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CAPITAL DYNAMICS AND SUSTAINABLE GROWTH IN SIX ASEAN NATIONS: GMM ESTIMATION IN THE PERSPECTIVE OF SDGS

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Abstract – Sustainable economic development in Southeast Asia remains a central theme in regional policy debates, particularly regarding the efficiency of factor accumulation. This study empirically investigates the dynamic relationship between physical capital, human capital, labor force, and economic growth in six ASEAN countries (Indonesia, Vietnam, the Philippines, Cambodia, Laos, and Myanmar). Using a Two-Step System Generalized Method of Moments (GMM) approach for the period 2017–2023, the study overcomes potential endogeneity issues and captures the path-dependent nature of regional growth. Empirical results demonstrate a high degree of growth persistence, with the lagged GDP coefficient indicating a strong momentum effect. Physical capital is found to be the primary and most significant driver of economic expansion, validating the importance of sustained infrastructure investment. In contrast, human capital and labor force participation do not have a statistically significant impact on GDP, highlighting the profound "education-growth puzzle" and potential skills mismatch in the region. These findings suggest that despite ASEAN's growth being underpinned by a capital-intensive strategy, the region faces structural challenges in transforming human capital expansion into tangible productivity. Policy recommendations emphasize the need for a shift from quantity-based to quality-based education, as well as better alignment between academic curricula and industry demand to ensure inclusive and productivity-based growth in line with SDGs 4, 8, and 9.

Keywords: *Economic Growth, Dynamic Panel GMM, Physical Capital, Human Capital, ASEAN, SDGs*

INTRODUCTION

The trajectory of economic development in Southeast Asia has been the subject of intense academic debate over the past few decades, particularly regarding how developing countries can maintain their sustainable growth amidst uncertain global dynamics. Under the pressure of the complexities of the 21st-century global economy, six countries in the region—Indonesia, Vietnam, the Philippines, Cambodia, Laos, and Myanmar—face enormous challenges in maintaining high economic growth rates while simultaneously undertaking structural transformations of their economic foundations. A fundamental question at the heart of this discourse is what factors are the primary drivers of growth in these countries, known for their high dynamism but still highly vulnerable to external shocks. Differences in institutional maturity and technology absorption capacity across these countries demand a more comprehensive understanding of the internal mechanisms that drive aggregate national productivity through appropriate synchronization of macroeconomic policies (Darku & Yeboah, 2018; Pinjaman et al., 2025). Growth in this region is also inseparable from the stability of governance and the ability to innovate in facing the shifting

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global economic paradigm that increasingly emphasizes aspects of sustainability and environmental quality (Amin et al., 2024).

The foundation of thinking regarding economic growth is traditionally rooted in classical and neoclassical growth theories pioneered by Solow (1956) and Swan (1956), which positioned the accumulation of capital and labor as primary inputs in the national production function. However, developments in economic theory later gave birth to the Endogenous Growth Theory developed by Lucas (1988), which began to shift the primary focus from the mere accumulation of physical factors to the role of human capital and technological innovation as the primary source of long-term prosperity for a nation. In the context of today's knowledge-based economic development, the aspect of productivity is considered far more crucial than the mere accumulation of raw production factors in order to overcome existing growth limitations (Taylor, 2018). In the six ASEAN countries that are the focus of this study, a significant surge in physical infrastructure projects is seen, accompanied by an influx of Foreign Direct Investment. This foreign investment not only serves as a source of new capital but also becomes a potential catalyst for improving the quality of human capital through the process of transferring valuable skills (Nguyen et al., 2020), which in turn will moderate the relationship between investment and the country's export performance in the international market (Nguyen, 2023).

