ERSUD
Economic Resilience and Sustainable Development
ERSUD 3(2): 171-185
ISSN 3047-0064

Institute for Advanced Science, Social and Sustainable Future
MORALITY BEFORE KNOWLEDGE

The influence of the digital economy on growth and its impact on unemployment rates: Indonesia and Thailand

Shedriko[1,*], Heru Subiyantoro[2], Muhammad Rozali[2]
[1] *Department of Informatics Engineering, Faculty of Technology and Computer Science, Universitas Indraprasta PGRI, West Jakarta, Special Capital Region of Jakarta 12530, Indonesia;*
[2] *Graduate School of Economics, Universitas Borobudur, East Jakarta, Special Capital Region of Jakarta 13620, Indonesia.*
*Correspondence: shedriko@gmail.com

Received Date: January 14, 2026 Revised Date: February 27, 2026 Accepted Date: August 10, 2026

ABSTRACT
Background: ASEAN makes a large and important contribution to the world economy. This can be seen from its contribution, which reached US$1.73 trillion to the world economy in 2021. Indonesia is slightly behind Thailand in terms of welfare and growth, but still has great potential to catch up with Thailand. This research aims to prove the model used by Sahoo et al (2021), regarding the digital economy that affects economic growth and its impact on the unemployment rate. **Methods**: This research uses 2 different models in its elaboration, along with 2 different methods in its calculations. For the first model, the calculation is done using the 2SLS (two-stage least squares) method, and the second model uses the OLS (ordinary least squares) method.. **Findings:** EYS (Expected Years of Schooling) indicates that in both countries, the quality of education is still low and there is a skill mismatch for industry needs. However, for Dc*EYS, it actually shows that, especially for Indonesia, education has sufficiently met the standard needs of the industrial world, which can be seen from the significant and positive value. Likewise, for CPI (Consumer Price Index), although it has a significant value, its direction is negative. This indicates that in Indonesia and Thailand, inflation has increased quite high. However, for Dc*CPI, specifically for Indonesia, CPI actually has a significant and positive value, which means that inflation is quite measured and does not even affect people's purchasing power. **Conclusion:** This research proves that the model used by Sahoo et al (2021) is very good at defining the influence of digital economic variables on economic growth in Indonesia and Thailand, both simultaneously and partially. And this has an impact on the unemployment rate in Indonesia and Thailand. **Novelty/Originality of this article:** This study extends the existing digital economy–economic growth framework to Indonesia and Thailand, two emerging ASEAN economies with distinct levels of digital development and economic characteristics.

KEYWORDS: digital; economy; unemployment.

1. Introduction

ASEAN makes a large and important contribution to the world economy. This can be seen from its contribution, which reached US$1.73 trillion to the world economy in 2021. Singapore and Brunei Darussalam still dominate economic growth in the Southeast Asian region in terms of income per capita and structural transformation. Meanwhile, Indonesia, Thailand, and Malaysia are the three countries that follow with relatively close economic performance in terms of aggregate output. However, Malaysia has reached a much better level of welfare and growth compared to Indonesia and Thailand, particularly in terms of

Cite This Article:
Shedriko, Subiyantoro, H., & Rozali, M. (2026). The influence of the digital economy on growth and its impact on unemployment rates: Indonesia and Thailand. *Economic Resilience and Sustainable Development, 3*(2), 171-185. https://doi.org/10.61511/ersud.v3i2.2026.2839

Copyright: © 2026 by the authors. This article is distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (https://creativecommons.org/licenses/by/4.0/).

human development indicators, industrial upgrading, and export diversification. Indonesia is slightly behind Thailand in welfare and growth indicators, but it still has great potential to catch up due to its demographic dividend, large domestic market, and expanding digital ecosystem (Fig. 1). This is in line with research conducted by Sahoo et al (2021) with the research object of 2 countries with rapid economic growth in Asia, namely India and China. This research aims to prove the model used by Sahoo et al (Sahoo et al., 2021), in calculating the influence of the digital economy on growth and its impact on the unemployment rate.

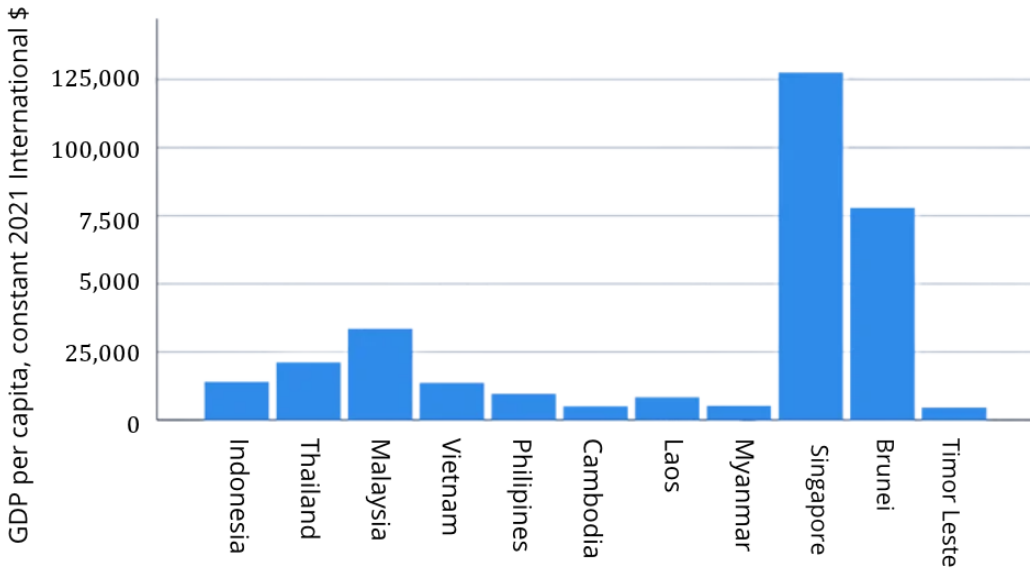


Fig. 1. Per capita gross domestic product from ASEAN with Indonesia and Thailand position (World Bank, 2023)

