Y): The Audit Quality variable shows a minimum value of 3.43, a maximum value of 5, and a mean of 4.2082. This indicates that respondents generally "strongly agree" with statements related to audit quality. The standard deviation of 0.46787 reflects moderate variation in responses.

These descriptive statistics provide a clear overview of the central tendencies and variations within the responses for each variable, serving as a foundational step for further analysis in this study.

Structural Equation Model Testing

The primary analytical method employed in this study is Structural Equation Modeling (SEM). The testing process is conducted using the SmartPLS 3.0 software, which facilitates the analysis of complex relationships between variables and their indicators. The SEM approach integrates both the measurement model and the structural model, allowing for a comprehensive evaluation of the hypothesized relationships. Figure 3 presents the results of the Full Model SEM analysis performed using the Partial Least Squares (PLS) method, providing insights into the validity, reliability, and path coefficients of the study's constructs.

Figure 2 SEM Full Model Test Using smart PLS



Based on the test results using smart PLS as shown in Figure 2, it can be seen that there is no loading factor value below 0.50, so there is no need to drop data to remove indicators with a loading value below 0.50 in order to obtain a good model.

Outer Model

Three measurement criteria are used in the data analysis technique using Smart PLS to assess the model. The three measurements are convergent validity and composite reliability and discriminant validity.

Table 8. Validity and Reliability

Variables	Indicators	r-calculated	Cronbach Alpha	Result
Professional Ethics	EP.1	0.831	0.934	Valid and Reliable
	EP.2	0.793		
	EP.3	0.855		
	EP.4	0.763		
	EP.5	0.767		
	EP.6	0.820		
	EP.7	0.838		
	EP.8	0.743		
	EP.9	0.770		
	EP.10	0.712		
Auditor Experience	PA.1	0.819	0.968	Valid and reliable
	PA.2	0.875		
	PA.3	0.938		
	PA.4	0.898		
	PA.5	0.899		
	PA.6	0.940		
	PA.7	0.920		
	PA.8	0.916		
Professional skepticism	SP.1	0.958	0.979	Valid and reliable
	SP.2	0.800		
	SP.3	0.924		
	SP.4	0.961		

Variables	Indicators	r-calculated	Cronbach Alpha	Result
	SP.5	0.965		
	SP.6	0.944		
	SP.7	0.932		
	SP.8	0.934		
	SP.9	0.922		
Audit Quality	K A.1	0.875	0,958	Valid and reliable
	K A.2	0.924		
	K A. 3	0.914		
	K A. 4	0.841		
	K A. 5	0.845		
	K A. 6	0.926		
	K A. 7	0.921		

According to the above table, the estimated results of the external loading test using PLS for indicators such as auditor ethics, auditor experience, professional scepticism and audit quality show that the load factor for each reflective indicator is greater than 0.70, indicating that all the constructed indicators are valid. This shows that all indicators can effectively measure their respective constructs. The results of the reliability test also show strong consistency, with each variable's Cronbach's Alpha value exceeding the critical minimum of 0.70. In addition, the average variance extraction (AVE) of all constructs exceeds 0.50, ensuring the high consistency and stability of the instrument. This shows that auditor ethics, auditor experience, professional scepticism and audit quality are reliable measurement tools for assessing the issues of each construct with a high degree of reliability. Discriminant validity refers to the principle that different constructs should not be highly correlated. Discriminant validity is tested by comparing the square root of the mean AVE with the correlation value between the constructs, using the reflector index. If the square root of the AVE is higher than the correlation value between the constructs, the criterion for discriminant validity is met (Ghozali 2015). These results confirm that the measurement model fits well and has valid and reliable constructions that can be used for further structural model analysis.

Table 9. Discriminant Validity

	Professional Ethics	Audit Quality	Moderating Effect EP*SP	Moderating Effect PA*SP	Auditor Experience	Professional skepticism
Professional Ethics	0.791					
Audit Quality	0.488	0.893				
Moderating Effect EP*SP	-0.020	0.363	1.000			
Moderating Effect PA*SP	-0.041	0.512	0.155	1.000		
Auditor Experience	-0.073	0.403	-0.053	0.108	0.902	
Professional skepticism	0.542	0.461	0.322	-0.084	-0.228	0.928

As shown in Table 3, the diagonal values indicate the square root of the AVE, while the values below the diagonal indicate the correlation between the structures. The results show that the square root of AVE is always higher than the correlation between structures, confirming that the model meets the discriminant validity criteria. This indicates that each structure is independent and not highly correlated with the other structures, thus ensuring the validity of the measurement model.

Inner Model

An internal model (also known as an internal relationship, structural model or content theory) describes the relationships between latent variables based on an underlying theoretical framework. This model provides the basis for testing hypotheses and analysing how constructs interact in the research context, ensuring that structural relationships are consistent with established theoretical principles.

Table 10. R-Square Construct Variable

	R Square	R Square Adjusted
Audit Quality	0.842	0.815

From Table 4, the R-Square value for the Audit Quality variable is 0.842, indicating that it falls within the high category. This means that 84.2% of the variation in Audit Quality can be explained by the variables Professional Ethics and Auditor Experience, with Professional Skepticism acting as a moderate variable. The remaining 15.8% is influenced by other factors not included in this study, such as workload, time pressure, and other external variables. This high R-Square value suggests that the model provides strong explanatory power for the determinants of audit quality.

Table 11. Path Coefficient Analysis

	Original Sample	Sample Mean	Standard Deviation	T Statistics	P Values	Information
Professional Ethics ➔ Audit Quality	0.359	0.369	0.101	3.573	0.000	Approved
Auditor Experience ➔ Audit Quality	0.468	0.453	0.118	3.978	0.000	Approved
	Original Sample	**Sample Mean**	**Standard Deviation**	**T Statistics**	**P Values**	
Moderating Effect EP*SP ➔ Audit Quality	0.269	0.273	0.122	2.211	0.028	Approved
Moderating PA *SP fee audit ➔ Audit Quality	0.469	0.464	0.107	3.393	0.000	Approved

Hypothesis Testing Results

Based on the inner weight values, which include Professional Ethics (X1) and Auditor Experience (X2), the partial effect on Audit Quality (Y) can be analyzed as follows:

1.Hypothesis Testing 1 (H1)

The first hypothesis states that professional ethics have a positive and significant effect on audit quality. Table 18 shows that the professional ethics variable has a significance level of 0.000, which is less than 0.05, and a t-statistic value of 3.573, which is greater than 1.96. The parameter coefficient is +0.359, indicating a positive relationship between professional ethics (X1) and audit quality (Y). This means that for every one-unit increase in X1, audit quality (Y) will increase by 0.359, assuming other independent variables remain constant. The positive coefficient confirms that professional ethics directly improve audit quality. Therefore, H1 is accepted, reinforcing the idea that higher professional ethics leads to better audit quality.

2.Hypothesis Testing 2 (H2)

The second hypothesis suggests that auditor experience has a positive and significant effect on audit quality. Table 18 indicates that the auditor experience variable has a significance level of 0.000 (less than 0.05) and a t-statistic value of 3.978, which is greater than 1.96. The parameter coefficient is +0.468, signifying a positive relationship between auditor experience (X2) and audit quality (Y). This implies that for every one-unit increase in X2, audit quality (Y) will increase by 0.468, assuming other independent variables remain constant.

The positive coefficient confirms that increased auditor experience leads to enhanced audit quality. Thus, H2 is accepted, proving that more experienced auditors contribute to higher quality audit.

3.Hypothesis Testing 3 (H3)

The third hypothesis examines whether professional ethics positively and significantly influence audit quality when moderated by professional skepticism. Table 19 reveals that professional ethics has a significance level of 0.028, which is less than 0.05, and a t-statistic value of 2.211, exceeding 1.96. The parameter coefficient is +0.269, indicating that when professional ethics (X1) increase by one unit and are moderated by professional skepticism (M), audit quality (Y) increases by 0.269, with other independent variables held constant. The positive coefficient suggests that professional skepticism strengthens the relationship between professional ethics and audit quality. Therefore, H3 is accepted, indicating that professional ethics positively and significantly impact audit quality, especially when moderated by professional skepticism. The higher the level of professional ethics, when combined with professional skepticism, the better the audit quality.

4.Hypothesis Testing 4 (H4)

The fourth hypothesis posits that auditor experience has a positive and significant effect on audit quality when moderated by professional skepticism. Table 19 indicates that auditor experience has a significance level of 0.000, which is less than 0.05, and a t-statistic value of 4.393, exceeding 1.96. The parameter coefficient is +0.469, meaning that for every one-unit increase in auditor experience (X2) while being moderated by professional skepticism (M), audit quality (Y) increases by 0.469, assuming all other independent variables remain constant. The positive coefficient confirms that professional skepticism strengthens the effect of auditor experience on audit quality. Therefore, H4 is accepted, suggesting that as auditors gain more experience and apply professional skepticism, audit quality improves significantly.

