

From Capital Deepening to Productivity-Driven Growth: Reassessing the Quality - Quantity Debate in Indonesia



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Abstract: This research examines whether economic growth is mainly caused by an increase in the amount of capital that is accumulated versus an increase in the quality of the capital that is used in the context of the long-term development of Indonesia. In this study, the ARDL model was used to analyse the differences between the effects of capital quantity, proxied by gross fixed capital formation and capital quality, proxied by total factor productivity (TFP), using time series data spanning the years 1967 to 2023. Labor is used as a control variable. The long-run equilibrium relationship between the variables has been established and is confirmed by the results. In the short run, the accumulation of physical capital has a significant effect on economic growth; however, in the long run, there is no statistically significant effect. In the long run, growth in TFP has a robust positive impact. While 19% of the short-run disequilibrium is corrected by the error correction term annually, indicating a stable adjustment mechanism. The results of this research indicate that the growth sustainability of Indonesia is highly dependent on an improvement in the productivity performance as opposed to the volume of the investment that is made. The results also indicate that productivity improvement is the most important factor, while the effect of capital deepening is reduced, and the productivity growth is sustained, thus the economic growth is sustained. This study aids the growth literature and Indonesia's structural transformation challenges by empirically disentangling capital quantity from capital quality. Under the Indonesia Emas 2045 vision, the most important prerequisite for attaining high-income status is the transition to a productivity-driven growth regime.

Keywords: economic growth; capital accumulation; total factor productivity; structural transformation; middle-income trap; indonesia; ARDL Model.

JEL Classification: O40; O47; O11; E22; E13.

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Introduction

Recent literature on economic growth continues to focus on capital, usually measured by Gross Fixed Capital Formation or capital stock (Cervellati *et al.* 2023; Corrado *et al.* 2022). In this line of thinking, greater investment in physical capital leads to higher economic growth through capital deepening (Ghouma *et al.* 2024). An increase in physical capital raises production capacity, boosts labor productivity, and raises total output, thereby driving the economy as a whole. Therefore, many developing countries centre their macroeconomic and development policy frameworks on expanding investment (Miar, 2025).

Nevertheless, this view of the long-term relationship between capital accumulation and economic growth appears to be an oversimplification of reality (Khellat *et al.* 2023). Countries with similar capital stocks exhibit different rates of growth, productivity, and income convergence. An increasing capital stock does not guarantee economic growth (Felipe & McCombie, 2020). In some instances, a spectacular rise in capital formation occurred

with little or no increase in productivity. This suggests that without sufficient technological improvement, quality institutions, and proper resource distribution, capital deepening may lead to diminishing returns and, therefore, to lower economic growth (Liu *et al.* 2023).

The final economic worth of a form of capital is its utility and value from an output standpoint (Dykas *et al.* 2022). For capital-to-output value to be at its optimum, a combination of value-enhancing changes, such as technological advancement and innovation, improvements in managerial and institutional structures, improvements in systems for value-enhancing productive capital, and the creation of productive value ecosystems, is needed at all levels of a system. A qualitative element in empirical growth studies is best expressed as a function of Total Factor Productivity (TFP) (Haider *et al.* 2021). TFP is the ratio of value attributed to output growth to value attributed to input growth. TFP is an indicator of the production system and the technological improvement therein (Šlander Wostner *et al.* 2023).

The economic development system of an economy, especially one in a state of structural transformation, relies heavily on capital accumulation and improvements in the system's productivity (Schlogl & Sumner, 2020). In such systems, for economic development to be sustainable and to accelerate beyond a gradual pace, further development of productivity systems, improved technological systems, and improved institutional systems is essential. This is why it is of utmost importance to determine whether structural economic development results from increased capital systems or from improved economic value productivity systems (Salimova *et al.* 2021).

The relevance of this issue is particularly notable in this study's focus region, Indonesia. It has been 20 years since Indonesia's substantial accumulation of capital and the subsequent rise in investment, driven by the country's macroeconomic stability, infrastructure improvements, and structural reforms (Agusalim *et al.* 2022). Most remarkable is the stability of the country's economic growth and the consistent evolution of its economic structure. The country's resilience is evident in its recovery from crisis, its decentralised reforms, and its overall integration into the global market.

Despite these remarkable improvements, Indonesia is in the middle of an economic reform and is encountering barriers to progress out of what is known as the middle-income trap (Kapotwe, 2021). For Indonesia to move from being classified as a middle-income economy to being classified as a high-income economy, its economic growth will need to shift from being sustained by the accumulation of factors to being sustained by increases in productivity. Empirical evidence derived from the experiences of other nations classified as middle-income economies suggests that, to improve economically, the country will need to rely on a combination of improvements in labor, capital, and advanced technology to avoid diminishing economic returns (Furuoka *et al.* 2024; Kapotwe, 2021).

In Indonesia, the rising level of investment has not translated into productivity increases proportional to that investment (Salawali *et al.* 2025). Investment in capital formation increases production capacity; however, the extent of improvement in Total Factor Productivity (TFP) questions the pace of investment. Indonesia's growth can be described as the accumulation of capital inputs or as an improvement in the productivity growth structure (Agusalim *et al.* 2022).

Sustaining long-run economic growth depends on the answers to the questions above. If accumulation is the main driver of economic growth, growth would be expected to slow as returns deteriorate. However, if the growth structure is underpinned by productivity improvements, the growth pathway would be expected to be solid for Indonesia on the journey to becoming a high-income nation.

This is a critical issue for policy formation in developing economies, particularly Indonesia. Most research on developing economies focuses on capital volume (Agbolosoo *et al.* 2025; Agusalim *et al.* 2022; Dolgunova, 2023). However, the underexplored dimensions, proxied by a long history of TFP measurement, have been neglected over time in developing economies. The scarcity of research on developing economies has led to a large amount of short-run analysis, panel data, and data from several dozen countries, which have helped clarify the structural elements of the economy. These approaches are unlikely to capture the long-run growth of a single economy or of developing economies. The long-run focus on TFP growth has not been captured by research in developing economies, leading to a lack of conduits that reflect the long accumulation of productivity in developing economies.