Historically, the economic transformation of Indonesia and Thailand has followed a similar pattern, beginning with agriculture-based economies in the 1970s–1980s, moving toward manufacturing-led industrialization in the 1990s, and gradually transitioning into service- and technology-oriented economies in the 2000s. In Thailand, export-oriented industrialization—especially in automotive and electronics manufacturing—played a crucial role in boosting GDP (Gross Domestic Product) growth. Indonesia, on the other hand, relied heavily on natural resources and commodities such as oil, gas, coal, and palm oil. The Asian Financial Crisis of 1997–1998 marked a turning point for both countries, leading to structural reforms, financial sector restructuring, and greater openness to foreign direct investment.

Entering the 2000s, both countries began to experience rapid digital transformation. The diffusion of the internet, mobile telecommunications, and digital infrastructure significantly changed economic interactions. Thailand implemented the "Thailand 4.0" strategy to promote innovation, high technology, and digital industries. Indonesia launched initiatives such as the "Making Indonesia 4.0" roadmap and accelerated digital connectivity through broadband expansion and mobile penetration. The rise of digital platforms, e-commerce, fintech, and ride-hailing services reshaped labor markets and business models. Digitalization improved productivity, reduced transaction costs, and increased market access, especially for small and medium enterprises (SMEs).

This development aligns with research conducted by Sahoo et al. (2021), which examined two rapidly growing Asian economies, India and China. Their model analyzed how the digital economy influences economic growth and how growth subsequently affects unemployment. Inspired by this framework, the present research aims to test a similar model in the context of Indonesia and Thailand. This research uses two structural models: the influence of variable X on variable Y, and the influence of variable Y on variable Z (Figure 2).

