JURNAL ILMU MANAJEMEN (JIM)
Vol 23, No 1, June 2026, Page 016-027
p-ISSN: 1683-7910 | e-ISSN: 2549-0206
DOI : 10.21831/jim.v23i1.96586

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 relationships among physical capital, human capital, the labor force, and economic growth across 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 addresses 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 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 translating human capital expansion into tangible productivity gains. Policy recommendations emphasize the need to shift from quantity-based to quality-based education, as well as to better align academic curricula with industry demand, to ensure inclusive, productivity-based growth in line with SDGs 4, 8, and 9.

Keywords: *ASEAN, dynamic panel GMM, economic growth, human capital, 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 sustain their growth amid 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, which are known for their high dynamism but remain 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 the face of the shifting global economic paradigm, which increasingly emphasizes sustainability and environmental quality (Amin et al., 2024). The foundation of thinking about economic growth is traditionally rooted in classical and neoclassical growth theories, pioneered by Solow (1956) and Swan (1956), which posited capital and labor as primary inputs in the national production function. However, developments in economic theory later gave rise to the Endogenous Growth Theory developed by Lucas (1988),

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which shifted the primary focus from the mere accumulation of physical factors to the roles of human capital and technological innovation as the primary sources of long-term prosperity for a nation. In the context of today's knowledge-based economic development, productivity is considered far more crucial than the mere accumulation of raw production factors 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 that higher education has a nonlinear impact on economic growth, with its influence doubling when the participation rate exceeds a threshold. However, significant challenges arise as the educated unemployment rate rises, necessitating appropriate policies to ensure that investment in higher education remains a key driver of 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 et al. (2021) confirmed that renewable energy use and sound natural resource management are inversely related to carbon emissions and the ecological footprint, whereas uncontrolled population growth 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 Environmental Kuznets Curve, with energy consumption as the primary driver of environmental degradation, while 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 aging of the population (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

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ASEAN countries by 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- and short-term relationships, often found in interactions among highly complex economic variables, such as the close relationship among economic growth, national energy consumption, and public health expenditure (Haseeb et al., 2019). The significance of this study lies in its specific focus on a selected cluster of six ASEAN countries, thereby providing a more homogeneous and in-depth analysis than previous studies that often mix countries with very contrasting economic structures (Zapata et al., 2023). By addressing endogeneity with appropriate instrumental variables, this study is expected to provide a robust update to the economic literature in the Southeast Asian region and offer solutions to opportunities for transitioning 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 in which 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, with developing countries expected to catch up with developed countries. However, empirical evidence from the ASEAN region suggests a much more volatile reality: economic growth tends to depend heavily on internal policy choices regarding 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 that increase absorptive capacity for imported technology (Darku & Yeboah, 2018). Without this absorptive capacity, technology transfer will be only a passive physical investment, without 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, thereby shifting the production function toward greater efficiency. In the ASEAN region, governments have allocated significant budgets to the education sector, aiming 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 increases 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 over the drivers of growth continue to yield mixed, and often

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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 remains a major constraint to economic activity (Zapata et al., 2023). 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 more competitive innovation 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 and development and promote 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, but are not matched by a proportional surge in economic productivity because graduates are not well-suited 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 by including lagged dependent variables in the dynamic model, recognizing that economic growth is not a series of isolated events but a continuous, interconnected process. By employing the Generalized Method of Moments (System-GMM), this study accounts for the time-varying nature of economic variables and addresses 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 as a whole, while also evaluating the extent to which past momentum can effectively drive the achievement of the 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

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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 results from a complex interaction among massive physical capital, the quality of human resources, and the growth momentum that has historically built up in the region.

METHODOLOGY

This study adopts the framework of the extended neoclassical growth model (the 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 examine how the interaction among physical capital (CAP), human capital (EDU), and the labor force (LBR) affects 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 serves 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 is measured by the 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 is a proxy for the availability of human resources.	Number of Persons	World Bank

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

Given the time dependence (path dependence) in macroeconomic data, where past output influences future production expectations and capacity, this study uses a dynamic panel model. 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:

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

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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 for its ability to address endogeneity issues, particularly in physical capital and education variables, which often have a reciprocal relationship with economic growth (Nguyen, 2023). As 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 arising from the large-scale difference between National Income (measured in trillions of USD) and human capital variables, this study transforms GDP and Physical Capital into their natural logarithms. While Table 1 presents the operational definitions based on the raw data metrics for conceptual clarity, the actual estimation uses these transformations to ensure the estimated coefficients can be interpreted as elasticities and to stabilize the residuals' variance.

RESULT

Estimation Results and Validity Tests

The analysis in this section used the Two-Step System GMM estimator to address the endogeneity inherent in macroeconomic variables. The use of internal instruments, in the form of levels and differences, allows the acquisition of unbiased parameters despite the correlation between the explanatory and residual variables. The complete results of data processing are presented in Table 2, which details the coefficients and significance levels for 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 assess the instrument's overall validity

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using 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.

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 high 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 aligns with the findings of Maneejuk and Yamaka (2021) on the need to reach a threshold in educational quality before it can have a significant impact on the economy. Furthermore, the small size of the labor force suggests 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 the development of 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) show that the coefficient on the lag GDP variable, $GDPit-1$, of 0.717 is highly statistically significant at the 1% confidence level, confirming the existence of a strong path dependency phenomenon across the six ASEAN countries. This finding implies that the regional economic structure has significant internal persistence and momentum, in which economic performance in the current year is largely a function of institutional stability and the accumulation of capital stocks built in the previous period. From a

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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 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 any given period will have lasting negative consequences.

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 serves as a proxy for gross fixed capital accumulation, encompassing 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 in a phase of highly intensive capital accumulation, during which large-scale infrastructure projects such as transportation networks, modern ports, and integrated industrial estates have proven to yield tangible returns by increasing aggregate output capacity. Theoretically, these results validate the Neoclassical Growth Model framework developed by Solow and Swan, which posits that physical capital is 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 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) variables, in which neither variable has 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 driven by skills mismatch. Curricula at the secondary and tertiary levels often lag in adapting to the needs of the rapidly expanding high-tech industry, leaving graduates with competencies that are not 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

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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 to investment in people truly driving innovation and economic efficiency. By making this shift, 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 (Tarigan & Larasati, 2025).

The consistency of these estimation results is further strengthened by the fact that physical capital serves not only as a production input but also as a platform for technology transfer, particularly through massive Foreign Direct Investment (FDI) in countries such as Vietnam and Indonesia (Le et al., 2017; Lindblad, 2015). 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 very strong persistence, with economic performance in previous periods providing a crucial foundation for current output. Empirical findings from the Two-Step System GMM method confirm that physical capital is the main driver, making a positive, statistically significant contribution to the region's Gross Domestic Product. This validates the effectiveness of capital accumulation and infrastructure development as growth engines in the short and medium term, consistent with the neoclassical growth theory framework's emphasis on 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

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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 the data using a GMM approach, this study makes an important contribution to the Southeast Asian economic literature and provides a basis for a more inclusive and sustainable development strategy aligned with global long-term development targets.

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 reflect the diversity of economic dynamics across the region, especially compared to those of more advanced ASEAN countries. 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 limits this analysis to a relatively short balanced panel sample, so the phenomenon of long-term economic transition may not be fully captured.

RECOMMENDATIONS

Based on the empirical findings, governments in the six ASEAN countries are advised to reorient their economic policies to strengthen human capital quality and 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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