An extended longitudinal approach is critical for Indonesia, which has undergone several decades of extensive structural reform, crisis adaptation, decentralisation, and industrial transformation. An evaluation of several decades of reform, along with structural change, technological diffusion, and productivity growth, provides a clearer perspective. Analysis of the relationship between the amount and quality of capital over a long period is critical to understanding the more structural aspects of Indonesia's growth.

This work is the first attempt to address the literature on economic growth in Indonesia by considering both the quantity and quality of capital, expressed as Total Factor Productivity (TFP), within a single, unified ARDL-ECM framework that spans 56 continuous years (1967–2023). This design departs from three common limitations in the existing Indonesia-focused literature: studies that rely on cross-country panels in which country-specific dynamics are averaged away, studies that treat TFP purely as a residual rather than as an explicit long-run determinant estimated jointly with capital and labor, and studies confined to shorter post-crisis or post-decentralisation sub-periods that cannot speak to structural change across the full span of Indonesia's development trajectory. Unlike other studies that treat technological change as a residual adjustment variable, this work estimates the long-run elasticity of TFP with respect to capital. Using a long time series, this work attempts to assess whether Indonesia's economic growth is driven by accumulation or productivity.

Most critically, this study offers an empirical recalibration of the capital-led growth hypothesis for Indonesia. It assesses the relative scale of productivity improvement vis-à-vis the sustained growth that capital deepening has supported over the decades. By applying growth theory and a specific dynamic econometric model tailored to Indonesia's structural circumstances, this study empirically answers whether Indonesia's middle-income trap can be overcome by simply increasing investment volume or whether an investment reorientation toward productivity is warranted.

1. Literature Review

This study draws on both classical and neoclassical theories of economic growth and capital's role in long-term economic performance. The classical tradition holds that economic growth is driven primarily by capital accumulation. In this view, investment increases productive capacity and drives output growth. For this study, this is operationalised through GFCF (Gross Fixed Capital Formation), which quantifies capital. By contrast, neoclassical growth theory recognises that capital accumulation has limits and that the real basis of sustained growth is improvements in productivity and technological advancement. In this regard, TFP (Total Factor Productivity) is used to analyse capital qualitatively, reflecting the efficiency and effectiveness with which capital is used to produce output.

1.1. Relation between Quality of Capital and Economic Growth

Numerous studies have documented the positive impact of Total Factor Productivity (TFP) on economic growth across countries and institutional contexts. For example, Le et al. (2024) document TFP's contribution to economic growth in middle-income countries. In these countries, a one-point improvement in TFP is associated with a 16.38 percentage-point increase in economic growth. The study attributes this effect to improvements in labor quality and innovative production methods that enhance productivity. The findings are consistent with growth and industrialisation theories, particularly those that recognise the crucial role of technological advancements and production innovations in sustaining economic growth.

Total factor productivity (TFP) affects economic growth through several channels. Improvements in labor quality, training, and technology transfer boost productivity by improving the efficient use of capital (Le et al. 2024). In addition, Siller et al. (2021) document substantial TFP spillover effects across 190 regions in Europe and argue that the diffusion of knowledge, R&D investment, and regional social culture promote TFP. Wang et al. (2021) also note that technological advancement contributes positively and significantly to improving Green Total Factor Productivity (GTFP) by enhancing productivity while preserving the environment. Collectively, these findings show that TFP operates not only through internal efficiency improvements but also through external knowledge diffusion and transformative innovation.

The impact of Total Factor Productivity (TFP) on economic growth depends on various contextual and institutional factors. Kéïta and Laurila (2021) state that TFP is negatively affected by corruption and excessive taxation, although higher taxation may offset the negative effects of corruption. In the same vein, Tang et al. (2020) show that firm-level TFP growth is stifled by so-called "command-and-control" environmental regulations, especially among small, foreign, and pollution-heavy firms. Moreover, Albanese et al. (2021) find that local TFP does not respond positively to the European Union's development initiatives, except in cases where infrastructure development and regions with stronger institutional frameworks are present. This body of work underscores the importance of institutional frameworks and policy settings for productivity.

2.2. Relation between Quantity of Capital and Economic Growth

Extensive empirical research supports the theory that economic growth is strongly, positively, and consistently associated with capital accumulation. For example, Walheer and Bignandi (2024) examine 92 countries between

1965 and 2019 and report that long-term economic growth is primarily driven by capital accumulation. This finding is also supported by Rahman & Velayutham (2020), who report that in South Asian countries, a 1% increase in gross fixed capital formation raises economic growth by 0.58%. Similarly, Pasara and Garidzirai (2020) analyze the South African economy and find empirical evidence that, in the long run, gross capital formation is positively related to economic growth. These findings reinforce the view that economic expansion is primarily driven by capital accumulation. The strength and nature of the relationship vary by a country's level of development. Topcu et al. (2020) report a positive influence of gross capital formation on growth in high-income economies, but this effect is not comparable in middle- and low-income economies, regardless of the formation. In line with this, Walheer and Bignandi (2024) describe a distinct pattern for developing economies, where a lack of capital creates a greater need for capital formation and accumulation to promote further growth, whereas in more developed economies, growth is stagnated because they operate below full capacity and can be more productive through better, more efficient use of the available stock of capital rather than acquiring more.