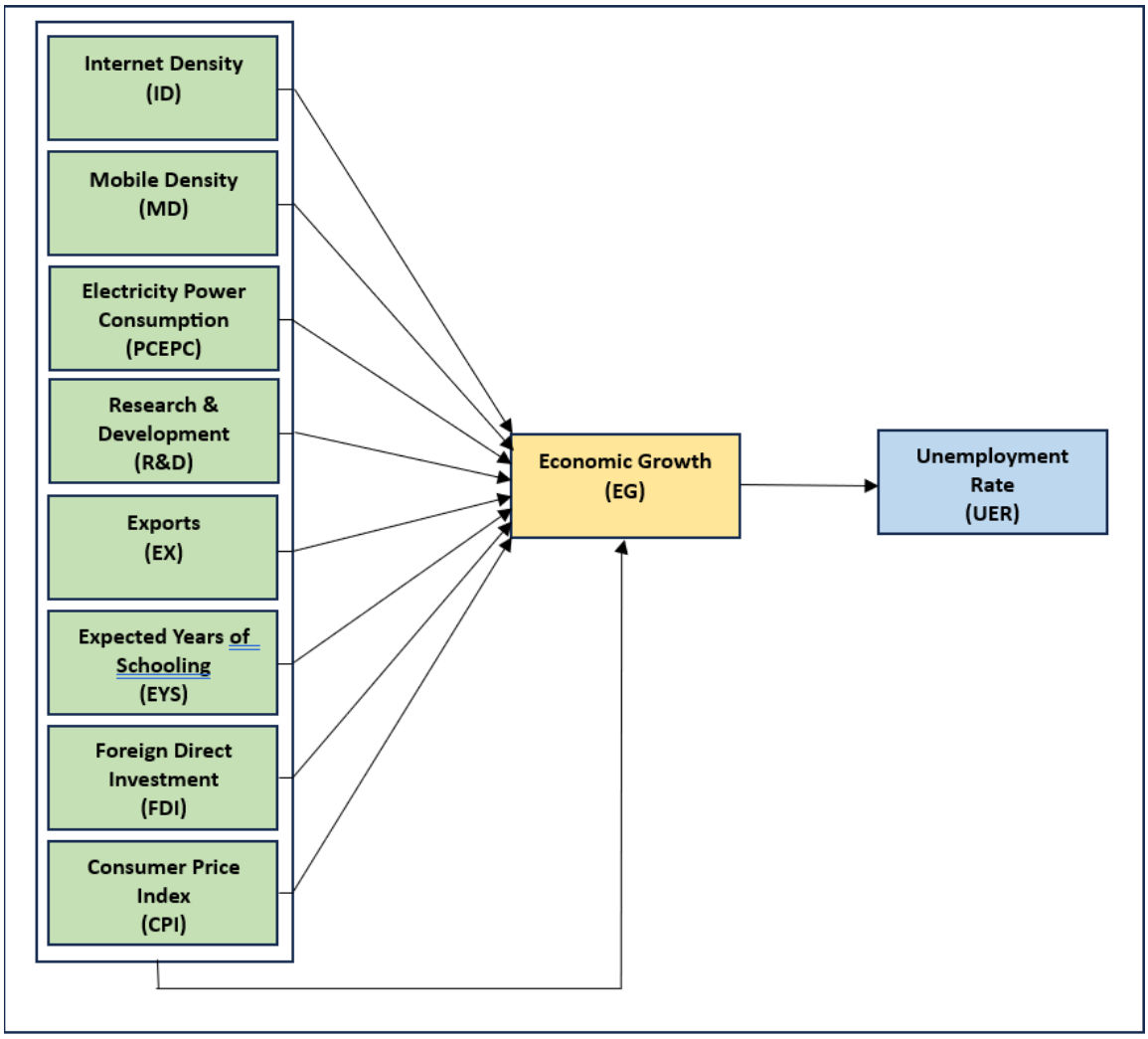


Fig. 2. Conceptual framework

In this framework, the digital economy, defined as the integration of digitalization and economic performance, represents variable X. It consists of eight indicators. First, Internet Density (ID), measured as the number of wired internet subscribers per 100 people, captures the depth of digital connectivity (Rumbia et al., 2022; Abdulqadir & Asongu, 2022; Rosnawintang et al., 2021; Maurseth, 2018; Ding & Huang, 2021). Higher internet penetration facilitates information flows, enhances business efficiency, and supports digital entrepreneurship. Second, Mobile Density (MD), measured as the number of mobile phone subscribers per 100 people, reflects the accessibility of communication technology and digital services. In developing countries, mobile technology often becomes the primary gateway to the digital economy (Phale et al., 2021; Duong, 2023; Saidi & Mongi, 2018; Kumar et al., 2016; Thoyibah & Sugiharti, 2022).

Third, Per Capita Electricity Power Consumption (PCEPC) reflects infrastructure readiness and industrial capacity. Electricity consumption per capita is closely related to technological adoption and productive activity (Zhang et al., 2017; Phadkantha & Yamaka, 2022; Güler et al., 2022; Kantar et al., 2016; Raza et al., 2016). Fourth, Research and Development (R&D) expenditure represents innovation capacity and technological upgrading. R&D enhances long-term competitiveness and supports structural transformation from low-value-added to high-value-added industries (Boeing et al., 2022; Badri et al., 2019; Nomaler et al., 2021; Hong, 2017; Choi & Yi, 2018).

Fifth, Export (EX) performance indicates international competitiveness and integration into global value chains. Export diversification and technological sophistication are essential for sustainable growth (Sunde et al., 2023; Sultanuzzaman et al., 2019; Zhu et al.,

2022; Sultanuzzaman et al., 2018; Khan & Khan, 2021). Sixth, Expected Years of Schooling (EYS) measures human capital accumulation and educational attainment, which are critical in adapting to technological change (Fadli et al., 2019; Wulandari et al., 2019; Agusalim et al., 2022; Singh et al., 2024; Metzger & Shenai, 2021). Seventh, Foreign Direct Investment (FDI) captures external capital inflows, technology transfer, and managerial expertise. FDI can stimulate growth through spillover effects and productivity gains (Fazaalloh, 2024; Ullah et al., 2023; Rao et al., 2023; Muhammad & Khan, 2019; Miao et al., 2021). Finally, the Consumer Price Index (CPI) reflects macroeconomic stability, particularly inflation dynamics, which influence investment decisions and purchasing power (Didya, 2024; Muye & Hassan, 2016; Lu et al., 2023; Boujelbene, 2021; Kunwar et al., 2023).

These eight X variables are hypothesized to influence variable Y, namely economic growth measured by Per Capita Gross Domestic Product (PCGDP), both simultaneously and partially. Digital connectivity, infrastructure readiness, innovation, trade openness, human capital, foreign investment, and price stability jointly determine the trajectory of per capita income growth. In turn, PCGDP affects variable Z, namely the unemployment rate (UER). According to classical and neoclassical growth theories, higher economic growth should generate job creation, reduce unemployment, and improve welfare. However, empirical evidence often shows mixed results, particularly in developing countries (Tumanoska, 2020; Septrila & Kurniasih, 2022; Papik et al., 2022; Masserini et al., 2024; Mehmetaj & Xhindi, 2022).

This leads to the central research problem: why has economic growth not always resulted in a significant reduction in unemployment despite rapid digital advancements? In Indonesia and Thailand, GDP growth has been relatively stable over the past two decades, yet unemployment reduction has been uneven and sometimes stagnant. Several structural factors may explain this phenomenon. First, digital transformation may generate skill-biased technological change. Digitalization increases demand for high-skilled labor while reducing demand for routine and low-skilled jobs. If the education system fails to provide adequate digital and technical skills, a skill mismatch emerges. As a result, economic growth driven by technology does not automatically absorb low-skilled workers, leading to structural unemployment.

Second, the digital economy may create more informal or gig-based employment rather than stable formal jobs. In Indonesia, the expansion of platform-based services has increased labor participation but often in precarious forms of employment without long-term security. While these activities contribute to GDP, they may not significantly reduce open unemployment or underemployment. Third, automation and efficiency gains may lead to labor-saving production processes. In Thailand's manufacturing sector, increased adoption of robotics and automation enhances productivity but reduces labor intensity. Consequently, growth becomes less employment-intensive (jobless growth). This structural shift weakens the traditional relationship predicted by Okun's Law between GDP growth and unemployment reduction.