The problem in this research is rooted in the apparent disconnect between the rapid expansion of educational participation on the one hand and the growth of real gross domestic product on the other in several ASEAN countries. This phenomenon, often referred to in the literature as the "education-growth puzzle," demonstrates the reality that simply increasing the quantity of human capital does not guarantee immediate economic dividends for society (Pritchett, 2001). Hanushek and Woessmann (2012) emphasize that educational attainment, measured by cognitive skills, has a very stable and strong relationship with GDP growth, and school policies can be a crucial instrument for spurring such growth by creating a high-performing workforce. In the ASEAN-5 region, research by Maneejuk and Yamaka (2021) demonstrates the nonlinear impact of higher education, where its influence on economic growth doubles when the participation rate exceeds a certain threshold. However, significant challenges arise as educated unemployment rates rise, necessitating appropriate policies to ensure investment in higher education remains key to future growth and sustainability (Maneejuk & Yamaka, 2021). Often, inadequate education quality and a mismatch between graduate skills and industry needs are key obstacles to converting human capital into real output (Liu et al., 2020).

In addition to the human capital dimension, environmental quality and energy use are now integral to the analysis of modern economic growth within the framework of achieving sustainable development targets. A study by Khan, Hou, and Le (2021) confirmed that renewable energy use and sound natural resource management are inversely related to carbon emissions and ecological footprint, while uncontrolled population growth actually contributes to environmental degradation. In the ASEAN region, Tebourbi et al. (2023) found a non-linear relationship between carbon emissions and real GDP, confirming the existence of the Environmental Kuznets Curve, where energy consumption is the primary driver of environmental degradation, but investment in education and FDI can help mitigate these emissions. The demographic transition, characterized by a declining ratio of productive workers to consumers, also threatens long-term economic sustainability if investment in human capital fails to keep pace with the increasingly rapid population aging trend (Ha & Lee, 2018). It is important to realize that macroeconomic data is inherently highly dynamic in nature where the current economic output is a function of institutional stability as well as the capital stock accumulated in the past, so dynamic models are needed to avoid biased estimates (Haseeb et al., 2019).

The main objective of this study is to empirically investigate the dynamic relationship between physical capital, human capital, and economic growth in six ASEAN countries by

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applying the Generalized Method of Moments (GMM) approach developed by Arellano and Bond (1991), Arellano and Bover (1995), and Blundell and Bond (1998). The use of this methodological approach is crucial for capturing both long-term and short-term relationships often found in the interaction of highly complex economic variables, such as the close relationship between economic growth, national energy consumption, and the amount of expenditure in the public health sector (Haseeb et al., 2019). The significance of this study lies in its specific focus on the selected cluster of six ASEAN countries, thus providing a more homogeneous and in-depth analysis compared to previous studies that often mix countries with very contrasting economic structures (Pradhan et al., 2017). By attempting to address the endogeneity issue through the use of appropriate instrumental variables, this study is expected to provide a robust update to the economic literature in the Southeast Asian region and provide solutions to opportunities for transition to clean energy and poverty alleviation (Nassary et al., 2025).

LITERATURE REVIEW

The evolving theoretical landscape of economic growth has shifted from a focus on exogenous factors to a much deeper understanding of the internal drivers of economic systems. Classically, the Neoclassical Growth Model, pioneered by Solow (1956) and Swan (1956), argued that countries would eventually reach a steady state, where long-term growth was driven solely by exogenous technological progress beyond the control of the economic model. Within this framework, physical capital accumulation was assumed to have diminishing marginal returns, thus economic convergence across countries was considered a theoretical certainty where developing countries would catch up with developed countries. However, empirical evidence in the ASEAN region suggests a much more volatile reality; economic growth tends to depend heavily on internal policy choices related to fixed capital formation and macroeconomic stability. In many developing ASEAN countries, economic openness has shown mixed results; while it has accelerated convergence in some regions, its success depends heavily on human capital stocks capable of increasing the absorptive capacity for imported technology (Darku & Yeboah, 2018). Without this absorptive capacity, technology transfer will only be a passive physical investment without having a transformative impact on total factor productivity.