Economic growth is influenced not only by the total amount of capital available but also by the quality of capital. Mengesha & Singh (2023) demonstrate that the accumulation of physical capital promotes economic growth in Ethiopia and that the accumulation of what they call human capital, which is operationalized as secondary and tertiary education along with life expectancy, also positively and statistically significantly impacts economic growth. Additionally, Rapetti (2020) explains that a competitive exchange rate can promote capital accumulation within modern tradable sectors, which in turn supports structural change and sustained economic growth. The body of empirical literature on capital accumulation and economic growth is extensive. However, the most appropriate growth strategy is contingent on the level of economic development. Developing countries require greater investment, while advanced economies derive growth from better utilization of available capital.

The literature documents in detail how capital accumulation and productivity improvements drive economic growth. Research on capital formation consistently finds a positive relationship with output growth, especially in developing economies where the availability of capital limits production. Simultaneously, an emerging body of research underscores the critical importance of Total Factor Productivity (TFP) in the long run. The growth literature attributes TFP to efficiency, technological improvement, and improvements in the quality of institutions. Taken together, the literature demonstrates that sustained economic growth relates to the amount of capital accumulation and the productivity with which that capital is employed.

Nonetheless, the literature demonstrates a lack of comprehensive analysis of the quantitative and qualitative aspects of capital. Most literature tends to concentrate on either capital accumulation or productivity. This is especially the case for emerging economies undergoing structural changes, where the rate of investment increases without a corresponding rise in productivity growth.

As capital accumulation in Indonesia has increased in recent decades and productivity performance has been variable, it has been pertinent to consider both capital quantity and capital quality. This study engages with both ends of the spectrum of arguments from classical economics regarding capital-led growth and the neoclassical explanations of productivity by attempting to differentiate, in the context of Indonesia's economic growth, the roles of Gross Fixed Capital Formation (GFCF) and Total Factor Productivity (TFP) in the long run. This study attempts to disentangle the economic phenomenon of sustained growth by analyzing it in terms of two possibilities: increased volume of capital or increased efficiency and productivity of capital.

2. Materials and Methods

2.1. Research Design and Empirical Strategy

This research employs a quantitative time-series methodology to assess the significance of capital quantity and quality for Indonesia's long-run economic growth. The empirical structure is based on classical and neoclassical growth frameworks. These frameworks diverge on whether capital accumulation or capital productivity is more important. Classical growth theories argue that increases in a nation's physical capital are the primary source of economic development (Dolgunova, 2023; Kurteš *et al.* 2022; Sun *et al.* 2023), whereas neoclassical theories counter that further capital accumulation yields diminishing returns and that productivity and technological advancement are the dominant factors of growth (Alani *et al.* 2023; Quan & Phuoc, 2021). To balance these theories empirically, the study develops a comprehensive growth equation that captures the long-run equilibrium between the quantity and quality of capital.

2.2. Data Source and Period of Analysis

The analysis spans almost six decades of observations to understand Indonesia's long-run growth dynamics. Longer time horizons provide a more thorough analysis of phenomena such as structural transformations, changes

in policy regimes, and significant economic disruptions, including oil booms, the Asian Financial Crisis of 1997–1998, and the ensuing structural reforms.

Data for this analysis were drawn from internationally established databases in macroeconomic research. To explain the dynamics of economic growth, the study used annual time-series secondary data for both the short run and the long run.

For this study, economic growth was measured by Gross Domestic Product (GDP) data from the World Bank's World Development Indicators (WDI). The World Bank classifies Gross Fixed Capital Formation (GFCF) as a form of capital investment. GFCF measures the total value of all investments in the production of durable goods in the economy, including the construction of new structures, the acquisition of new machinery and equipment, and new systems of or investments in productive infrastructure. In the literature on economic growth, GFCF is consistently regarded as a leading measure of physical capital investment growth.

The quality of capital in this analysis is measured by Total Factor Productivity (TFP) from the Penn World Table (PWT), version 11.0, released in October 2025 by the Groningen Growth and Development Centre, which extends the coverage of the database to 185 countries for the period 1950–2023 and thereby supersedes the earlier PWT 10.01 release that covered only up to 2019. The specific variable employed is *rtfpna* (TFP at constant national prices, 2021 = 1), which is available for Indonesia continuously from 1964 to 2023 and therefore fully spans the 1967–2023 estimation window used in this study without requiring interpolation or imputation of missing observations. The TFP measure reflects the most productive (or least wasteful) use of the various inputs in production to produce the output, and TFP is typically regarded as a measure of the level of technology, the quality of the institution that coordinates the use of production inputs, and the quality of the production inputs. The inclusion of TFP enables the study to distinguish conceptually and empirically between output growth attributable to the growth of the capital stock and output growth attributable to an increase in the productivity of the factors of production.

Later, the World Bank's World Development Indicators (WDI) provide this study with data on the working-age (15–64 years) population, which represents the potential labor supply and demographic factors influencing economic growth.

Table 1. Variable Definitions, Units, and Data Sources

Variable	Definition	Unit	Source	Sample Period
log_gdp	Natural log of real Gross Domestic Product (capital quantity/quality-adjusted output measure)	Constant-price value	World Development Indicators (WDI), World Bank	1967–2023
log_capital	Natural log of Gross Fixed Capital Formation (capital quantity)	Constant-price value	World Development Indicators (WDI), World Bank	1967–2023
log_tfp	Natural log of Total Factor Productivity, <i>rtfpna</i> (capital quality)	Index, 2021 = 1	Penn World Table (PWT) 11.0	1967–2023
log_labor	Natural log of working-age population, 15–64 years (labor, control variable)	Number of persons	World Development Indicators (WDI), World Bank	1967–2023

Note: All series are transformed into natural logarithms prior to estimation.

2.3. Estimation Procedure and Analytical Steps

To ensure econometric robustness and provide a detailed empirical analysis, we have implemented the analysis across a set of organized channels. As the first step, we perform unit root tests, namely the Augmented Dickey-Fuller (ADF) tests, to determine the order of integration (Chowdhury 2024). This step is necessary to select an appropriate cointegration framework and to avoid the spurious regression problem.