These results confirm that professional ethics and auditor experience significantly influence audit quality, and their effects are further strengthened when moderated by professional skepticism. The findings emphasize the importance of strong ethical standards, extensive auditor experience, and professional skepticism in ensuring high-quality audits

5. Discussions

The results of the hypothesis testing in this study show that professional ethics and auditor experience have a positive and significant impact on audit quality, while professional scepticism plays the role of a confirming and moderating variable in this relationship. These results are consistent with previous research findings that emphasise the importance of ethics, experience and conscientiousness in improving audit quality. For example, Svanberg and Öhman (2016) found that auditors with high levels of professional scepticism were more effective at detecting material misstatements in financial statements. This suggests that professional scepticism is a key mechanism for improving an auditor's ability to identify and manage deviations or inconsistencies during the audit process. In addition, research by Shaub and Lawrence (1996) shows that a strong professional ethic improves audit quality. Auditors who adhere to ethical standards tend to be more objective and independent in their judgments, which in turn increases stakeholders' confidence in the audit results. Auditor experience is also considered a key factor affecting audit quality. Owhoso, Messier and Lynch (2002) found that experienced auditors are more effective at detecting errors and fraud in financial reports. Experience provides auditors with the practical knowledge and insight necessary to handle complex audit procedures and make informed professional judgments. Therefore, the results of this study are consistent with existing literature and support the view that professional ethics, auditor experience and professional scepticism are important determinants of audit quality. The implications of these findings suggest that in order to improve audit quality, organisations need to promote a strong ethical culture, provide opportunities for auditors to gain relevant experience and encourage auditors to develop a professional sceptical attitude.

Conclusions and Further Research

The objectives of this study were to explore the relationship between professional ethics and audit experience, with professional skepticism as the moderating variable. The results confirmed that professional ethics and audit experience have a positive and significant impact on audit quality, and the presence of professional skepticism can enhance the impact of professional ethics and audit experience on audit quality. The presence of professional skepticism can be used as a moderating factor to enhance the impact of professional ethics and audit experience on audit quality.

Based on these findings, several recommendations can be made. First, the sample of this study is relatively small and is limited to auditors working for audit firms in South Sulawesi. Future research should consider expanding the geographical scope and increasing the number of respondents to increase the generalisability of the findings. Second, future research should include variables other than those examined in this study to better understand the various factors that influence audit quality. Other possible factors include moderating effects of accounting knowledge, incentives/rewards, preferences, experience, and understanding of information systems.

Ultimately, this study is expected to provide valuable insights and knowledge to the South Sulawesi Audit Office to improve the quality and efficiency of the audit process. Strengthening auditors' professional ethics, professional development and encouraging professional scepticism can help improve audit quality and increase public confidence in financial reporting.

Credit Authorship Contribution Statement

The authors 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 during the preparation of this work.

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Financial Education in Amazonas: Evaluating Virtual and Traditional Methods

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Abstract: This research focused on examining how digital financial education, financial innovation, digital literacy, digital finance, and globalization influence face-to-face financial education in Bagua, Peru. The aim is to contribute to the fulfillment of the Sustainable Development Goal (SDG) related to quality education. The study uses a quantitative approach, and a descriptive-explanatory non-experimental design and data collected from 304 participants using a validated questionnaire. The results showed that digital financial education faces significant barriers, mainly due to the lack of connectivity and familiarity with digital tools; however, participants showed a strong preference for face-to-face financial education, although they also expressed a willingness to integrate digital methods; the analysis of the predictor variables revealed that digital financial education and digital finance positively influence face-to-face financial education, while financial innovation and

digital literacy did not show a significant influence. In conclusion, the results express the need for public policies and educational strategies that promote a hybrid model, compounding both digital and in-person learning, to improve financial inclusion in regions with technological gaps. Besides, globalization plays an important role but is not yet fully integrated into financial education.

Keywords: digital financial education; financial innovation; digital finance; globalization; financial inclusion; digitalization.

JEL Classification: J21; O33; Q56; A20.

Introduction

Financial education has been established as a fundamental factor for the particular and economic development of individuals in modern societies, especially in the current digital context. Technological transformation and the advance of globalization have reconfigured access to financial information; it opens the way to digital financial education, which offers new opportunities to acquire key knowledge in areas such as finance, investment and personal data protection; however, the lack of this knowledge can lead to serious errors in financial decision-making that affect both individuals and the economy in general; the lack of financial knowledge has been identified as one of the factors that contribute to the inability of many people to effectively manage their assets and make appropriate decisions (Remund, 2010; Agasisti *et al.* 2023; Lusardi & Mitchell, 2014).

In this sense, digital financial education, both in-person and online, has become one of the most relevant skills in the 21st century, especially with the advancement of the technological and digital environment; the ability to efficiently manage personal assets has become an essential skill to work in the modern economic environment; furthermore, during the COVID-19 pandemic, many young people, initially were affected by the lack of access to digital media, excelled in developing financial skills through digital platforms once they adapted to the digital environment; however, in countries such as India, the lack of accessibility to technology aggravated financial problems, highlighting the digital divide that limits people's ability to access financial education (Kumar *et al.* 2022; Bucciol *et al.* 2021; Lusardi, 2015; Gouda, 2022).

Worldwide, Sconti (2022) and Ali & Ghildiyal (2023) argues that limited access to digital financial education remains a serious problem, even in advanced economies, such as rapid technological developments and the complexity of financial services exclude part of the population; this phenomenon is reflected in the case of older people, who face big difficulties adapting to new digital paradigms due to the demand complex for digital education and socioeconomic factors that make it hard to their access to modern financial services.

In the national context, although financial literacy is essential for efficient savings and investment management, many citizens lack the necessary knowledge to effectively manage their personal finances (Álvarez *et al.* 2022). According to INEI (2022), people with less access to digital services are the most affected by the lack of financial culture, which increases their vulnerability to financial problems. Salas & Ticlla (2022) point out that the lack of financial skills is directly related to poor entrepreneurial attitudes and the inability to properly manage financial resources.

This research examines the influence of digital financial education, financial innovation, digital literacy, digital finance, and globalization on face-to-face financial education in Bagua; this study supported the fulfillment of the Sustainable Development Goal (SDG) related to quality education, focusing on financial inclusion and strengthening the digital skills of the inhabitants of this region; in this context, it seeks to generate a deeper understanding of how these factors contribute to the financial literacy of the population in an increasingly globalized and digitalized environment.

1. Literature Review and Background

After a review of the scientific literature, there were several relevant studies related to financial education in digital and face-to-face contexts. As well as theories linked to financial behavior and learning. In that sense, Tan *et al.* (2025) found that virtual financial education in Portugal increased student satisfaction, supporting the government's decision to approve this modality, which favored the financial inclusion of mature students. Pillai *et al.* (2023) they found that digital financial education significantly affects financial decisions, although it had no direct impact on perceived financial well-being. Clark *et al.* (2025) showed that in-person courses generated more stable financial literacy than digital ones in the long term, but both were beneficial. In a study of Olano *et al.* (2024), digital financial education was found to improve e-banking behavior, although many participants had little confidence in their digital financial skills. Mohd & Halim (2023) concluded that the digitalization of financial education is key to economic growth, as it improves financial ecosystems through digital infrastructure.

Likewise, Bellocchi & Travaglini (2025) showed that the use of digital payments is correlated with financial literacy, especially among young individuals and urban residents with Internet access. Garcia-Santillan *et al.*

(2025) found that greater financial literacy improves users' money organization, while Cook *et al.* (2024) highlighted that Peruvian student have basic knowledge about savings, but less advanced skills related to financial security. Ramos *et al.* (2023) highlighted that financial education programs aimed at women support to financial inclusion and the development of human capital in households, while Castro *et al.* (2022) indicated that digital financial education was positively received by students during the pandemic, especially among those who were financially dependent on their parents.

According to theoretical perspective, the theory of behavioral finance, related to financial literacy, highlights the importance of having financial knowledge to make informed decisions (Xiao y Kumar, 2023). The theory of ubiquitous learning, which focuses on the acquisition of knowledge through digital platforms, has also been taken into account (Ortiz *et al.* 2024). Regarding face-to-face financial education, theories such as autonomous learning have been addressed (Kallenos *et al.* 2025) and social learning (Zhou *et al.* 2023), which suggest that social interactions and group environments increases the acquisition of financial knowledge. Regarding digital financial literacy, the definition provided by Van Nguyen *et al.* (2022), which describes digital financial literacy as the set of skills, attitudes and knowledge necessary to make efficient financial decisions; also, the theory of digital literacy, according to Zahoor (2023), emphasizes the importance of digital skills to understand and use financial information. Regarding globalization, Choudhury (2022) highlights how the interaction and integration of countries drives economic and social changes that affect financial literacy and global financial inclusion. The studies have also identified various indicators, such as the availability of credit (Bhattacharyaa *et al.* 2023), indebtedness (Abdallah *et al.* 2025) and liquidity (Roy *et al.* 2022), which are directly related to individual and collective financial development.

Based on these backgrounds and theories, the following general hypothesis is proposed: H1: The factors of digital financial education, financial innovation, digital literacy, digital finance and globalization exert a positive and significant influence on the face-to-face financial education of people in Bagua, improving their financial knowledge, skills and attitudes, supporting adequate decision-making and financial inclusion.