Human Capital Theory, as extensively developed by Becker (1964) and Mincer (1974), posits that investment in education, training, and health constitutes a form of capital accumulation that directly increases labor productivity, which in turn shifts the production function toward greater efficiency. In the ASEAN region, governments have allocated significant budgets to the education sector with the aspiration to replicate the success of the "East Asian Miracle." Contemporary views even expand the role of education beyond simply increasing output; recent findings suggest that human capital not only serves to increase GDP but also plays a crucial role in mitigating environmental risks and transitioning to renewable energy through green technology innovation (Amin et al., 2024; Pinjaman et al., 2025). However, the effectiveness of this human capital depends heavily on synergies with physical capital. As Acemoglu and Restrepo (2018) argue, automation and physical capital accumulation must be accompanied by adaptation of workforce skills to prevent structural disruption. For example, in the agricultural sector, which remains the economic backbone of many ASEAN countries, human capital is a key determinant of total factor productivity growth, helping mitigate declines in technical efficiency due to land constraints and climate change (Liu et al., 2020).

Empirical debates on the drivers of growth continue to yield mixed and often paradoxical conclusions. Some scholars argue that physical capital remains the single most reliable predictor of growth for countries in the early and middle stages of development, where basic infrastructure

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remains a major constraint to economic activity (Pradhan et al., 2017). On the other hand, analyses of the financial viability of human investment note that advanced education, such as postgraduate degrees, often yields higher returns on investment (ROI) and faster recovery periods than basic education in today's knowledge-based economy (Namraksa et al., 2025). This provides theoretical justification for developing advanced human capital in ASEAN to foster innovation that is more competitive in the global marketplace. Furthermore, the transition to sustainable growth models, such as the adoption of clean energy technologies, presents unique opportunities for new job creation and poverty reduction, provided that national institutional frameworks remain consistent and supportive of transparent market mechanisms (Nassary et al., 2025).

Furthermore, the emergence of Endogenous Growth Theory, pioneered by Romer (1986) and Lucas (1988), provides a more dynamic framework by rejecting the law of diminishing returns through the role of knowledge accumulation and the positive externalities of human capital. In the context of the six ASEAN countries studied, this theory implies that growth can be sustained permanently through policies that encourage research, development, and technology diffusion. However, the effectiveness of this human capital is often hampered by structural problems such as skill mismatch and low-quality educational institutions, giving rise to the "education paradox" or "education-growth puzzle." This phenomenon occurs when school enrollment rates increase statistically, but are not followed by a proportional surge in economic productivity due to the low relevance of graduates to the needs of modern industry (Pritchett, 2001). This is particularly relevant for ASEAN, where the expansion of educational quantity has often not been accompanied by improvements in quality essential to drive sustainable economic efficiency.

As the primary conceptual foundation for capturing complex growth dynamics, this study adopts the Path Dependency framework, where historical economic performance is seen as creating institutional and structural momentum that strongly determines the likelihood of future growth. This framework recognizes that economic policies do not operate in a vacuum but are rooted in pre-existing trajectories, where past stability facilitates future stability. This is statistically modeled through the inclusion of lagged dependent variables in the dynamic model, recognizing that economic growth is not a series of isolated events but rather a continuous, interconnected process. By utilizing the Generalized Method of Moments (System-GMM) approach, this study considers the time-varying nature of economic variables and overcomes the endogeneity problem that often plagues conventional growth models. This approach ensures a robust analysis of how the interaction between human and physical capital over the observation period shapes the ASEAN economic landscape holistically, while also evaluating the extent to which past momentum can effectively drive the achievement of Sustainable Development Goals (SDGs) in the future.

The integration between physical capital accumulation and human capital development must also be viewed through the lens of allocative efficiency. In the ASEAN region, investment in physical capital is often driven by foreign direct investment (FDI). The literature shows that the effectiveness of FDI in driving growth depends heavily on the education level of the local workforce; without sufficient human capital, the technology brought by foreign investment will not permeate the local economy through spillover effects. Therefore, synergy between infrastructure investment policies (as reflected in SDG 9) and policies to improve the quality of education (SDG 4) is an absolute prerequisite for inclusive and sustainable growth (SDG 8). By connecting these various theoretical schools, this literature review builds a strong argument that economic growth in ASEAN is the result of a complex interaction between massive physical capital, the quality of human resources, and the growth momentum that has historically built up in the region.