The second step is to apply the ARDL bounds testing procedure to examine whether a long-run cointegrating relationship exists among economic growth, the quantity of capital, the quality of capital, and the control variables. If cointegration is confirmed, the long-run coefficients are estimated, and the error correction model (ECM) is then estimated simultaneously to capture short-run dynamics and the speed of adjustment to the long-run equilibrium. The model is evaluated for stability using the CUSUM and CUSUMSQ tests to determine the presence of time-dependent structural instability.

2.4. Model Specification

The empirical model is based on an extended production function framework. Conceptually, aggregate output is assumed to be produced by a combination of physical capital, labor, and total productivity. However, this study does not treat productivity as a residual. Instead, it clearly distinguishes between the quantity and quality of capital and analyzes the contributions to sustained long-run growth.

Beginning with a generalized Cobb–Douglas production function (Felipe & McCombie, 2020):

$$Y_t = A_t K_t^\alpha L_t^\beta \quad (1)$$

Where Y_t denotes output, K_t represents physical capital, L_t denotes labor, and A_t captures total factor productivity. The model is reformulated to explicitly operate the conceptual distinction between capital quantity and capital quality. In this study, capital quantity is proxied by Gross Fixed Capital Formation (GFCF), reflecting the scale of capital accumulation, while capital quality is proxied by Total Factor Productivity (TFP), reflecting efficiency, technological progress, and the effectiveness of capital use.

Additional control variables are included in the empirical specification to avoid omitted variable bias and to maintain theoretical consistency with the Solow growth framework. The inclusion of labor input is justified as a core factor of production, since growth theory identifies labor as a critical factor. If labor is omitted, its effect could be attributed to the capital variables, thereby biasing the estimated elasticities.

The production function can be transformed into a log-linear and estimable form, which gives us:

$$\log_gdp_t = \alpha_0 + \alpha_1 \log_capital_t + \alpha_2 \log_tfp_t + \alpha_3 \log_labor_t + \varepsilon_t \quad (2)$$

where $capital_t$ denotes capital quantity (GFCF), tfp_t denotes capital quality (TFP), and $labor_t$ denotes labor as a control variable. This specification enables the direct estimation of long-run elasticities and facilitates a comparison of the magnitude and statistical significance of α_1 and α_2 . The central analytical objective is to determine whether economic growth in Indonesia is more strongly associated with the expansion of capital volume or with improvements in the productivity and efficiency of capital use.

A methodological clarification is warranted regarding the use of TFP as a proxy for capital quality. The $rtfpna$ series is constructed by the Penn World Table through an independent growth-accounting procedure that is external to, and not re-estimated within, the empirical model of this study; it is therefore not a residual mechanically extracted from equation (2), which mitigates the risk of a purely tautological or mechanically circular relationship between $\log_gdp$ and $\log_tfp$. Nonetheless, because TFP is, by construction, itself derived from output, capital, and labor data, it cannot fully escape the possibility of measurement-driven association and interpretive overlap with the dependent variable. TFP should therefore be understood as an imperfect, composite proxy for capital quality that blends technical efficiency, allocative efficiency, and measurement error, rather than a clean structural measure of technology alone. This limitation is revisited in the concluding section.

3. Research Results

This section details the empirical evidence on the determining factors of Indonesia's long-term economic growth, whether widely accepted economic theories would attribute this to the country's long-term investments in capital or to the country's long-term investments in productivity. The empirical evidence is aimed at testing Indonesia's economy within the Solow growth model framework of 'capital-deepening' or at transitioning the model to a productivity-dominated economy.

In the growth model described by Robert Solow, sustained economic growth is attributed to high levels of capital and financial investment, while advances in technology are treated as an external factor (exogenous) not directly related to growth (Dykas *et al.* 2022). In contrast, advocates of the endogenous growth model, such as Romer (1994) and Lucas (1988), argue that sustained long-term economic growth stems from efficiency improvements, knowledge, and the exploitation of human capital. This divergence in economic theory is particularly evident in Indonesia, which has experienced a 'resource-driven' period of economic growth, followed by a 'state-led' period, an 'Asian financial crisis' requiring structural economic adjustments, and, more recently, attempts to promote a more innovation-based economic growth.

The debate in question requires Indonesia's economic history as a backdrop. During the 1970s oil boom, economic growth was attributed to the formation of natural resource rents. In the era following the 1998 reforms, the economy experienced restructuring and liberalization of the markets. There were also efforts to expand industrial capacity and productivity during the subsequent 2000s. However, the question remains whether

Indonesia's economy has experienced a structural transformation from an accumulation-based economy to one emphasizing productivity, or whether its growth is fueled by deepening capital formation.

The question is addressed in this paper by means of the Autoregressive Distributed Lag (ARDL) model, which is designed to distinguish between the short run and the long run and to examine their respective relationships with economic growth, gross fixed capital formation (the quantity of capital), total factor productivity (the quality of capital), and the working-age population. Given its ability to estimate long-run elasticities in the presence of mixed integration among the variables, the ARDL framework treats the relationships as a single reduced form.

The empirical strategy comprises several stages. In the first stage, the order of integration is established through unit root testing. In the second stage, the optimal lag length is selected using information criteria. In the third stage, bounds testing is carried out to determine the presence of cointegration. Once a long-run relationship is established, the long-run coefficients are estimated to assess the relative size and significance of the quantity of capital versus the quality of capital. The linked Error Correction Model (ECM) then captures short-run dynamics and the speed of convergence towards equilibrium. Finally, to demonstrate the empirical strategy's reliability within Indonesia's extensive and structurally varying economic framework, the long-term diagnostics and stability tests are presented.