2. Materials and Methods

The study was framed by expanding knowledge about the influence of digital and face-to-face financial education on the population of Bagua, that is a context explored a little in previous research. In this sense, we sought to understand deeply how people access and use financial education in an increasingly digitalized environment, which was crucial to promote inclusive financial education in regions with diverse digital and socioeconomic gaps; in addition, numerical data and statistical analysis were collected to test the hypotheses about the influence between the variables, providing relevance evidence on the effectiveness of financial education models in urban and rural contexts.

Furthermore, the variables were not deliberately modified or controlled but rather observed in their natural context; this approach was innovative because, unlike previous research focused on urban or highly connected contexts, the study addressed the influence between digital and in-person financial education in a region with socioeconomic and cultural characteristics, such as Bagua, where access to digital services was limited; this perspective allowed for a more complete and nuanced view of the influence of educational tools on financial habits in contexts of digital inequality.

The sample of 304 people was an exact representation of the population of Bagua, which allowed for a detailed view of citizens' perceptions and attitudes towards financial education; this approach was relevant, as it targeted a specific segment of the population in a geographic and cultural context that had been little researched in relation to digital and in-person financial education; non-probabilistic sampling, focused on the availability and willingness of participants, ensured that the data collected was significant for the study, it allowed a direct connection with the reality of the territory; the instrument was a questionnaire validated by experts, it was specifically adapted to the context of Bagua, which ensured its cultural relevance and relevance in measuring digital and in-person financial education.

At the methodological level, the research proposed a significant advance by integrating descriptive and inferential analysis to explore how the variables of digital financial education, financial innovation, digital literacy and globalization influenced the face-to-face financial education of the population of Bagua; this approach allowed us not only to describe the levels of knowledge, but also to infer the relationships between the factors that affect the financial behavior of individuals; in addition, ethical principles were considered, ensuring good research practices and transparent manners, respecting the autonomy of the participants and guaranteeing the confidentiality of their responses.

3. Research Results

Table 1, showing mean scores above 2.2 on a scale of 1 to 3, shows that digital and in-person financial education are generally well received. The more traditional approach seems to be slightly preferred in the VET dimension (in-person financial education), which has the highest mean score of 2.48. The data show that participants tend to score higher, with moderate standard deviations and negative skewness across all dimensions. The distribution is very even, with few outliers, as indicated by the negative kurtosis values. The results show that both teaching methods are well received, with a slight preference for face-to-face classes.

Table 1. Descriptive statistics on digital and in-person financial education

	N	Range	Minimum	Maximum	Average		Standard deviation	Variance	Asymmetry		Kurtosis	
			Statistical		Statistical	Standard error	Statistical			Standard error	Statistical	Standard error
EFD	304	2	1	3	2.38	0.031	0.549	0.301	-0.094	0.140	-0.876	0.279
IF	304	2	1	3	2.40	0.032	0.560	0.314	-0.228	0.140	-0.852	0.279
AD	304	2	1	3	2.33	0.032	0.565	0.319	-0.111	0.140	-0.658	0.279
FD	304	2	1	3	2.34	0.036	0.623	0.389	-0.384	0.140	-0.663	0.279
G	304	2	1	3	2.27	0.032	0.564	0.318	-0.039	0.140	-0.482	0.279
EFP	304	2	1	3	2.48	0.030	0.526	0.277	-0.182	0.140	-1.359	0.279
N valid (by list)	304											

Note: Prepared with SPSS data V 27 - 2025

Table 2 reveals that the combination of the independent variables - globalization, financial innovation, digital literacy, digital finance and digital financial education - has a significant impact on in-person financial education, as shown by the statistically significant model ($F = 30.625$, $p < 0.001$) in the analysis of variance (ANOVA). The high F-value and p-value, both less than 0.001, demonstrate the explanatory power of the model. These results point to the fact that elements related to digital transformation and globalization have a direct impact on how mainstream financial education is perceived and how effective it is.

Table 2. An analysis of Variance (ANOVA) to assess the influence of globalization, financial innovation, digital literacy, digital finance and digital financial education on face-to-face financial education.

Model		Sum of squares	gl	Root mean square	F	Sig.
1	Regression	28.457	5	5.691	30.625	,000[b]
	Residue	55.382	298	0.186		
	Total	83.839	303			

a. Dependent variable: VARDEP: IN-PERSON FINANCIAL EDUCATION

b. Predictors: (Constant), VAR5: Globalization, VAR2: Financial innovation, VAR3: Digital literacy, VAR4: Digital Finance, VARINDEP: Digital Financial Education

Table 3 reveals that digital financial education (DFE) is the most influential and statistically significant predictor of in-person financial education ($\beta = 0.314$, $p < 0.001$). Both globalisation (G) and digital finance (FD) have positive and substantial effects ($p = 0.001$ and $p = 0.028$, respectively). Both effects are statistically significant. In contrast, financial innovation (FI) and digital literacy (DL) do not have a statistically significant influence. No evidence of multicollinearity problems was found.

Table 4 shows that based on factors such as globalization, financial innovation, digital literacy, digital finance and digital financial literacy, the regression model explains 33.9% ($R2 = 0.339$) of the variance of in-person financial literacy. There are also predictors including digital financial literacy. The Durbin-Watson statistics, equal to 1.747, suggest that the residuals are not autocorrelated. There is a strong shift at $F = 30.625$, which confirms that the model is statistically significant ($p < 0.001$). This indicates that the model fits the data well overall.

Table 3. Regression coefficients to assess the influence of digital financial education, financial innovation, digital literacy, digital finance and globalization on face-to-face financial education.

Model	Unstandardized coefficients		Standardized coefficients			Correlations			Collinearity statistics	
	B	Desv. Error	Beta	t	Sig.	Zero order	Partial	Part	Tolerance	VIF
1 (Constante)	1.006	0.147		6.862	0.000					
EDF	0.301	0.076	0.314	3.957	0.000	0.544	0.223	0.186	0.353	2.832
IF	-0.049	0.051	-0.052	-0.953	0.341	0.244	-0.055	-0.045	0.741	1.350
AF	0.080	0.051	0.086	1.577	0.116	0.331	0.091	0.074	0.742	1.348
FD	0.173	0.052	0.206	3.314	0.001	0.466	0.189	0.156	0.576	1.736
G	0.125	0.056	0.134	2.208	0.028	0.427	0.127	0.104	0.606	1.650

a. Dependent variable: VARDEP: IN-PERSON FINANCIAL EDUCATION.

Table 4. Summary of the regression model to assess the influence of digital financial education, globalization, financial innovation, digital literacy, digital finance on face-to-face financial education

Model	R	R square	R square tight	Standard error of the estimate	Statistics of change					Durbin-Watson
					Change in R squared	Change in F	gl1	gl2	Sig. Change in F	
1	,583[a]	0.339	0.328	0.431	0.339	30.625	5	298	0.000	1.747

a. Predictors: (Constant), VAR5: Globalization, VAR2: Financial innovation, VAR3: Digital literacy, VAR4: Digital Finance, VARINDEP: DIGITAL FINANCIAL EDUCATION

b. Dependent variable: VARDEP: IN-PERSON FINANCIAL EDUCATION

4. Discussion

The result of the descriptive analysis provides a clear and revealing view of the respondents' perception regarding digital and in-person financial education in Bagua. It revealed both general trends and relevant particularities; at a general level, a slight preference was observed for traditional methods over digital alternatives, a finding that could be linked to the low familiarity with digital technologies, which is consistent with the perspective of Maldonado *et al.* (2023). It underlines the importance of digital financial education in more advanced students; the Digital Financial Education variable showed a mean of 2.38, reflecting a moderate perception of its accessibility and relevance; the notable dispersion in the responses (standard deviation of 0.549) suggests unequal exposure to digital tools, a phenomenon also observed by Pillai *et al.* (2023), who found that digital financial education influences financial decisions, although it does not always improve perceived financial well-being.

Regarding financial innovation, the average of 2.40 shows a slight improvement in the perception towards digital financial education, aligning to what was indicated by Sconti (2022), who observed that face-to-face methods tend to generate more stable financial education than digital ones; on the other hand, digital literacy had the lowest mean (2.33) and the highest standard deviation (0.565), which reflects that many participants consider themselves inexperienced in the use of digital tools; this result supports the claim of Van Nguyen *et al.* (2022), who highlighted that digital competence as crucial for making effective financial decisions; the variable Face-to-face Financial Education obtained an average of 2.48, that means a positive perception towards traditional methods, in line with the findings of Ramos *et al.* (2023), who found that face-to-face programs favor the development of human capital and financial inclusion; the lowest finding was in Globalization, with a mean of 2.27, suggesting that participants do not directly associate globalization with significant changes in their financial education; this could reflect a disconnect between global effects and local realities, as indicated Choudhury (2022), noting that globalization drives economic changes that affect financial education, but these effects are not strongly perceived in areas with limited access to globalized financial information.