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METHODOLOGY

The following is a combination of the Research Methodology section into a narratively flowing paragraph: This study adopts the framework of the extended neoclassical growth model (Augmented Solow-Swan Model). In accordance with the propositions of Solow (1956) and Swan (1956), the accumulation of physical capital and labor are primary inputs of production, but in line with the endogenous growth theory developed by Romer (1986) and Lucas (1988), this model is extended to include human capital as the main driver of long-term productivity. In this context, the Cobb-Douglas production function is transformed to see how the interaction between physical capital (CAP), human capital (EDU), and labor force (LBR) National Income (GDP).

To provide a clear understanding of the empirical framework, the operational definitions and proxies of the variables used in this study are detailed in Table 1.

Table 1. Operational Definition of Variables

Code	Variable Name	Operational Definition	Scale	Source
GDP	*National Income*	The market value of all final goods and services produced in a country during a given period, serving as a proxy for the size of the economy.	Constant USD	World Bank
CAP	*Physical Capital*	National physical capital accumulation, measured by gross fixed capital formation as a proxy for infrastructure, machinery, and equipment investment.	% of GDP	World Bank
EDU	*Human Capital*	Investment in human capital, measured by mean years of schooling as a proxy for educational attainment.	Years	World Bank
LBR	*Labor Force*	The number of working-age people actively providing labor as a proxy for human resource availability.	Number of Persons	World Bank

*GDP and CAP variables are log-transformed (Ln) during the estimation process to address scale differences.

Given the nature of time dependence (path dependency) in macroeconomic data, where past output influences future production expectations and capacity, this study uses a dynamic panel model specification. This approach is supported by Darku and Yeboah (2018) who stated that including the lag of the dependent variable is crucial to capture growth momentum and avoid specification bias.

While the raw variable GDP strictly represents the National Income of the country, the application of the natural logarithm ($ln\ GDP$) transforms the interpretation of its changes into Economic Growth. Therefore, the dynamic panel model is formulated as follows:

$$ln\ GDP_{it} = \beta_0 + \delta\ ln\ GDP_{it-1} + \beta_1\ ln\ CAP_{it} + \beta_2\ ln\ EDU_{it} + \beta_3\ ln\ LBR_{it} + \eta_i + \nu_t + \epsilon_{\{it\}}$$

In this equation, $lnGDP_{it-1}$ is the lagged dependent variable, while η_i and ν_t represent country-specific effects and time effects, respectively, to control for unobserved heterogeneity. To produce consistent estimates, this study applies the Two-Step System Generalized Method of Moments (GMM) developed by Blundell and Bond (1998). This technique was chosen based on its ability to address systemic endogeneity issues, particularly in physical capital and education variables, which often have a reciprocal relationship with economic growth (Nguyen, 2023). As

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emphasized by Arellano and Bover (1995), System GMM is more efficient than Difference GMM in data with high persistence because it uses additional instruments in the form of levels and differences simultaneously. Finally, the robustness of the model is tested using two standard diagnostic procedures: the Hansen Test of Over-identifying Restrictions to ensure the validity of exogenous instruments, and the Arellano-Bond Test to detect autocorrelation in the residuals. The model is considered eligible if there is autocorrelation in the first order AR(1) but no serial correlation in the second order AR(2) is found, indicating that the model is free from biased residual correlation problems (Darku & Yeboah, 2018).

To address the potential for model misspecification caused by the excessive scale difference between National Income (measured in trillions of USD) and human capital variables, this study transforms GDP and Physical Capital into their natural logarithmic forms. While Table 1 presents the operational definitions based on the raw data metrics for conceptual clarity, the actual estimation utilizes these transformations to ensure that the estimated coefficients can be interpreted as elasticities and to stabilize the variance of the residuals.