Fourth, regional disparities also play a role. Digital infrastructure and economic opportunities are often concentrated in urban centers such as Jakarta and Bangkok. Rural and peripheral regions may not fully benefit from digital expansion, resulting in unequal job creation. Growth at the national level may mask localized unemployment challenges. Fifth, the absorptive capacity of FDI and technological spillovers varies between countries. Without sufficient institutional quality, governance effectiveness, and human capital, digital investments may not translate into broad-based employment gains. Similarly, inflation dynamics (CPI) can influence real wages and purchasing power, affecting labor market adjustments in a non-linear manner.

The research gaps addressed in this study further strengthen the analysis. For Internet Density (ID), the integration of institutional quality, digital inclusion, and productivity remains underexplored. For Mobile Density (MD), issues of data utilization and market saturation effects require deeper examination. PCEPC may have heterogeneous impacts across countries depending on industrial structure. The effectiveness of R&D in developing economies depends on innovation ecosystems and collaboration networks. Export

performance must consider commodity dependence and diversification levels. Expected Years of Schooling (EYS) must be evaluated alongside education quality and skill relevance. FDI effects depend on absorptive capacity and technology spillovers. CPI may exhibit a non-linear relationship with growth, complicating macroeconomic policy implications.

Digital Resilience refers to a country's ability to adapt, recover, and transform in response to digital disruption while maintaining economic stability, employment absorption, and social inclusion. It goes beyond digital adoption; it includes institutional readiness, workforce adaptability, regulatory flexibility, cybersecurity capacity, and inclusive access to digital infrastructure. In the ASEAN context, digital resilience determines whether technological advancement leads to inclusive growth or deepens inequality. Singapore represents one of the strongest examples of digital resilience in ASEAN. Through initiatives such as SkillsFuture and Smart Nation, Singapore invested heavily in digital skills upgrading, lifelong learning, and innovation ecosystems. Rather than allowing automation to displace workers permanently, the government emphasized reskilling programs in data analytics, artificial intelligence, and cybersecurity. Strong institutional coordination ensured that digital transformation aligned with labor market policies.

Malaysia adopted a similar strategy through the Malaysia Digital Economy Blueprint (MyDIGITAL). The country strengthened digital infrastructure, promoted SME digitalization, and expanded e-government services. Importantly, Malaysia integrated digital inclusion policies to reduce the urban–rural gap, supporting small businesses and informal workers in transitioning to online platforms. Vietnam demonstrates digital resilience through export-oriented digital manufacturing and technology parks. By integrating into global value chains in electronics and ICT (Information and Communication Technology) production, Vietnam managed to shift labor from low-productivity agriculture to higher-value manufacturing and digital services. Investment in STEM (Science, Technology, Engineering, and Mathematics) education has been central to this transition.

Meanwhile, Philippines leveraged its strong English proficiency to expand the Business Process Outsourcing (BPO) and digital services sector. This enabled large-scale employment in IT-enabled services, helping offset job losses in traditional sectors. These cases show that digital resilience requires coordinated policy: investment in human capital, adaptive labor market institutions, infrastructure expansion, and innovation support. Without such measures, digitalization risks producing job polarization rather than inclusive employment growth. Then, the state of the art concerning the relationship between PCGDP and UER highlights the variation in the impact of growth on unemployment in developing countries. Growth elasticity of employment differs depending on structural transformation, labor market flexibility, demographic factors, and technological adoption.

Therefore, this research contributes by integrating digital economy indicators into a comprehensive growth–unemployment framework for Indonesia and Thailand. By examining both direct and indirect effects, the study provides empirical evidence on whether digital-driven growth can effectively reduce unemployment, or whether structural reforms in education, labor markets, and industrial policy are required to ensure inclusive growth. In conclusion, while ASEAN plays a significant role in the global economy and Indonesia and Thailand demonstrate promising growth trajectories, digital transformation alone does not guarantee employment absorption. Understanding the complex interaction between digitalization, economic growth, and unemployment is essential for designing policies that promote not only higher GDP per capita but also inclusive and sustainable labor market outcomes.

2. Methods

This study uses secondary panel data obtained from internationally recognized databases such as the World Bank, International Labor Organization (ILO), and United Nations Development Program (UNDP) for the period 1994–2023. World Bank for ID-MD-R&D-EX-FDI-CPI-PCGDP, UNDP for EYS, lowcarbonpower for PCEPC, and ILO for UER. Before conducting the econometric analysis, a rigorous data cleaning process was

implemented to ensure consistency, reliability, and comparability across countries and years.

First, missing values were identified through descriptive statistical screening. If missing observations were minimal and randomly distributed, interpolation methods were applied cautiously to avoid bias. However, variables with excessive missing data were excluded to maintain robustness. Second, outliers were detected using standardized residual checks and graphical visualization (boxplots and trend analysis). Extreme values were winsorized only when they were statistically abnormal and not economically meaningful. Third, all variables were checked for unit consistency. Indicators such as Internet Density (ID) and Mobile Density (MD) were standardized per 100 people to ensure comparability. Monetary variables were adjusted to constant prices where necessary to eliminate inflation bias. In addition, logarithmic transformation was applied to selected variables, including PCGDP and FDI, to reduce heteroskedasticity and interpret coefficients as elasticities.