This structure allows the section to report statistical results while also assessing whether Indonesia's growth aligns more with capital accumulation theory or productivity-driven growth theory, a question with important implications for long-term development strategies and policy priorities.

3.1. Stationarity Test

Before estimating the ARDL model, it's essential to examine the stochastic properties of the variables to ensure none are integrated of order two, $I(2)$, because the ARDL bounds testing approach only works when variables are $I(0)$ or $I(1)$ (Georgescu & Kinnunen, 2023). The Augmented Dickey–Fuller (ADF) test was used to check the stationarity of each variable: real GDP ($\log_gdp$), gross fixed capital formation ($\log_capital$), total factor productivity ($\log_tfp$), and labor ($\log_labor$) (Tanaya & Suyanto, 2022).

Table 2. Stationarity Test Using ADF-Test

Variables	Stationarity Degree	t-Statistics	Prob.	Decision
$\log_gdp$	Level	-1.5786	0.4871	Non-Stationer
	1 st Difference	-5.6590	0.0000	Stationer
$\log_capital$	Level	-2.5244	0.1151	Non-Stationer
	1 st Difference	-4.8322	0.0002	Stationer
$\log_tfp$	Level	-1.6191	0.4666	Non-Stationer
	1 st Difference	-6.1554	0.0000	Stationer
$\log_labor$	Level	-12.3124	00000	Stationer

Source: Raw Data Processed Using Eviews 13, 2026

The findings indicate that $\log_gdp$, $\log_capital$, and $\log_tfp$ are non-stationary at level. The respective t-statistics are $\log_gdp$, -1.5786 ($p = 0.4871$), $\log_capital$, -2.5244 ($p = 0.1151$), and $\log_tfp$, -1.6191 ($p = 0.4666$). These t-statistics do not reject the null hypothesis of a unit root at the conventional levels of significance. However, the three variables become stationary after the first difference. The t-statistics after the first difference are $\log_gdp$ at -5.6590 ($p = 0.0000$), $\log_capital$ at -4.8322 ($p = 0.0002$), and $\log_tfp$ at -6.1554 ($p = 0.0000$). These results are significant at the 5 percent level, so the null hypothesis of a unit root is rejected. This means that the variables are integrated of order one, that is, $I(1)$. However, $\log_labor$ is level stationary having a t-statistic of -12.3124 ($p = 0.0000$), which is a very strong rejection of the null hypothesis of a unit root. This means that the labor variable is integrated of order zero, which is $I(0)$.

In summary, the observed results suggest that the variables have been integrated at different orders, including $I(0)$ and $I(1)$ processes. Since none of the variables are integrated of order two, $I(2)$, the Autoregressive Distributed Lag (ARDL) approach is appropriate for estimating the short-run and the long-run relationships of the variables.

3.2. Cointegration Test

Since the unit root test results $\log_gdp$, $\log_capital$, and $\log_tfp$ are integrated of order one ($I(1)$), and $\log_labor$ is integrated of order zero ($I(0)$), the ARDL (Autoregressive Distributed Lag Bounds Testing) approach is used to check for the absence of a long-run relationship among the variables (Pesaran *et al.* 2001; Pesaran & Shin, 1996).

The empirical results show an F-statistic of 11.5002. Following Pesaran, Shin, and Smith (2001), for $k = 3$ regressors under the restricted-intercept, no-trend specification, the computed F-statistic exceeds the upper bound $I(1)$ critical value at the 1% significance level [exact critical value bounds from Pesaran *et al.* (2001), Table CI, Case II, to be verified and inserted by the authors against the original source table]. This value is much higher than the upper bound critical value for a 1% significance level. This means the null hypothesis stating the variables are not cointegrated can be rejected. A stable long-run equilibrium relationship is established between economic growth ($\log_gdp$), quantity of capital ($\log_capital$), quality of capital ($\log_tfp$), and labor ($\log_labor$). To further support the validity of the estimated ARDL-ECM model, diagnostic tests for serial correlation (Breusch-Godfrey LM test), heteroskedasticity (Breusch-Pagan-Godfrey or ARCH test), and residual normality (Jarque-Bera test) should be reported alongside the CUSUM and CUSUMSQ stability tests already discussed in Section 4.4; the corresponding test statistics and p-values [to be inserted by the authors from the underlying Eviews output] would further strengthen confidence in the model's specification. A robustness check using an alternative TFP proxy (*e.g.*, $ctfp$) or an alternative lag structure is also recommended as a supplementary analysis.

The short-run deviations are temporary, and the variables are expected to behave more consistently as time progresses. In this case, it makes sense to calculate the long-run coefficients alongside an Error Correction Model (ECM) that captures the long-run elasticities as well as short-run adjustments.

3.3. Long-Run Estimation

The long-run coefficients derived from the Conditional Error Correction (CEC) regression provide important insights into the structural determinants of economic growth.

Table . Conditional Error Correction (CEC)

Variable	Coefficients	t-Statistics	Prob.
$\log_capital (-1)$	0.1386	0.9051	0.3695
$\log_tfp (-1)$	1.0022	3.5624	0.0008
$\log_labor (-1)$	2.0914	3.4839	0.0010

Source: Raw Data Processed Using Eviews 13, 2026

The estimation results reveal that there is a positive, yet statistically insignificant, long-run impact of the quantity of capital ($\log_capital$) on economic growth. This is evident from the estimated coefficient of 0.1386 ($p = 0.3695$), which shows a long-run 0.14% increase in GDP for every 1% increase in gross fixed capital formation, which is not statistically significant at conventional levels. This shows that an expansion of only physical capital does not create sustained long-term growth.

On the other hand, the quality of capital ($\log_tfp$) has a statistically significant and strong positive long-run impact on economic growth. The estimated elasticity of 1.0023 ($p = 0.0008$) shows that a 1% increase in total factor productivity results in an increase of approximately 1% in GDP in the long run. This result shows that in order to achieve sustained economic growth, there must be improvements in productivity, which includes the positive impact of technological improvements, increased efficiency, and better distribution and allocation of resources.