RESULT

Estimation Results and Validity Tests

The analysis in this section was conducted using the Two-Step System GMM estimator to address the endogeneity issue often inherent in macroeconomic variables. The use of internal instruments, both in the form of levels and differences, allows for the acquisition of unbiased parameters despite the correlation between the explanatory variables and the residual variables. The complete data processing results are presented in Table 2, which details the coefficients and significance levels of each observed variable.

Table 2. Dynamic GMM Estimation Results (6 ASEAN Countries)

Dependent Variable: GDP				
Method: Panel Generalized Method of Moments				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
GDP(-1)	0.717035	0.051728	13.86176	0.0000
CAP	0.256781	0.032215	7.970976	0.0000
EDU	0.019904	0.103474	0.192361	0.8485
LBR	0.331489	0.396344	0.836367	0.4082
	Effects Specification			
Cross-section fixed (first differences)				
Mean dependent var	0.029799	S.D. dependent var		0.034649
S.E. of regression	0.032169	Sum squared resid		0.039325
J-statistic	3.292096	Instrument rank		6
Prob(J-statistic)	0.192810			

The validity of the above estimation results was verified through two main diagnostic tests. First, the Hansen test was used to test the overall validity of the instrument through over-identifying restrictions. With a J-statistic probability value of 0.1928, this study failed to reject the null hypothesis, indicating that the selected instrument is valid and uncorrelated with the error term. Second, the Arellano-Bond test was used to detect serial correlation in the model.

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Table 3 Arellano-Bond Serial Correlation Test

Arellano-Bond Serial Correlation Test				
Sample: 2015 2023				
Included observations: 42				
Test order	m-Statistic	rho	SE(rho)	Prob.
AR(1)	-2.200132	-0.010760	0.004891	0.0278
AR(2)	-1.690323	-0.007422	0.004391	0.0910

The results of the serial correlation test show a significant $AR(1)$ value of 0.0278 and an insignificant $AR(2)$ value of 0.0910. These results confirm that while first-order autocorrelation exists as a logical consequence of using a dynamic model, there is no second-order autocorrelation. This ensures that the GMM estimator used in this study remains consistent and reliable for further interpretation.

Based on the estimation results in Table 2, the lagged dependent variable, $GDP(-1)$, shows a positive coefficient of 0.717035, which is highly significant at the one percent confidence level. This finding indicates persistent strong economic growth in the six ASEAN countries, where past economic performance is an important determinant of current growth. This aligns with the view of Haseeb et al. (2019), who stated that economic output is a function of past stability and ongoing capital accumulation.

Furthermore, the physical capital (CAP) variable has a coefficient of 0.256781, with a high level of significance. This confirms that physical investment remains the primary driver of economic growth in the region. Conversely, the study's results indicate that the education (EDU) and labor force (LBR) variables do not have a statistically significant effect, with probability values of 0.8485 and 0.4082, respectively. The insignificance of this education variable reinforces the argument regarding the educational growth puzzle, as explained by Pritchett (2001) and Hanushek and Woessmann (2012), where increasing the quantity of education does not necessarily boost GDP unless accompanied by improvements in the quality of cognitive skills relevant to industry needs.

This phenomenon also relates to the findings of Maneejuk and Yamaka (2021) regarding the need to reach a certain threshold in educational quality before it can have a significant impact on the economy. Furthermore, the insignificance of the labor force indicates that growth in these six ASEAN countries tends to be capital-intensive. In the context of environmental sustainability, growth patterns that rely heavily on physical capital and non-renewable energy without optimizing quality human capital risk hindering the achievement of sustainable development targets in the future (Khan et al., 2021; Tebourbi et al., 2023).