The analysis of variance (ANOVA) confirmed the relevance of the proposed model, which included the variables Digital financial education, Financial innovation, Digital literacy, Digital finance and Globalization ($F=30.625$, $p<0.001$); this highlights the significant influence of these variables on the variability in in-person financial education, although the presence of a significant proportion of unexplained variability suggests that other factors not yet considered could be affecting participants' perceptions.

Finally, the results of the multiple regression confirmed that Digital Financial Education has a positive and significant impact on In-person Financial Education (coefficient of 0.301, p=0.000), supporting the importance of digitalization in financial education, as suggested by Mohd & Halim (2023); on the other hand, the variables Financial Innovation and Digital Literacy did not present significant effects, suggesting that these areas require further development and contextualization in future studies; digital finance showed a significant impact (coefficient of 0.173, p=0.001), highlighting the importance of integrating digital tools into educational programs. Globalization also presented a significant coefficient of 0.125 (p=0.028), indicating that, although its impact is moderate, it remains relevant in the formation of financial education, as previously pointed out by studies of Grabiel *et al.* (2021).

5. Conclusions and Further Research

The findings obtained throughout the study have allowed us to understand the perceptions and attitudes of participants regarding digital and face-to-face financial education, revealing both the strengths and weaknesses of current educational strategies.

Firstly, it has been shown that although digital financial education is seen as an important tool for economic development, its adoption faces significant obstacles, particularly in regions such as Bagua, where connectivity limitations and familiarity with digital tools negatively impact its effectiveness; this underlines the urgent need for public policies that promote technological infrastructure and access to digital education platforms, in line with the conclusions of studies such as that of Maldonado *et al.* (2023), who highlighted the importance of virtual financial education for financial inclusion.

Secondly, despite the moderate perception of digital financial education, face-to-face financial education remains the most valued approach among participants, reflecting the persistent preference for traditional teaching methods; this finding is consistent with the claims of Sconti (2022) who argue that face-to-face financial education offers more stable and durable literacy, which is relevant for areas with technological limitations; however, it is crucial to consider that a significant portion of participants also showed willingness to integrate digital methods into their learning processes, suggesting that a hybrid model could be the solution to cover the educational needs of all communities.

The analysis of the predictor variables, such as digital financial education, digital finance, digital literacy, financial innovation and globalization, has shown that these variables explain a significant proportion of the variability in face-to-face financial education; in particular, digital financial education and digital finance showed a positive and significant influence with face-to-face education, which emphasizes the importance of integrating these digital variables into educational curricula however, financial innovation and digital literacy did not present a significant influence in the model, which could indicate that these elements require further contextualization and deepening in future research.

Finally, the results suggest that financial education, both digital and in-person, plays a key role in developing fundamental economic skills; it is imperative that both governments and educational institutions restructure their approaches to incorporate both methods in a complementary way, considering the particular characteristics of each community and region; digital financial education, while essential for global economic progress, must be accompanied by inclusion strategies that guarantee equitable access for all people, regardless of their location or level of digital literacy.

This study also highlights the relevance of incorporating globalization as a component of financial education, since the effects of global integration must be understood in their local context; globalization, although not yet fully rooted in the perceptions of participants, has a potential impact on financial education and should be considered in the design of policies and teaching strategies.

Future studies should focus on the following:

Future research	Independent variable	Intervening variables	Dependent variable	Methodology	Statistics to be used
Impact of digital financial education on face-to-face financial education	Digital financial education	Internet connectivity, attitude towards digitalization, cultural context	In-person financial education	Quantitative, experimental design, pre-post test	ANOVA, multiple regression, Student's t test
Factors affecting the acceptance of digital financial education in	Digital financial education	Access to technologies, cultural resistance,	Perception of the usefulness of digital	Quantitative, descriptive design	Regression analysis, Pearson

Future research	Independent variable	Intervening variables	Dependent variable	Methodology	Statistics to be used
rural areas		educational level	financial education	Explanatory	correlation
Evaluating the effectiveness of financial innovation programs in financial inclusion	Financial innovation	Degree of familiarity with financial innovations, access to financial services	Financial inclusion of participants	Quantitative, longitudinal design	Multivariate regression, analysis of variance (ANOVA)

Note: Prepared with information from the findings of this study.

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Authors' contributions

Anita Maribel Valladolid Benavides: Conceptualization, and methodology.
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Julca Maluquis, Eder: Data curation and writing of the original draft.
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The authors declare that they have no competing financial interests or personal relationships that could have influenced the work presented in this article.

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 prior to submission, but only to improve the language.

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The Role of Adaptive Management in Ensuring Enterprises' Sustainable Development

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Abstract: In an ever-evolving business landscape, designing adaptive management systems and agile business models emerges as a pivotal element in guaranteeing companies' enduring growth and competitiveness in the long term. The aim of the study is to examine the role of adaptive management in ensuring the enterprise's stable development in a changing business environment. The study utilized empirical methods such as: experimental method, questionnaire method, analysis method, control method based on key performance indicators and modeling method. The mechanism of adaptive management of the enterprise has been developed and tested within the framework of the training course. The author's model of manufacturing enterprises' adaptive management via the introduction of digital tools into the business model of sustainable development is presented. The survey results demonstrated that the implementation of adaptive management helped their companies achieve key performance indicators. Namely: strategic - 79%, operational - 81%, financial - 76%, production - 84%, marketing - 86%, HR - 77%. The expediency of introducing an adaptive approach to management was confirmed by 93% of respondents. The practical significance of the study lies in the presented model of adaptive enterprise management. It can serve as the basis for the development of sustainable development programs in the context of Industry 4.0.

Keywords: adaptive management; digital technologies; business model; flexibility; innovation; competitiveness; sustainable development.

JEL Classification: L22; L52; M13; M14; C15.

Introduction

Adaptive capabilities of the enterprise in the face of a rapidly evolving business environment, digital transformations of the socio-economic system, and paradigm shifts in the management and organization of business processes hold significant value in the business ecosystem.

To not only survive, but also uphold their competitive edge, organizations must exhibit resilience, enabling them to thrive, being flexible and adaptive (Almutairi & Ghandour, 2021). Accordingly, the formation of adaptive management mechanisms to respond to changes is companies' priority aimed at long-term productivity and sustainable efficiency.

In modern business circles, issues related to enterprises' adaptive management in the context of technological progress and digital transformations of business systems are becoming increasingly relevant. Adaptability is an integral characteristic of the socio-economic system. It combines flexibility, mobility, maneuverability and other characteristics that ensure the rearrangement of the system elements without significant changes in its structure. At the enterprise level, adaptability reflects the ability level of the overall enterprise management system to function in a changing external environment. Adaptive enterprise management, based on flexibility and innovative solutions, is becoming a key tool to ensure their sustainability and competitiveness in the face of rapid technological advances and digital transformations (Nikonenko et al., 2022).

Adaptive management is indispensible in the face of uncertainty and constant unpredictable changes. An adaptive approach to management contributes to a deeper design of management decisions that draw upon scientific pespectives. This is not a "trial and error" process but rather learning through the process of practical application (Rogers & Macfarlan, 2020). Adaptive management is a key component of crisis management, as it allows us to quickly identify external threats and new opportunities. It also contributes to a deep analysis of the enterprise's internal strengths and weaknesses, which makes it possible to develop effective solutions to prevent crisis situations (Korytko & Piletska, 2022). The USAID Adaptive Management Discussion Note (USAID, 2018) states that adaptive management does not involve any objectives' revision. The essence of adaptive management is not to change the goals themselves in the process of implementation, but to adjust the ways to achieve them in response to the emerging changes. Adaptive management is carried out at both tactical and strategic levels (Lelyk et al., 2022). At the tactical level, solutions are developed to respond to market changes, while strategic management includes indicative planning, monitoring and diagnostics of the business environment, ensuring decision correction grounded on new information (Zinchenko et al., 2022). Accoding to Rangwala (2024), adaptive management involves responding to a situation after it has occurred, offering solutions to eliminate destructive consequences. This approach is less preferable for overcoming uncertainty, as it does not take into account the importance of time and the potential financial consequences of decisions made. Adaptive management, drawing upon a scientific approach and flexibility in decisions' implementation, becomes a key factor for successfully confronting crises and ensuring sustainable development in conditions of uncertainty. Therefore, the relevance of delving into adaptive enterprise management is due to rapid changes in the business environment, technological progress as well as digital transformations. Under such conditions, companies must be flexible and adaptable to maintain their competitiveness and ensure sustainable development.

The aim of the study is to examine the role of adaptive management in ensuring the enterprise's stable development in a changing business environment. To achieve the goal of the study, the following tasks were set:

- develop the concept of the training course "Strategy of Adaptive Management at Manufacturing Enterprises" and conduct a training experiment with manufacturing enterprises managers from Ukraine, Poland, Romania and Moldova;
- design and test the enterprise's mechanism of adaptive management, as well as evaluating the feasibility of introducing adaptive approaches to managing the activities of manufacturing enterprises;
- evaluate the impact of implementing the adaptive management approach on the achievement of the elaborate performance indicators.
- design an adaptive model of managing the manufacturing enterprises through the introduction of digital tools into the business model of sustainable development.