In addition, labour ($\log_labor$) also has a positive impact on economic growth, which is statistically significant and has a long-run impact with a coefficient of 2.0914 ($p = 0.0010$). This shows that labour input has a significant impact and role as a factor of production in the long-run growth process. An increase of 1% in labour results in an increase in GDP of 2.09%. This indicates that the expansion of labour has a positive impact on aggregate output in the long run.

3.4. Short-Run ECM

Following the confirmation of a long-run relationship through the ARDL Bounds test, the short-run dynamics were estimated using the error correction representation of the selected $ARDL(3,1,1,2)$ model under the restricted constant specification.

The estimated coefficient of the error correction term (COINTEQ) is -0.1887, indicating a 1% level of significance ($p = 0.0000$). The negative coefficient also strengthens the evidence of a long-run equilibrium relationship among the variables. The coefficient suggests that, on average, 18.9% of the deviation from long-run

equilibrium is adjusted within a period. Therefore, a moderate speed of adjustment is suggested, which means that short-run shocks to economic growth are expected to converge to the long-run equilibrium path.

Table 3. Error Correction Model Estimation Results

Variable	Coefficients	t-Statistics	Prob.
COINTEQ	-0.1887	-7.9057	0.0000
D(log_capital)	0.1473	6.5413	0.0000
D(log_tfp)	0.6047	10.5411	0.0000
D(log_labor)	19.2584	6.4464	0.0000
R-square = 0.9121		F-stat = 97.8208 (Prob = 0.0000)	

Source: Raw Data Processed Using Eviews 13, 2026

In the short run, modification of physical capital ($\Delta\log_capital$) positively influences economic growth (coefficient = 0.1473, $p < 0.01$), implying that the enhancement of the physical capital causes a positive expansion of the output in the short run. Alterations in the total factor productivity ($\Delta\log_tfp$) also have a relevant and positively strong influence on the economic growth (coefficient = 0.6047, $p < 0.01$), implying that productivity enhancement leads to improvements in a short span of time. Positive results are also seen in the labour variations. The labour contemporary change ($\Delta\log_labor$) has a positive impact (19.2584, $p < 0.01$) whereas the impact of the labour change in the previous periods was -17.7947 ($p < 0.01$) which is negative and significant, this shows the short-run adjustment impacts of the labour on the output. Out of the lagged dependent variables, the second lag of $\Delta\log_gdp$ is negative and significant, implying that the lagged variables also have short-run adjustment impacts on the output growth.

The model has a strong explanatory power with the adjusted R-squared of 0.9121, which shows that 91% of the economic growth can be explained by the model. The overall F-statistic (97.82, $p < 0.01$) proves the joint significance of the independent variables of the model. The value (2.18) of the Durbin–Watson statistic shows that there is no evidence of serial correlation.

3.5. Stability Test

To further assess the stability of the estimated ARDL-ECM model, both the CUSUM and CUSUM of Squares (CUSUMSQ) tests were performed based on recursive residuals.

Figure 1. CUSUM

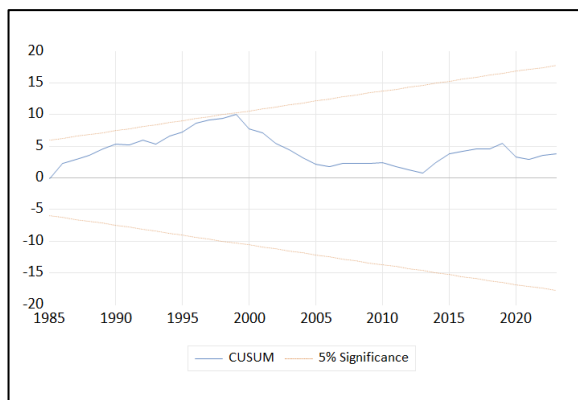
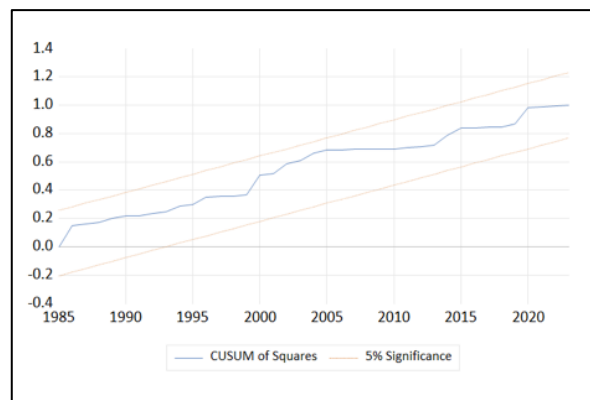


Figure 2. CUSUMQ



The CUSUM plot shows that the cumulative sum of recursive residuals stays within the 5% critical limits throughout the entire sample period. Similarly, the CUSUMSQ plot indicates that the sum of squared recursive residuals does not breach the critical boundaries. Since neither test signals structural instability, we cannot reject the null hypothesis of parameter stability. These findings confirm that the estimated coefficients remain consistent over time and that the model is free from structural breaks during the observed period. The stability in both the mean and variance of the recursive residuals enhances the trustworthiness of the long-term and short-term estimates derived from the ARDL approach.

4. Discussions

The empirical findings provide evidence of the distinctive impact that the quantity of capital and the quality of capital each have on economic growth. When examining long-run estimates, gross fixed capital formation, on average, does not have a statistically significant effect on output, but total factor productivity does. However, in the short run,

both capital accumulation and productivity improvements stimulate output growth. In addition, the error correction term shows the presence of a stable long-run equilibrium, with each period adjusting about 19% of short-run disequilibrium. These results indicate that while the expansion of investments may facilitate economic growth in the short run, ultimately, the improvement of productivity and not just the increase of the capital stock is what is primarily important for sustainable economic growth in the long run.