DISCUSSION

The estimation results using the Two-Step System Generalized Method of Moments (GMM) method show that the coefficient of the lag GDP variable GDP_{it-1} of 0.717 has very strong statistical significance at the 1% confidence level, which empirically confirms the existence of a massive path dependency phenomenon in the six ASEAN countries. This finding implies that the economic structure in the region has a significant degree of internal persistence and momentum, where economic performance in the current year is a large function of institutional stability and the achievement of capital stocks that have been built in the previous period. From a macroeconomic policy perspective, this high coefficient indicates that the government's success in maintaining stability and growth in the long run will create a multiplier effect that keeps the economic trajectory on track. However, the flip side of this finding provides a warning about systemic risk; if an external economic shock occurs that is not mitigated quickly, the negative

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impact is likely to persist for a longer period of time because the economic characteristics of these six countries have structural rigidities that can shift instantly from their original trajectory after experiencing a contraction. This underscores the importance of policy consistency to ensure uninterrupted growth momentum, as failure in one period will have lasting negative consequences in the future.

The dominance of physical capital as the primary driver of growth in the ASEAN region is strongly validated by the CAP coefficient of 0.256, which is significant at the 1% level. Based on the operational definition in this study, the physical capital variable is a proxy for gross fixed capital accumulation, which includes investment in strategic infrastructure, machinery procurement, and production equipment. This finding strengthens the argument that economic development in the six ASEAN countries studied is currently still in a phase of highly intensive capital accumulation, where large-scale infrastructure projects—such as transportation networks, modern ports, and integrated industrial estates—have proven to yield tangible returns in increasing aggregate output capacity. Theoretically, these results validate the Neoclassical Growth Model framework developed by Solow and Swan, which positions the physical capital stock as the primary engine of production in developing countries. However, the over-reliance on physical capital also reflects that the current ASEAN growth model remains extensive, meaning growth is driven more by increases in the quantity of physical inputs than by improvements in pure technological quality or intensive innovation. Without efforts to improve the overall efficiency of production factors, the region risks facing the challenge of diminishing marginal returns in the future, where the effectiveness of additional physical capital will increasingly decline in driving economic growth.

In stark contrast to the dominant role of physical capital, this study reveals a profound paradox in the human capital (EDU) and employment (LBR) aspects, where neither variable was found to have a statistically significant impact on GDP. Theoretically, referring to Endogenous Growth Theory, an increase in the average years of schooling as a proxy for educational attainment and the number of productive workers should be able to shift the production frontier upward. However, the data demonstrate significant structural obstacles in transforming quantitative human capital expansion into real economic productivity in the region. This situation reinforces the discussion of the "education-growth puzzle" in ASEAN, which is likely triggered by the phenomenon of skills mismatch. Curricula at the secondary and tertiary levels often lag behind in adapting to the needs of the rapidly expanding high-tech industry, resulting in graduates lacking competencies aligned with job market demands. Furthermore, the large proportion of the workforce still concentrated in the low-value-added informal sector means that workers' marginal productivity cannot contribute significantly to aggregate GDP in this estimation model. This suggests that simply increasing the number of workers or years of schooling without improving its quality and relevance will not yield substantial economic dividends for the region.

Holistically, the results of this discussion call for a fundamental reorientation of development strategies to align economic growth with the targets of the 2030 Agenda, or the Sustainable Development Goals (SDGs). While the significance of physical capital validates the successful achievement of infrastructure targets in accordance with SDG 9, the major challenge for policymakers in the ASEAN region lies in shifting the direction of physical investment from conventional to digital and green infrastructure development, which can trigger more inclusive and sustainable growth, in line with the spirit of SDG 8. Furthermore, the findings regarding the insignificance of human capital provide a strong argument that achieving SDG 4 should no longer focus solely on quantitative parameters such as school enrollment rates. Substantial reform of education quality, integrating curricula with global industry competency standards, is essential for investment in people to truly drive innovation and economic efficiency. By making this shift,

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ASEAN countries are expected to transform from an input-driven growth model to an efficiency-driven growth model, ensuring more equitable and sustainable long-term prosperity.