1. Literature Review

In the dynamic landscape of business management, the integration of advanced technologies has become a prerequisite for maintaining competitiveness and efficiency (Rane, 2023). Modern digital technologies are making significant and positive changes in the enterprises' activity, radically changing established models and pushing

enterprises towards more efficient and innovative activities (Bruno, 2024). In the ever-changing landscape of digital transformation, monitoring, measurement, and metrics are the pillars that drive progress, efficiency, and innovation (Aldoseri et al., 2024). Business models based on digital service-oriented solutions enable manufacturers to gain a competitive edge through the use of innovations in the field of products and services. Moreover, it provides an opportunity for knowledge sharing and externalizing risks (Naeem et al., 2024).

According to Bejarano-Auqui (2024), the constant changes in the socio-economic system under the influence of 21st century technologies require entrepreneurs to be far-sighted in business management. This prioritizes the use of knowledge and effective management of information value. Adama and Okeke (2024) point out that digital transformation has radically changed traditional business models, forcing companies to innovate and adapt quickly to dynamic market conditions. Digital technologies allow us to quickly create prototypes, experiment and integrate new business models. According to Marion et al. (2025), digital technologies have a significant positive impact on radical innovation in firms by opening up new opportunities to obtain, analyze, and use knowledge. The use of digital technologies allows companies to analyze vast amounts of data, extract valuable information, and generate innovative ideas that can provide a competitive advantage. According to Gin (2025), artificial intelligence-driven systems can significantly improve forecasting accuracy and decision-making efficiency by learning from dynamic data environments.

Furthermore, Lecocq, Warnier, Demil and Plé (2024) consider that generative digital technologies are powerful tools for management. They allow creating new business models and improve existing ones. Digital technologies are able to model the performance of business models in different scenarios, which helps companies to be aware of risks and opportunities for making informed management decisions. Drawing on the above, generative digital technologies are becoming an important tool for creating and optimizing business models. Thus, enabling companies to more effectively assess risks and opportunities, as well as to make more balanced management decisions in conditions of instability. Researchers Daskalopoulos and Machek (2025) argue that the implementation of AI technologies can reduce planning costs, which will allow for more complex, flexible and informed decisions. AI can be an effective tool in developing organizational ambidexterity, promoting rational diversification and sustainable improvement in the performance of companies.

In recent years, there has been significant progress in integrating technological solutions into enterprise resource planning systems. In this light, Jawad and Balázs (2024) argue that the use of machine learning in enterprise resource planning systems is a top priority of technical progress in today's corporate environment. Machine learning allows resource planning systems to adapt dynamically based on real-time information, resulting in increased efficiency and adaptability. This is consistent with the opinion of Madanaguli, Sjödin, Parida and Mikalef (2024), who argue that the use of digital tools allows enterprises to implement cyclical business models. These models are developed in order to minimize the cost of resources and energy in the value chain. In addition, existing business cyclic typologies can be extended through technological capabilities. In a study by Marion et al. (2025), it was shown that integrating AI into the uncertain early stage of new product development enables companies to improve the accuracy and speed of product development. This is due to the ability to synthesize large-scale consumer data to improve decision-making, accelerate concept development, and enhance product evaluation. The above perspective is consistent with the opinion of Prasanth, Vadakkan, Surendran and Thomas (2023). The said authors argue that businesses can make more effective decisions owing to the ability of AI systems to analyze huge amounts of data and generate forecasts and recommendations based on them. AI can revolutionize corporate decision-making by providing faster and more accurate insights that can guide both operational and strategic decisions. According to researchers Pallathadka et al. (2021), these analytical results can help maximize sales and optimize resources. Thus, the integration of AI and machine learning into enterprise resource planning systems ensures higher efficiency, adaptability and accuracy of management decisions. Accordingly, this contributes to the processes' optimization and the creation of sustainable business models focused on minimizing the resources cost as well as meeting the customer needs. Furthermore, Farayola, Abdul, Irabor and Okeleke (2023) believe that enterprises can automate marketing research using artificial intelligence-based tools. In the context of the said approach, adaptation to the changing conditions and maintaining operational efficiency is ensured. According to Roy et al. (2025), AI adoption is not monolithic, and its nature and subsequent value appropriation processes may vary depending on external factors and the organization's strategic approach to innovation and resource management. Researchers Bhardwaj et al. (2025) draw attention to the challenges of integrating AI into organizational processes related to data privacy, model transparency, and ethics. According to Santos and Carvalho (2025), at the stage of integrating digital technologies into management processes, the formation of a comprehensive AI strategy based on ethical principles and active community involvement plays a key role. Such an approach ensures fair and inclusive

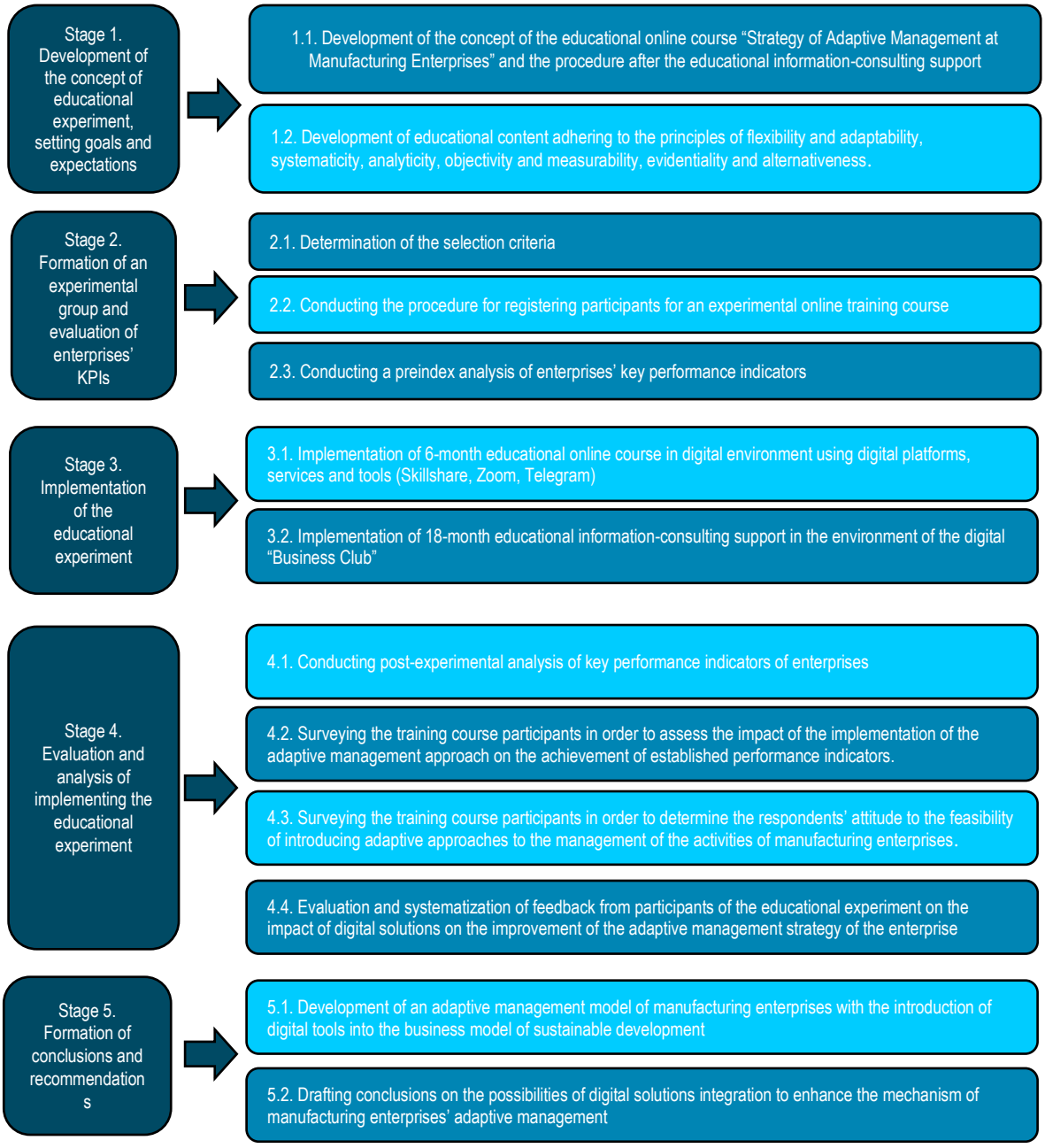
adoption of AI, promoting sustainable development and harmonious interaction of technology with society. According to researcher Ghosh (2025), the integration of modern digital solutions based on AI functions also requires a cultural shift in which leaders develop digital AI skills, begin to trust the conclusions made with its help, and adapt leadership styles to effectively use all the opportunities that artificial intelligence offers. Thus, to successfully integrate AI into business processes, companies need to develop technological competencies and train employees to manage data. In addition, it is indispensable to strengthen cybersecurity measures and create a culture of continuous learning.

2. Method also Called Materials and Methods or Experimental Methods

2.1. Research Procedure

The research stages that were carried out when writing this work are presented in Figure 1.

Figure 1. Research Stages



Source: elaborated by the authors.