The selection of Indonesia and Thailand is theoretically and empirically justified. Both countries are major ASEAN economies with similar development status as upper-middle-income (Thailand) and lower-middle-income transitioning to upper-middle-income (Indonesia) economies. Historically, both experienced structural transformation from agriculture to manufacturing and are now undergoing digital transition. However, Thailand has demonstrated slightly stronger performance in industrial upgrading and welfare indicators, while Indonesia possesses a larger domestic market and demographic dividend. This comparative setting allows for meaningful cross-country analysis of how digital economy indicators influence growth and unemployment under relatively similar regional conditions but different structural capacities. Moreover, both countries provide consistent and sufficiently long time-series data, enabling robust panel estimation.

This research uses 2 different models in its elaboration, accompanied by 2 different methods in its calculations. For the first model, the calculation is carried out using the 2SLS (two-stage least squares) method, and the second model uses the OLS (ordinary least squares) method. The 2SLS method uses endogenous and exogenous effects in relation to the determination of instruments in calculating common, fixed, and random effects. These instruments are used by differencing the endogenous factors. Meanwhile, with OLS, the common, fixed, and random effects models are calculated directly and then compared with the Chow test, the Lagrange multiplier test, and the Hausman test for their selection. This study employs the Common Effects Model (CEM) and the Random Effects Model (REM), as presented in Tables 3 and 5.

The Common Effects Model assumes that all cross-sectional units (countries) share a common intercept, meaning that differences across countries are not explicitly modeled. Mathematically, it treats panel data as pooled ordinary least squares (OLS), assuming homogeneity across entities. This model is appropriate when country-specific effects are assumed negligible or when cross-sectional variation is limited. In contrast, the Random Effects Model recognizes that each country may have unique, unobserved characteristics influencing economic growth and unemployment. Instead of estimating separate intercepts, REM assumes that these country-specific effects are randomly distributed and uncorrelated with the independent variables. Mathematically, the composite error term consists of two components, the idiosyncratic error and the country-specific random error. This structure improves efficiency when individual heterogeneity exists but is not systematically correlated with regressors. The choice between CEM and REM is typically supported by statistical testing (such as the Hausman test), ensuring that the selected model provides consistent and efficient estimates.

3. Results and Discussion

The calculations in this study are based on 2 models that are used. For model 1, it is calculated using the 2SLS method, with the following formula

$$lnPCGDP_{i.t} = \delta + \gamma_1 lnID_{i.t} + \gamma_2 lnMD_{i.t} + \gamma_3 lnPCEPC_{i.t} + \gamma_4 lnR\&D_{i.t} + \gamma_5 lnEX_{i.t} + \gamma_6 lnEYS_{i.t} + \gamma_7 lnFDI_{i.t} + \gamma_8 lnCPI_{i.t} + \gamma_9 (lnEYS * lnR\&D)_{i.t} + \gamma_{10}(D_c * lnEX)_{i.t} + \gamma_{11}(D_c * lnEYS)_{i.t} + \gamma_{12}(D_c * lnFDI)_{i.t} + \gamma_{13}(D_c * lnID)_{i.t} + \gamma_{14}(D_c * lnMD)_{i.t} + \gamma_{15}(D_c * lnPCEPC)_{i.t} + \gamma_{16}(D_c * lnR\&D)_{i.t} + \gamma_{17}(D_c * lnCPI)_{i.t} + \gamma_{18}(D_c * lnEYS * lnR\&D)_{i.t} + \varepsilon_{i.t}$$ (Eq. 1)

For the second model, it is calculated using the OLS method, with the following formula, where i = Cross-section, t = Time-series , δ = constant, γ = coefisient, ε = Standard Error, D_c = Dummy of Country; with 1 = Indonesia, 0 = Thailand.

$$lnUER_{i.t} = \delta + \gamma lnPCGDP_{i.t} + \varepsilon_{i.t}$$ (Eq. 2)

The next step is to perform a stationarity test with α = 5% using the ADF (Augmented Dickey-Fuller) method, the results of which can be seen in Tables 1 and 2. The following is a panel data regression calculation for model 1 using the 2SLS method, the results of which can be seen in Table 3. In the Table 3, it can be seen that the random effect is the chosen method. This can be seen from the adjusted R-squared value with a striking significance value compared to the other 2 methods, which is 0.971305, which is the simultaneous effect of model 1.

Table 1. Results of stationarity test for model 1

Variable	ADF	Category	Status
lnPCGDP - per capita gross domestic product	0.0000	first differenced	stasioner
lnID - internet density	0.0120	first differenced	stasioner
lnMD - mobile density	0.0000	level	stasioner
lnPCEPC - per capita electricity power consumption	0.0149	level	stasioner
lnR&D - research & development	0.0008	first differenced	stasioner
lnEX - exports	0.0001	first differenced	stasioner
lnEYS - expected years of schooling	0.0000	first differenced	stasioner
lnFDI - foreign direct investment	0.0002	level	stasioner
lnCPI - consumer price index	0.0000	level	stasioner
lnEYS*lnR&D	0.0008	first differenced	stasioner
Dc*lnEX	0.0008	first differenced	stasioner
Dc*lnEYS	0.0212	first differenced	stasioner
Dc*lnFDI	0.0001	level	stasioner
Dc*lnID	0.0425	first differenced	stasioner
Dc*lnMD	0.0000	level	stasioner
Dc*lnPCEPC	0.0084	level	stasioner
Dc*lnR&D	0.0142	first differenced	stasioner
Dc*lnCPI	0.0001	level	stasioner
Dc*lnEYS*lnR&D	0.0157	first differenced	stasioner