4.1. Indonesia's Growth Experience: Investment-Led but Productivity-Constrained?

From the late 1960s onwards, during the oil boom, the post-Asian financial crisis recovery, and more recently, the period of infrastructure development, waves of capital accumulation have been observed in Indonesia's economy (Agusalim *et al.* 2022). Each of these eras saw a sharp rise in gross fixed capital formation, which, in several cases, was associated with a temporary acceleration in economic growth. However, in Indonesia, empirical evidence suggests that, in the long run, capital deepening, or the rate of increase of capital relative to the labour force, has no statistically significant impact on economic growth (Abidin *et al.* 2021).

This is particularly important in the context of the middle-income trap. The middle-income trap literature shows that initial economic growth is complemented by factor accumulation, with growth supported by labour and capital (Masatoshi, 2025; Oliveira *et al.* 2025). Over time, however, growth slows despite increases in the number of workers and available capital, and the economy becomes stagnant. In the early phases of development and structural economic change, from subsistence agriculture to productive industrial activities, capital deepening is likely to yield healthy economic returns. The economy, however, will eventually become more sophisticated, and growth will begin to depend primarily on more innovative practices, improvements in the technological framework, and enhanced levels of institutional quality (Law *et al.* 2020).

Indonesia's growth trajectory indicates this pattern. Although investment levels, particularly during infrastructure booms, have risen considerably, productivity has grown at a more consistent, modest pace (Huda & Istiana, 2024). The minimal long-term impact of capital accumulation suggests that further capital investment might no longer be beneficial unless accompanied by improvements in total factor productivity. On the other hand, the strong and significant elasticity of TFP indicates that, in the long run, the sustainability of growth will depend on productivity improvements. This aligns with the structural-change perspective in the middle-income trap literature, where a growth economy is stuck until it radically changes its growth approach (Bacovic, 2021).

This perspective is significant in relation to Indonesia's long-term development plan, 'Visi Indonesia Emas 2045', which aims for Indonesia to become a high-income economy when the country celebrates its 100th year of independence. This will be possible only with sustained, high economic growth over the next 20 years. Findings from the studies indicate that this growth will not be achieved through increased investment or infrastructure spending. The focus will have to be on productivity, through technological improvements, enhancements to human-induced changes, and improvements to the country's institutions, along with a focus on industry (Furuoka *et al.* 2024; Thawley *et al.* 2024).

The data show that Indonesia's long-run growth constraints are not due to insufficient capital accumulation, but rather to investment that cannot be translated into productivity improvements. Without structural changes to improve efficiency and the ability to innovate, the expansion of capital will most likely worsen the problem of a quantity-based growth model, making it difficult for the economy to transition to high-income status (Kamuhuzza & Jianya, 2022).

From a theoretical perspective, this information supports the shift from a Solow-type capital accumulation framework to an endogenous growth theory of capital (Felipe & McCombie, 2020; Jones, 2022). For the purposes of understanding Indonesia's development, the distinction between the quantity and quality of capital is more than an analytical distinction it is a key factor in the strategy for developing the country's economy.

4.2. From Capital Accumulation to Productivity Regime: Structural Transformation and the Rodrik Perspective

The empirical results support a significant shift in the paradigm of economic growth, moving from a Solow-type capital accumulation model to an endogenous productivity growth model. The pronounced long-run inelasticity of physical capital and the high elasticity of total factor productivity suggest that Indonesia is approaching a structural boundary for input-driven growth (Agbolosoo *et al.* 2025).

During the earliest stages of economic development, growth is typically the result of factor mobilisation, or the reallocation of resources and the movement of labour from low-productivity roles to more valuable and productive ones (Thach, 2025). This reallocation is valuable and leads to substantial increases in overall economic output. This is the Solow model in action, and when a society is capital- and resource-poor, deep capital

replenishment and resource reallocation are the single most growth-inducing activities available to that society (Cooper & Schott, 2023). This explains the very rapid growth of an economy when new resources and capital are introduced, as in the example of Indonesia's rapid economic growth during its most capital-accumulative periods, with incremental improvements in economic resources.

At more advanced stages of development, typically in the later stages of middle-income development, increases in capital and resources lead to lower levels of economic productivity enhancement or 'value-adding' activities, except when paired with technological advancements and smaller efficiency gains (Qi & Chu, 2022). This variation of the model explains how Indonesia's economy is at this structural point of the model. Expansion of economic resources and capital will lead to economic growth in the short term, limited by the level of economic resources available, but will not sustain economic growth over the long term when economic productivity is unrevised or 'missed' in the model. This pattern aligns with theoretical expectations that lengthy periods of economic expansion rely more heavily on endogenous factors such as innovation, accumulation of knowledge, upgrading of human capital, and improvement of institutional quality (Hughes & Narayan, 2021; Keshminder *et al.* 2025).

In the long-run estimates, the shift in the growth mechanism is reflected in the dominance of total factor productivity (TFP). Besides technology, productivity is also attributed to improvements in the allocation and management of resources, the upgrading of industries, and structural transformation. TFP, in this regard, reflects the quality of capital rather than its quantity (Šlander Wostner *et al.* 2023). That is particularly true of Indonesia. An economy that relies on growth from the expansion of investment in physical capital, especially in industries with few opportunities for technology transfer, is in danger of entering a capital-deep, productivity-shallow model. Such a model may produce a repetitive cycle of economic growth, but it may not possess the complex structural economic requirements for steady convergence to a high-income economy.