2.2. Methods

In the course of this study, the following methods were used:

1.The experimental method was applied in the process of implementing the experimental educational course and testing the effectiveness of the adaptive management mechanism at manufacturing enterprises.

2.The management method based on key performance indicators (KPI) was used to evaluate the effectiveness of implementing the adaptive approach to managing the manufacturing enterprises.

3.The questionnaire method was used in order to determine the respondents' attitude to the expediency of introducing adaptive approaches to managing the manufacturing enterprises' activities. The above method was also utilized to obtain data on the impact of implementing the adaptive management approach on the achievement of established performance indicators across the companies of the participants of the training course.

4.The analysis method was used to evaluate and consolidate the educational experiment participants' feedback in terms of the digital decisions impact on the improvement of the enterprise's adaptive management strategy.

5.The modeling method was used in the development of the author's model and adaptive control mechanism.

2.3. Instruments

The survey of respondents was carried out using Google Forms. The obtained data were analyzed and processed using statistical methods and Microsoft Excel software.

2.4. Sampling

The educational experiment was attended by the heads of 127 private manufacturing companies of small and medium-sized business from Ukraine, Moldova, Poland and Romania. The offer to participate in the online training course was sent to the companies owners whose activities were related to production. Since the analysis of the external business environment was one of the key elements of the online course concept, the experimental group consisted of business representatives from countries that are characterized by geographical proximity and have common economic interests, opportunities and challenges. The search for companies was carried out with the help of open services of state registers of legal entities. Course moderators sent proposals to 263 business owners, 127 of whom registered for the training course (Table. 1).

Table 1. Sampling

Number of participants	Scope of activity	Country
13	Food production	Ukraine (4 people), Moldova (3 people), Poland (2 people), Romania (4 people)
14	Beverage production	Ukraine (3 people), Moldova (2 people), Poland (6 people), Romania (3 people)
16	Textile production	Ukraine (4 people), Moldova (6 people), Poland (4 people), Romania (2 people)
19	Clothing production	Ukraine (3 people), Moldova (6 people), Poland (4 people), Romania (6 people)
15	Manufacture of furniture	Ukraine (3 people), Moldova (6 people), Poland (4 people), Romania (2 people)
12	Manufacture of leather, leather products and other materials	Ukraine (2 people), Moldova (4 people), Poland (3 people), Romania (3 people)
10	Manufacture of rubber and plastic products	Ukraine (3 people), Moldova (2 people), Poland (4 people), Romania (1 person)
28	Manufacture of other products	Ukraine (8 people), Moldova (5 people), Poland (9 people), Romania (6 people)
Total 127		Ukraine (30 people), Moldova (34 people), Poland (36 people), Romania (27 people)

Source: elaborated by the authors.

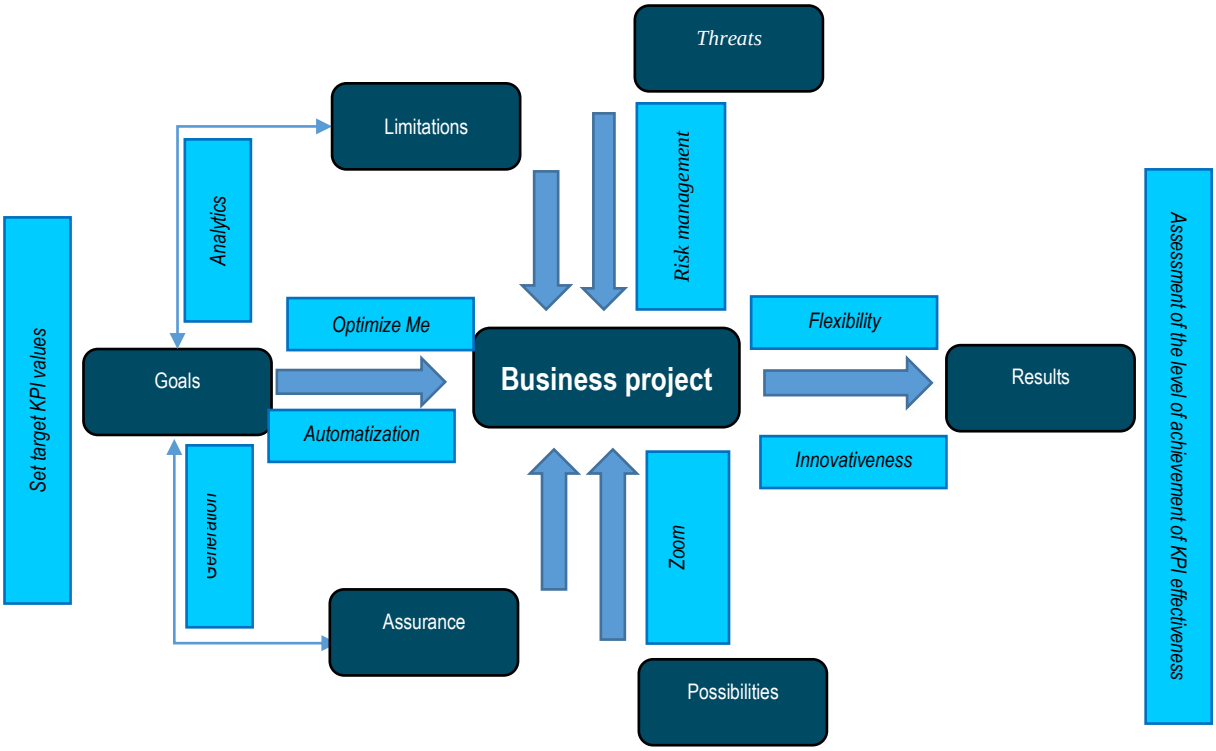
The number of participants in the online course was sufficient to realize the planned objectives of the study. The online course ran for 6 months (from September 2022 to February 2023) on the Skillshare online platform (https://www.skillshare.com) and included 15 modules with theoretical and practical cases.

Upon completion of the course, participants were provided with informational and advisory support. The support included collective training activities in the environment of the virtual "Business Club" and individual consultations to business owners on request. Collective training events were held on Zoom online communication platform (https://zoom.us/) once a week and within the course included 84 online seminars, which were conducted by 5 experts - course moderators and 12 invited experts - business consultants. In addition, a "Business Club" group was created in Telegram, where course participants had the opportunity to share feedback, conduct discussions, and discuss current problems of the modern business environment. The administration of the group in Telegram was carried out by 1 expert - the course moderator.

3. Research Results

The results of the training experiment conducted revealed the promising possibilities of applying an adaptive approach to management. The implementation of a scientifically grounded approach to the organization and management of the interaction between internal and external factors in the business environment has enabled managers to delineate competitive advantages and formulate strategic directions for the companies' development. The skills of systems analytics allowed managers to take a comprehensive approach to the management of the company, taking into account the impact of management decisions on all aspects of its activities. Analyzing and systematizing the discussion activities of the participants of the educational experiment in the Telegram Business Club group, the importance of this work was noted. In the adaptive management system, the analysis of external and internal factors of the business environment is the basis for making flexible management decisions. The above-mentioned analysis allows us to identify the key trends, risks and opportunities that shape the company's operating environment and allow the management team to project optimal trajectories for sustainable development. Figure 2 shows the adaptive control mechanism tested within the training course and is presented as follows.

Figure 2. Mechanism of Enterprise's Adaptive Management



Source: elaborated by the authors

The pivotal role in the mechanism is held by the target enterprise - a venture subject to adaptive management. At the initial stage of the process of adaptive management of the enterprise, the management sets the target values of the KPI. Finally, an assessment of the level of achievement of the indicators of the

effectiveness of KPI is carried out. Work with the project begins with the analysis of the external and internal environment. With the help of business analytics tools, opportunities and limitations in the implementation of the project are evaluated, collected, processed, and analyzed data from the external business environment. At this stage, promising target audiences of consumers are determined, a product concept is developed and improved to meet market requirements, and alternative directions of project implementation are outlined. Next, an assessment of the company's own capabilities for the implementation of the project goals, the search for possible resources, the generation of solutions for resource diversification and the search for alternative resources and their combinations is carried out. At this stage, the ideas of production processes' automation, the technological tools' introduction in the production and product sale are worked out.

Financial efficiency indicators increased by 17.4%, indicators of production process efficiency - by 13.5%, and indicators of enterprise's sales activity efficiency - by 12.8%. In addition, the performance indicators of labor management increased by 9.7%. In general, these indicators demonstrated a steady improvement in the financial condition of enterprises and their readiness for further development.