Table 2. Results of Stationarity Test for Model 2

Variable	ADF	Category	Status
lnUER - unemployment rate	0.0000	first differenced	stasioner
lnPCGDP - per capita gross domestic product	0.0120	first differenced	stasioner

Table 3. Summary of panel data regression testing for Model 1 with the selected random effects model

Variabel	Common Effect		Fixed Effect		Random Effect	
	Koef	Prob	Koef	Prob	Koef	Prob
lnID - internet density	-0.026323	0.8601	0.108466	0.5286	-0.024696	0.0958
lnMD - mobile density	0.129460	0.7486	-0.215520	0.5585	0.056479	0.0081

Variabel	Common Effect		Fixed Effect		Random Effect	
	Koef	Prob	Koef	Prob	Koef	Prob
lnPCEPC - electricity consumpt	2.288666	0.7127	1.539095	0.3408	0.935372	0.0000
lnR&D - research & develop	5.991982	0.7302	0.304537	0.8950	2.720629	0.0011
lnEX - exports	0.866037	0.7901	-0.531768	0.5328	0.134773	0.0001
lnEYS - exp years of schooling	-1.249979	0.7476	0.333729	0.7688	-2.108037	0.0231
lnFDI - foreign direct invest	-0.022425	0.8365	0.013600	0.8134	0.013249	0.1028
lnCPI - consumer price index	-3.626677	0.7130	-0.279571	0.8413	-1.418084	0.0000
lnEYS*lnR&D	-2.227915	0.7300	-0.118224	0.8932	-1.066673	0.0014
Dc*lnEX	-1.565008	0.7929	0.622202	0.4960	-0.201652	0.0000
Dc*lnEYS	-3.379505	0.8425	0.405147	0.8907	1.137069	0.0021
Dc*lnFDI	0.257025	0.7887	-0.033246	0.7873	-0.002079	0.6642
Dc*lnID	-0.005906	0.9878	-0.066365	0.7724	0.072448	0.0062
Dc*lnMD	-1.131567	0.8016	0.355253	0.4660	-0.118432	0.1310
Dc*lnPCEPC	-5.040380	0.7809	-1.029317	0.6294	-0.906311	0.0094
Dc*lnR&D	15.913430	0.8394	-4.331586	0.6360	-1.286826	0.1446
Dc*lnCPI	8.770970	0.7795	-0.536486	0.8231	1.647233	0.0066
Dc*lnEYS*lnR&D	-6.189133	0.8390	1.676291	0.6375	0.533669	0.1014
R^2 (Within)	-29.185352		-4.415871		0.983044	
R^2 (Overall)	-50.082903		-8.531932		0.971305	
F-Statistic	2.959321		2.770432		62.10088	
Durbin Watson	1.055593		1.013119		0.705127	

For the partial effect, of the 8 substantive variables, 6 of them are significantly related to growth (PCGDP), namely MD, PCEPC, R&D, EX, EYS and CPI. All of these variables are positively or unidirectionally correlated except for 2 variables, namely EYS and CPI, whose values are in the opposite direction to the dependent variable. These results indicate that the model used by Sahoo et al. is proven to provide a good influence value between the independent variables and the dependent variable, both simultaneously and partially, for model 1. Even when compared between the results of this study and the research conducted by Sahoo et al (2021), this study obtained better results than Sahoo. This can be seen from the number of partially significant variables that Sahoo obtained, which was only 2 variables. A comparison of the results of this study with that of Sahoo can be seen in Table 4.

Table 4. Comparison of significance and determination between the results of Sahooet al. (2021) and this study for Model 1

Variable	Sahoo (2021)	This Research
lnID – Internet density	0.013	-0.096
lnMD – Mobile density	0.161	0.008
lnPCEPC – Per capita electricity power consumption	0.572	0.000
lnR&D – Research and development	7.669	0.001
lnEX – Exports	0.326	0.000
lnEYS – Expected years of schooling	2.210	-0.023
lnFDI – Foreign direct investment	0.108	0.103
lnCPI – Consumer price index	0.046	-0.000
lnEYS × lnR&D	3.355	-0.001
Dc × lnEX	-0.591	-0.000
Dc × lnEYS	-0.678	0.002
Dc × lnFDI	0.012	-0.664
Dc × lnID	0.018	0.006
Dc × lnMD	-0.150	-0.131
Dc × lnPCEPC	0.260	-0.009
Dc × lnR&D	10.124	-0.145

Dc × lnCPI	0.335	0.007
Dc × lnEYS × lnR&D	-4.318	0.101
R^2 (Within)	0.998	0.983
R^2 (Overall)	0.998	0.971

The use of the Two-Stage Least Squares (2SLS) method in Model 1 is theoretically justified due to the potential endogeneity problem among digital economy variables and economic growth. Variables such as FDI, R&D, and exports may simultaneously influence and be influenced by PCGDP. If estimated using simple OLS, the coefficients could be biased and inconsistent. Therefore, 2SLS helps isolate the exogenous variation of the independent variables through instrumental estimation, ensuring that the estimated parameters reflect causal relationships rather than mere correlations.