This dominance of productivity over accumulation is directionally consistent with recent evidence from other middle-income economies. Le *et al.* (2024), for instance, report that a one-point improvement in TFP is associated with a 16.38 percentage-point increase in economic growth across middle-income countries, while Keshminder *et al.* (2025) and Thach (2025) similarly emphasize human capital quality and productive reallocation, rather than raw factor accumulation, as the binding constraint on ASEAN growth trajectories. The elasticity estimated for Indonesia in this study (approximately 1.00) is not directly comparable in magnitude to these percentage-point effects, since the underlying model specifications and units differ, but the qualitative conclusion is the same across settings: as middle-income economies approach the limits of factor-driven expansion, the marginal contribution of additional capital volume diminishes relative to the contribution of productivity-enhancing capital use. A more granular, unit-consistent comparison against elasticity estimates from other ASEAN economies (*e.g.*, Vietnam, Malaysia, the Philippines) using comparable ARDL specifications would further sharpen this cross-country positioning and is identified here as a priority for future extensions of this study.

In contrast, a productivity-focused economy will operate under a different set of economic growth mechanisms (Giombini *et al.* 2023; Jones, 2022). Such a system will require investment in improving adaptive and innovative capabilities, technological assimilation, institutional reforms, and the overall innovation of the system (Gao, 2021). This is what the literature describes as an economy that has transitioned from exogenous growth to endogenous growth, with technological progress assimilated as part of the economic system rather than an external factor (Keshminder *et al.* 2025).

Thus, the distinction between quantitative and qualitative capital is not merely a theoretical construct. It illustrates two possible paradigms of growth: one about factor expansion and the other to efficiency and innovation. Empirical observations indicate that Indonesia's aspiration for high-income status, along with the long-term economic transformation, rests upon the successful completion of such structural changes.

Conclusions

Using an ARDL-ECM framework, this study empirically examines the short- and long-term effects of capital quantity and quality on economic growth. The results show that these capital factors can be differentiated. Gross fixed capital formation, for example, has a positive and statistically significant effect on economic growth in the short term; however, long-term effects are not statistically significant. By contrast, the long-term effects of output on total factor productivity are strong, positive and robust. The error correction term indicates a tendency to return to equilibrium, with approximately 19% of short-run disequilibrium adjusted each period.

The results demonstrate that capital accumulation is necessary but not sufficient to sustain long-term economic growth. Investment expansion may boost output growth temporarily, but long-term growth depends on productivity growth, efficiency improvements, and structural changes. The results are in line with the neoclassical

prediction of diminishing returns to physical capital and also support Endogenous growth theory, which emphasises the importance of technological progress and productive capacity in the modern economy.

Based on Indonesia's development trajectory and the evidence presented, the country is approaching the boundary of input-driven growth. Unproductive capital deepening will undermine most growth models that deliver transitional growth without adequate structural support. Therefore, reaching high-income status under the Indonesia Emas 2045 scenario will require moving to a productivity-focused growth regime, underpinned by technological advancement, strengthened institutions, and diversification of economic activities. In more concrete policy terms, this implies a reallocation of the state's investment mix away from an exclusive emphasis on the volume of physical infrastructure and toward complementary investments that raise the productivity of existing capital: vocational and higher-education reform tied to industrial demand, absorption capacity for technology transfer in manufacturing and services, streamlined regulatory and institutional quality to reduce misallocation, and support for firm-level innovation and digital adoption in the small and medium enterprise sector, where a large share of Indonesia's capital stock is deployed. Sectorally, the productivity gap is likely most binding in agriculture and low-end manufacturing, where labor productivity has historically lagged, suggesting that TFP-oriented policy should be sequenced to prioritize these sectors alongside the higher-productivity services and export-oriented manufacturing segments, rather than treating productivity policy as a uniform, economy-wide instrument. This distinction between where capital is added and how effectively it is used is precisely the trade-off Indonesian policymakers face in the run-up to 2045: continued reliance on investment-volume targets versus a deliberate shift of fiscal and regulatory incentives toward productivity-enhancing capital use.

In the context of sustained economic growth, this paper seeks to contribute to the literature by making an empirical case for distinguishing between the quantity and quality of capital, and in the process demonstrates that, when economic growth is sustained, the quality of capital is more important than its quantity. The distinction between the volume of capital amassed and the effectiveness of capital in the long run is a fundamental feature of economic transformation and will prove to be so in the long run.

Further Research

This study is subject to several limitations. First, because TFP is itself derived from a growth-accounting framework that combines output, capital, and labor, its use as an explanatory variable for output growth cannot eliminate concerns about measurement-driven association and interpretive circularity, even though the TFP series is constructed independently of this study's own estimation; readers should therefore interpret the estimated TFP elasticity as reflecting capital quality broadly defined, rather than as a fully exogenous structural technology parameter. Second, the single-country time-series design, while allowing a long and structurally rich sample, limits the extent to which the findings can be generalized to other ASEAN economies without further comparative analysis using harmonized data and specifications. Third, the ARDL-ECM framework, as applied here, does not by itself identify the specific channels, such as sectoral reallocation, institutional quality, or human capital, through which productivity gains are realized; disentangling these channels is a natural direction for future research. Future studies could usefully extend this analysis with a formal endogeneity diagnostic, a multi-country ARDL panel comparison across ASEAN economies, and a decomposition of TFP into its allocative, technical, and institutional components.

Declarations

Credit Authorship Contribution Statement

Bahrul Ulum Rusydi: Conceptualization, Investigation, Supervision, Methodology, Formal analysis, Writing – original draft, Writing – review and editing.

Abdul Hamid Paddu: Formal analysis, Writing – original draft, Supervision, Data curation, Validation, Writing – review and editing.

Sabir: Software, Writing – original draft, Validation, Writing – review and editing, Visualization.

Declaration of Competing Interest: We 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: We declare that we 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) and AI-assisted technologies in the writing process before submission, but only to improve the language and readability of our paper and with the appropriate disclosure.

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