Table 2. The effectiveness of the implementation of an adaptive approach to enterprise management

Key performance indicators of the company (KPI)	The effectiveness of implementing an adaptive approach to enterprise management (change of KPI level (+/-))
Financial Performance Indicators	**+17.4%**
Profitability	+17%
Liquidity	+14%
Solvency	+12%
Profitability	+21%
Business activity	+23%
Performance indicators of the production process	**+13.5%**
Production efficiency	+14%
Productivity	+16%
The level of quality of products	+7%
The level of the innovative component of the production cycle	+13%
Level of execution of production plans	+18%
The rate of growth of the volume of production	+13%
Indicators of the enterprise's sales activities efficiency	**+12.8%**
Sales volume	+23%
Profitability of sales	+19%
Efficiency of advertising and marketing activities	+16%
Sales cycle duration	+9%
Market share	+4%
Level of competitiveness	+6%
Indicators of labor resources' management effectiveness	**9.7%**
Workforce productivity	+7%
Efficiency in the use of working time	+9%
Percentage of completed planned tasks	+13%

Source: Elaborated by the authors

The results of surveying the participants of the educational experiment confirmed the expediency of introducing adaptive approaches to the management of the activities of manufacturing enterprises. 93% of respondents agreed with this. According to the respondents, the implementation of adaptive management helped their companies achieve key performance indicators: strategic - 79%, operational - 81%, financial - 76%, production - 84%, marketing - 86%, HR - 77% (Table 3).

The digital tools market is evolving rapidly, offering innovative services. Participants in the course were afforded the opportunity to experiment with cutting-edge technologies throughout the training and mentoring period. The analysis and systematization of the experience of corporate consulting within the framework of the experiment, as well as the evaluative observation of the activities of companies that implemented the principles of

adaptive management became the basis for the model development. The author's model of an adaptive management system for manufacturing enterprises integrates digital tools into a sustainable business model. (Figure 3).

Table 3. Results of the respondents' survey

Statements	Rating scale (1-5 points)				
	Totally disagree	*Rather disagree*	*Neutral*	*Rather agree*	*Totally agree*
The implementation of the adaptive management approach enabled the company to achieve the established performance indicators, namely:					
Strategic KPI		2%	7%	12%	79%
Operational KPI	2%	3%	5%	9%	81%
Financial KPI	4%	5%	8%	7%	76%
Production KPI			2%	14%	84%
Marketing KPI			3%	11%	86%
HR KPI	3%	6%	8%	6%	77%

Source: Elaborated by the author

The sustainable advancement of the company amidst the evolving external and internal operational landscape is regarded as the primary strategic aim of adaptive management. The tactical objective is to ensure the flexibility and efficiency of the company's response to external changes, allowing rapid adaptation of strategies and processes. An effective system of adaptive management of a manufacturing enterprise involves the integration of digital technologies into key areas of the company's activities, namely: i) business intelligence tools and generative artificial intelligence; ii) adaptive corporate systems and CRM systems; iii) Internet of Things, simulation systems and cloud platforms. Owing to the introduction of digital tools, the company is able not only to react instantly to changes, but also to proactively anticipate them. This greatly improves the company's competitiveness and ability to survive in dynamic market conditions. Analysis of the feedback from the participants of the experiment made it possible to identify the key arguments confirming the appropriateness of their use in the process of implementing the adaptive management strategy:

1. Digital technologies significantly increase the efficiency of adaptive enterprise management, providing flexibility and speed of response to change.

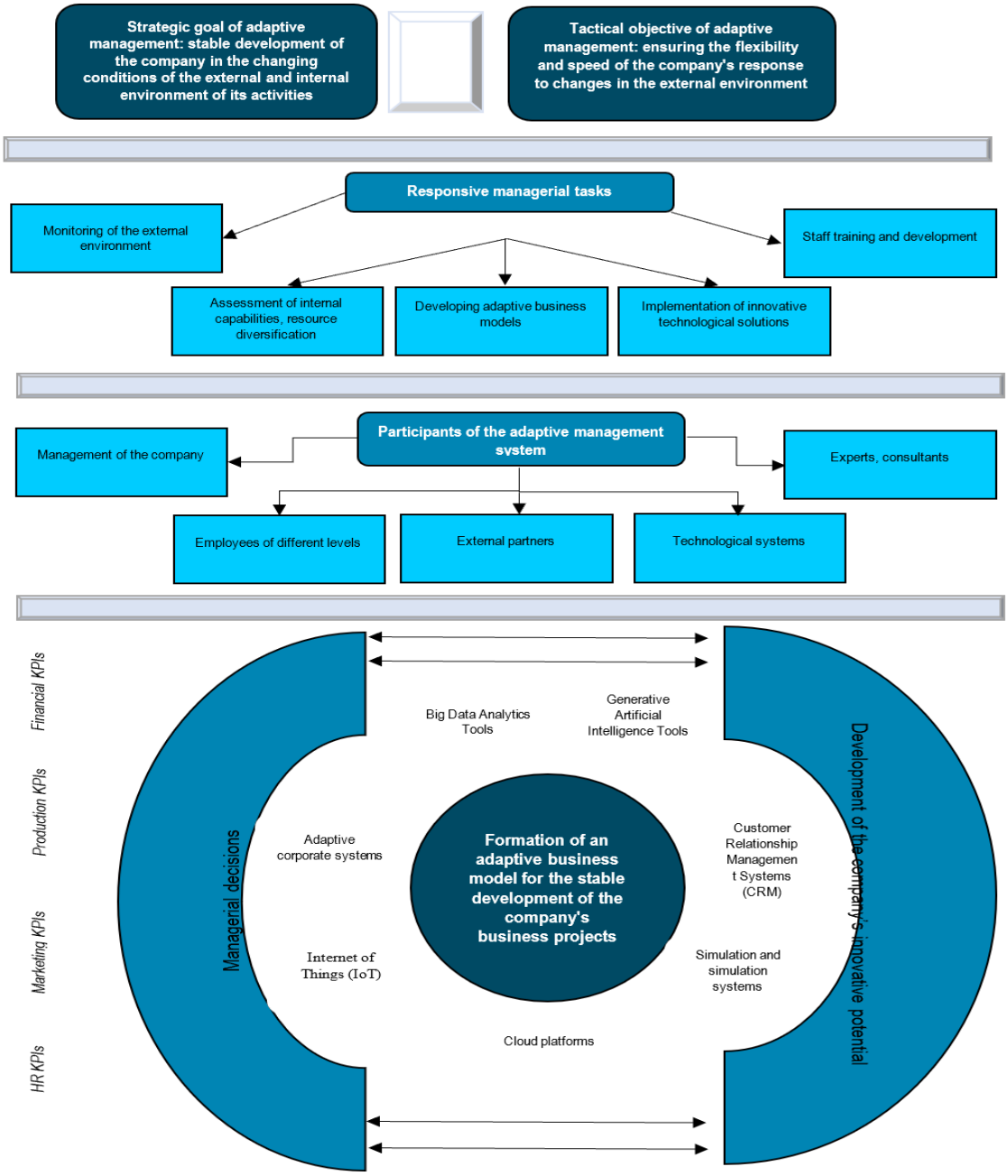
2.The generative functions of digital tools allows automating the monitoring of the external environment and the assessment of the internal capabilities of the company, helping to identify new resources and optimize their use.

3. An advantageous aspect of digital technologies lies in their capacity to formulate adaptive business models that can promptly adjust to fluctuating market conditions.

4. Modern digital technologies play a key role in predicting future changes and developing solutions that contribute to the sustainable development of the company.

5. The introduction of digital technologies allows creating a flexible business model that contributes to the sustainable development of business projects.

Figure 3. Adaptive Model of Manufacturing Enterprises' Management with The Introduction of Digital Tools into The Business Model of Sustainable Development



Source: Elaborated by the authors

4. Discussion

The results of the current research are consistent with those of studies conducted by Nigerian (Orishede et al., 2024), English (Sena & Nocker, 2021), Spanish researchers (Gutierrez-Broncano et al., 2024). The findings of the research confirmed that the integration of digital technologies in the management functions contributes to ensuring the company's competitiveness, sustainability and adaptability. The scientific research (Orishede et al., 2024) has shown that business intelligence systems are essential to support a multitude of business solutions, especially in the areas of personnel technological skills development, forecasting, and strategic planning. The results of a study conducted by researchers from the University of Essex (UK) (Sena & Nocker, 2021) confirmed that experimentation is an important aspect of digital technologies' introduction into new business models. The researchers concluded that the process of designing new business models forces company executives to experiment with alternative ways of generating value. The findings of a study conducted by Spanish researchers

(Gutierrez-Broncano et al., 2024) have validated that when confronted with enduring shifts in the external business landscape, the implementation of hybrid or integrated business strategies proves to be efficacious.

This approach stands out as the most optimal method to guarantee the longevity and advancement of enterprises. The researchers concluded that the implementation of a hybrid strategy requires flexible and mobile systems to adapt more and faster to change. Furthermore, it requires a combination of efficiency and innovation in both products and processes. In addition, the scientists concluded that the innovative abilities of companies depend to a large extent on the strengthening of adaptive abilities. As companies develop and implement adaptive capabilities into their procedures, systems, and organizational processes, innovation becomes a reality and helps companies stay competitive. In our study, the adaptive control mechanism is presented and tested, within the framework of a training experiment. The presented mechanism involves the integration of digital tools of business analytics into the decision-making process at all stages of the life cycle of business projects. The findings of our research validate that the implementation of adaptive management in manufacturing enterprises, coupled with the utilization of cutting-edge digital tools, can significantly enhance operational efficiency. This approach fosters resilience and adaptability in the face of dynamic business environments. The results of a study conducted by Chinese researchers (Ameen, et al., 2024) showed that the combination of AI capabilities and strategic flexibility can significantly improve the new products creativity and the productivity of developing companies' new services with a high level of institutional support. The scientists concluded that company management should promote the creation of an internal environment that simultaneously integrates the capabilities of digital technologies and maintains the strategic flexibility of the enterprise. The adaptive model of management in manufacturing enterprises outlined in our research, involving the integration of digital tools into the business framework, entails a synergistic amalgamation of cutting-edge digital solutions and adaptive management strategies. According to the authors, digital solutions can significantly increase the management efficiency.