The inclusion of interaction terms—particularly lnEYS*lnR&D and country dummy interactions (Dc*)—enhances the explanatory power of the model. The interaction between education (EYS) and R&D captures the complementarity effect between human capital and innovation capacity. Theoretically, R&D expenditure will not produce optimal growth outcomes without adequate educational quality and skilled labor. Thus, the positive and significant interaction term suggests that digital transformation requires synergy between knowledge accumulation and technological development.

The country dummy interaction (Dc) allows the model to capture structural differences between Indonesia and Thailand. Although both countries are ASEAN members with similar development stages, their institutional capacity, industrial structure, and digital readiness differ. By interacting Dc with each independent variable, the study identifies whether the marginal impact of digital economy variables varies across countries. This approach strengthens the comparative dimension of the research and avoids overgeneralization.

For model 2, PCGDP has a significant effect on UER. From the 3 models calculated and several tests conducted, common effect was selected with an R-squared value of 0.234928. However, the negative coefficient value indicates that the significance of the UER variable shows an inverse relationship. A 1% increase in the growth variable (PCGDP) will reduce unemployment (UER) by 3.832865, and it is elastic. This can be seen in Table 5.

Table 5. Summary of Panel Data Regression Testing for Model 2 with the Selected Common Effect

Variabel	Common Effect		Fixed Effect		Random Effect	
	Koef	Prob	Koef	Prob	Koef	Prob
lnPCGDP - gross domestic product	-3.832865	0.0001	-3.901029	0.0001	-3.832865	0.0001
R^2 (Within)	0.234928		0.241532		0.234928	
R^2 (Overall)	0.221266		0.213951		0.221266	
F-Statistic	17.19570		8.757302		17.19570	
Durbin Watson	2.567261		2.586377		2.567261	

In Model 2, the negative and elastic coefficient of PCGDP on UER confirms the theoretical expectation derived from Okun's Law, which states that economic growth reduces unemployment. However, the relatively modest R-squared value (0.234928) indicates that unemployment dynamics cannot be explained solely by growth. Structural factors such as labor market rigidity, demographic changes, technological substitution, and informal sector dominance also play crucial roles. This finding reinforces the central argument of this study: growth driven by digital transformation does not automatically translate into proportional employment absorption.

This Model 2 shows different conditions from the research of Sahoo et al (2021). Unemployment (UER) is a significant variable in this study. While in Sahoo's research, foreign direct investment (FDI) was obtained as the influential variable as its Z variable. Furthermore, the difference between this study and Sahoo et al. (2021) suggests that country context matters significantly. While Sahoo found FDI as the dominant determinant in affecting unemployment indirectly, this study shows that growth (PCGDP) remains a significant transmission channel in Indonesia and Thailand. This indicates that policy design

in ASEAN developing countries should focus not only on attracting investment but also on ensuring that growth is inclusive and employment-intensive.

Some findings in the research can be explained in the following explanation. For Indonesia and Thailand, EYS and CPI are significant but in opposite directions. EYS shows that in both countries education is still of low quality and there is a skill mismatch for industry needs. However, for Dc*EYS it actually shows that specifically for Indonesia, education has sufficiently met the standard needs of the industrial world, which can be seen from the significant and positive value. Likewise for CPI, although significant, the direction is negative. This indicates that in Indonesia and Thailand, the inflation rate is quite high. However, for Dc*CPI, specifically Indonesia, CPI is actually significant and positive, which means that inflation is quite measurable and does not even affect people's purchasing power. The ID variable is not significant in Indonesia and Thailand, which indicates that for both countries, internet consumption in many institutions does not contribute significantly to productivity compared to MD which is significant, and the public's preference tends to shift from fixed broadband to mobile broadband. However, for Dc*ID, the specific condition in Indonesia actually shows that fixed broadband contributes greatly to growth, which indicates high productivity in institutions in the use of the internet. While Dc*MD in Indonesia shows that mobile internet consumption does not contribute much to economic productivity. The R&D variable provides significant and positive values in Indonesia and Thailand. However, Dc*R&D in Indonesia is not significant. This indicates that R&D has not been implemented optimally in Indonesia. Downstreaming, which is a program currently being promoted by the government, can boost the use of R&D in Indonesia.

Overall, the empirical results confirm that digital economy variables significantly influence growth (Model 1), and growth significantly influences unemployment (Model 2). However, the transmission mechanism is complex, country-specific, and dependent on structural readiness. Therefore, policy interventions must integrate digital infrastructure development, human capital improvement, macroeconomic stability, and labor market reform to ensure that digital transformation enhances both economic growth and employment outcomes simultaneously.

4. Conclusions

This research demonstrates that the model is effective in capturing the influence of digital economic variables on economic growth in Indonesia and Thailand. The 8 X variables consisting of ID, MD, PCEPC, R&D, EX EYS, FDI and CPI have a significant simultaneous effect on economic growth in both countries. The 8 variables except ID and FDI, have a significant partial effect. EYS and CPI variables have significant but opposing directions to growth, indicating that EYS has increased but the quality of education remains low, and there is a skill mismatch with industry needs, as well as a high CPI which weakens purchasing power and reduces consumption. The ID variable is significant in Indonesia because institutions and households still predominantly use fixed broadband in carrying out productive economic activities, while the MD variable is the opposite because the use of mobile internet is dominated by unproductive and solely consumptive things. The R&D variable is not significant for growth in Indonesia because the government has not made optimal efforts to increase funding in this sector and there is a lack of commercialization efforts from research conducted by academics.