The consistency of these estimation results is further strengthened by the fact that physical capital acts not only as a production input but also as a platform for technology transfer, particularly through massive Foreign Direct Investment (FDI) in countries like Vietnam and Indonesia. However, without the support of quality human capital, the absorption capacity of imported technology will remain limited, which explains why the education variable has not shown significant results. Therefore, synergy between physical and human capital is key to avoiding the middle-income trap that threatens several countries in the region. Policy integration that links infrastructure investment (SDG 9) with improving workforce quality (SDG 4) will create an economic ecosystem that is more resilient to external shocks and able to maintain the positive growth momentum identified in this dynamic model. Finally, an emphasis on sustainable development will ensure that economic growth is measured not only by GDP figures but also by the region's ability to create decent jobs and environmentally friendly technological innovations for future generations.

CONCLUSION

This study concludes that economic growth in six ASEAN countries exhibits a very strong level of persistence, where economic performance in previous periods provides a crucial foundation for achieving current output. Empirical findings obtained through the Two-Step System GMM method confirm that physical capital is the main driver that makes a positive and statistically significant contribution to Gross Domestic Product in the region. This validates the effectiveness of capital accumulation and infrastructure development as growth engines in the short and medium term, which is in line with the neoclassical growth theory framework regarding the importance of fixed capital formation for developing countries.

However, this study reveals a paradox in the human capital and labor force variables, which were found to be statistically insignificant. This condition indicates that quantitative expansion in the education and labor sectors in the six ASEAN countries has not yet been successfully translated into real economic productivity. This phenomenon reinforces the existence of the "education-growth puzzle" in the region, which is most likely caused by a skills mismatch and the low quality and relevance of education to the needs of the industrial labor market. As emphasized in previous literature, simply increasing school enrollment rates without improving cognitive skills will not provide substantial economic dividends (Hanushek & Woessmann, 2012).

The policy implications of these findings emphasize the need for a paradigm shift in development in the ASEAN region, from focusing solely on quantity to strengthening quality. Policymakers are advised not only to pursue growth targets through physical investment but also to prioritize education system reform to align graduates with the demands of modern industry. Furthermore, the integration of human capital and environmental policies is crucial to ensure that economic growth does not come at the expense of future ecological quality. Efforts to promote a clean energy transition and increase technological efficiency must be accompanied by increased workforce capacity to manage these innovations productively. By addressing the endogeneity and dynamic nature of data through a GMM approach, this study makes an important contribution to updating the Southeast Asian economic literature and provides a basis for a more inclusive and sustainable development strategy in line with global long-term development targets.

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RESEARCH LIMITATIONS

While providing in-depth insights, this study has several limitations that should be noted for future studies. First, the human capital variable in this model is represented only by mean years of schooling, which technically fails to capture the full dimensions of education quality, such as PISA scores or the availability of technical competency certification. Second, the study's limited scope to six ASEAN countries may not fully represent the diversity of economic dynamics across the region, especially when compared to ASEAN countries with more advanced economic structures. Furthermore, this model does not include institutional variables or political stability, which theoretically could be strong moderating factors in the relationship between physical capital and economic growth. Finally, limited data availability across several time periods causes this analysis to focus on a relatively short balanced panel sample, so the phenomenon of long-term economic transition may not be comprehensively captured.

RECOMMENDATIONS

Based on the empirical findings, governments in the six ASEAN countries are advised to reorient their economic policies by focusing on strengthening the quality of human capital to support the achievement of SDGs 4 and 8. Investment in the education sector should no longer be solely oriented towards achieving quantitative enrollment rates, but should instead be directed towards linking and matching policies that integrate educational curricula with global industry competency standards. Given the continued dominance of physical capital, future infrastructure investment needs to be specifically targeted at sectors that support innovation, digitalization, and technological efficiency (SDG 9) to reduce dependence on conventional capital inputs. Finally, maintaining consistent macroeconomic stability is an absolute prerequisite; given the region's high path dependency, relevant authorities must ensure that growth momentum is not interrupted, as failure to maintain stability for a single period will have persistent negative impacts on the future economic trajectory.

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