The findings of a study conducted by Chinese researchers (Chen, et al., 2022) revealed that organizations can truly reap the technological benefits of digital advancements. This occurs when making strategic decisions in crucial domains such as marketing, product innovation, and customer relationship management. In this light, The Ukrainian and German researchers (Arefiev, et al., 2023) showed that organizing the effective functioning of marketing and logistics activities on the basis of adaptive management approaches in the conditions of digitalization is important. The process under analysis can be systematized in three main directions: i) the establishment of effective processes of financial and production logistics in their close relationship with the issues of promotion and marketing of products; ii) optimization of the internal movement of personnel resources as a component of effective personnel logistics in conjunction with the creation of effective pricing mechanisms formation and marketing of products; iii) implementation of active digitalization of business processes at the enterprise with possible attraction of credit and investment resources. Wahab, M.D.A. and Radmehr, M. (2024) concluded that Artificial Intelligence (AI) and other cutting-edge technologies are emerging as primary drivers for enhancing productivity. The above phenomenon stems from their capacity to revolutionize virtually all facets of operations within and beyond organizations. Integrating externally acquired knowledge into existing procedures and expertise allows achieving maximum efficiency in the implementation of new resource configurations, taking advantage of market opportunities. This can allow a firm to create services and products that fit the ever-changing business environment, thereby contributing to its productivity. The results of our study showed that the implementation of an adaptive management approach combined with the integration of digital tools can positively influence the achievement of key performance indicators, in particular: strategic, operational, financial, production, marketing, HR.

The adaptive management model presented in the study can serve as a basis for the development of adaptive sustainability strategies by manufacturing companies, taking into account the dynamic conditions of the business segment. The procedure of business analytics described in the study for making managerial decisions in the enterprise's adaptive management system will benefit in making flexible management decisions. Following the mechanism of implementing an adaptive management approach can shape management design optimal trajectories of stable development aimed at achieving the high level of company's flexibility and competitiveness.

4.1. Limitations

The overriding limitation of the study is its theoretical and descriptive nature. The assessment of the feasibility in terms of introducing adaptive approaches to managing the manufacturing enterprises activities as well as the effectiveness of their implementation draws upon the results of the respondents survey only. Research requires the application of more thorough quantitative and qualitative analytical methods.

Conclusions

Implementing adaptive management strategies and experimenting with new business models are key factors for success in a rapidly changing external environment. The results of the conducted training experiment, in which the industrial enterprises managers' participated, confirmed the expediency of introducing the adaptive management approach. The results of the experiment demonstrated that the implementation of enterprises' adaptive management strategy in combination with digital tools contributes to enhancing business efficiency. In particular, it ensures its flexibility and stability in the face of change. Within the framework of training and consulting, company executives were able to develop their own adaptive strategies for the company's development, taking into account the business segment's dynamic conditions. The introduction of a scientifically based approach to the organization and management of the interaction of internal and external factors of the business environment allowed managers outlining competitive advantages as well as elaborating competitive directions of companies' development. The proficiency in systems analytics empowered managers to adopt a holistic approach to the governance of the organization, considering the ramifications of managerial decisions on all facets of its operations.

The outcomes of the assessment regarding the efficacy of incorporating the adaptive approach in corporate management revealed that its integration led to a substantial enhancement in key performance indicators. Financial indicators of efficiency increased by 17.4%, efficiency of production process - by 13.5%, efficiency of sales activity of the enterprise - by 12.8%, and efficiency of labor management - by 9.7%. The price observation of the activities of companies that implemented the principles of adaptive management became the basis for the development of a model of adaptive management system of manufacturing enterprises.

The novelty of the research lies in the development of a model of an adaptive management system for manufacturing enterprises, which combines digital tools with the concept of sustainable development. Developing a personalized model of an adaptive management system is extremely important for modern companies, as it allows for prompt response to external challenges, ensuring flexibility in decision-making. This increases the company's ability to quickly adapt to market changes, which in turn helps strengthen its sustainability and long-term competitiveness.

Prospects for further research are to develop a mechanism for introducing into the system of manufacturing enterprise's adaptive management intelligent performance indicators based on AI technologies. The authors intend to formulate a consistent methodology for making management decisions based on key performance indicators, which will contribute to enhancing enterprises' competitiveness and sustainability.

Credit Authorship Contribution Statement

Nataliia Hurzhyi: Methodology, Providing the Survey, Formal Analysis.
Igor Rozovyk: Methodology, Providing Survey, Data Curation.
Tetiana Kharchenko: Validation, Formal Analysis, Writing.
Serhii Kobets: Writing and Editing, Visualization.
Veronika Komandrovska: Conceptualization, Project administration, Writing and Supervision.

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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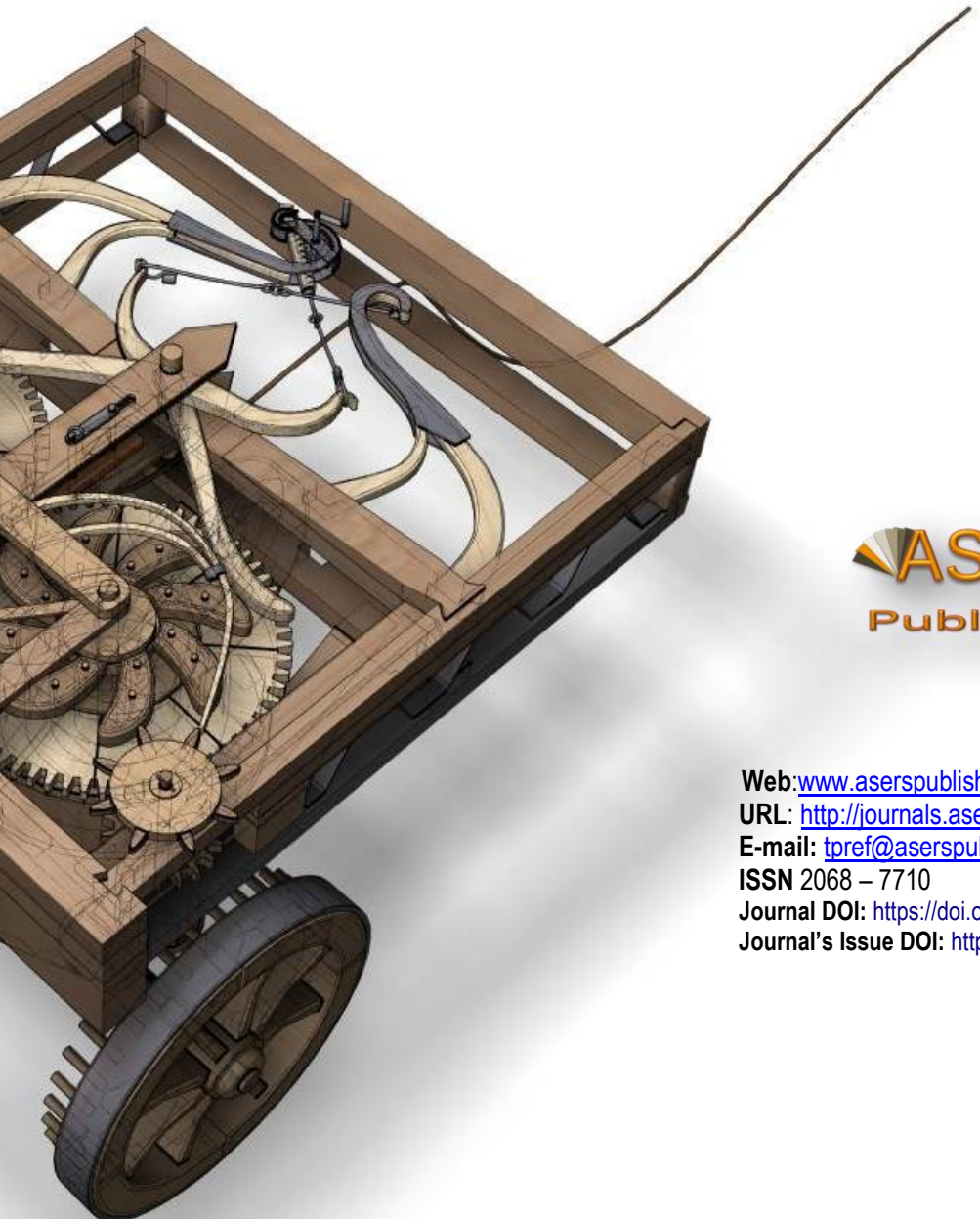

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