Based on the research findings, the main strategy to enhance economic growth (PCGDP) in Indonesia and Thailand is to accelerate digitalization integrated with the strengthening of real economic performance. From the digitalization perspective, expanding broadband, 4G, and 5G infrastructure to remote areas should be prioritized to reduce the digital divide. The digitalization of MSMEs through e-commerce, digital payments, and improved digital literacy is also essential to ensure that technology truly enhances productivity. In addition, strengthening e-government systems can improve bureaucratic efficiency, transparency, and state revenue. From the real sector perspective, productivity improvements must be pursued through vocational education, research,

innovation, and the adoption of industrial automation. Regulatory reforms and investment facilitation are necessary to attract high-quality FDI, particularly in the technology and green energy sectors. The integration of the ASEAN digital economy should also be optimized to create a more open and competitive regional market.

Regarding the Internet Density (ID) variable, its impact on growth will be more significant if quality, access, and utilization are improved. Expanding fiber optic networks, lowering subscription costs, and integrating broadband with productive sectors such as digital education, healthcare, e-commerce, and smart industries are strategic steps. Digital literacy must also be strengthened to ensure that internet usage is productive rather than merely consumptive. For Mobile Density (MD), strategies should focus on network expansion, affordable tariffs, and integration with digital economic services such as mobile banking, fintech, digital agriculture, and app-based MSMEs. Strengthening digital literacy is crucial to ensure that mobile phone usage generates economic value. For Per Capita Electricity Power Consumption (PCEPC), effectiveness can be enhanced by expanding electricity access, especially in remote areas, and directing consumption toward productive sectors such as manufacturing and the digital economy. Investment in renewable energy and improved energy efficiency are also important to ensure sustainable growth.

Regarding Research and Development (R&D), increasing budget allocation and providing tax incentives for private sector participation are essential. Collaboration between universities, industries, and research institutions must be strengthened to ensure that research outcomes are applicable and commercialized. The development of startup incubators, science parks, and venture capital support can accelerate innovation downstreaming, particularly in strategic sectors such as digital technology, renewable energy, modern agriculture, and healthcare. For exports (EX), the primary strategy involves product diversification and value-added enhancement. Dependence on primary commodities should be reduced by promoting manufacturing, technology-based products, and digital services. Industrial downstreaming, improved product standards, trade diplomacy, and export financing and digital logistics support for MSMEs will strengthen global competitiveness. Regarding Expected Years of Schooling (EYS), improving education quality must go hand in hand with expanding access. The curriculum should emphasize 21st-century skills such as digital literacy, critical thinking, and entrepreneurship. Vocational and technical education should be aligned with industry needs to reduce skill mismatches. For FDI, policies should focus on improving investment quality. Simplifying licensing procedures, ensuring legal certainty, strengthening infrastructure, and fostering synergy between foreign investors and local MSMEs are essential to promote technology transfer and workforce capacity development. For the Consumer Price Index (CPI), price stability must be maintained through coordinated monetary and fiscal policies. Ensuring food and energy supply, improving distribution efficiency through digitalization, and protecting the purchasing power of low-income groups are crucial to sustaining domestic consumption. Finally, to ensure that economic growth effectively reduces unemployment (UER), development strategies must be inclusive and employment-oriented. Labor-intensive sectors, human capital development, job-creating investments, entrepreneurship strengthening, and labor market reforms are key to ensuring that economic growth translates into sustainable unemployment reduction.

Acknowledgement
The authors would like to thank all parties who have contributed to this research.

Author Contribution
Each author contributed to every part of this research.

Funding
Does not accept funding from any party.

Ethical Review Board Statement
Not available.

Informed Consent Statement
Not available.

Data Availability Statement
Data can be obtained at: https://datacatalog.worldbank.org/search/dataset/0037712/World-Development-Indicators

Conflicts of Interest
The authors declare no conflict of interest.

Declaration of Generative AI Use
During the preparation of this work, the authors used Grammarly to assist in improving grammar, clarity, and academic tone of the manuscript. After using this tool, the authors reviewed and edited the content as needed and took full responsibility for the content of the publication.

Open Access
©2026. The authors. This article is licensed under a Creative Commons Attribution 4.0 International License, which permits use, sharing, adaptation, distribution and reproduction in any medium or format, as long as you give appropriate credit to the original authors and the source, provide a link to the Creative Commons license, and indicate if changes were made. The images or other third-party material in this article are included in the article's Creative Commons license, unless indicated otherwise in a credit line to the material. If material is not included in the article's Creative Commons license and your intended use is not permitted by statutory regulation or exceeds the permitted use, you will need to obtain permission directly from the copyright holder. To view a copy of this license, visit: http://creativecommons.org/licenses/by/4.0/

References
Abdulqadir, I. A., & Asongu, S. A. (2022). The asymmetric effect of internet access on economic growth in sub-Saharan Africa. *Economic Analysis and Policy, 73*, 44–61. https://doi.org/10.1016/j.eap.2021.10.014

Agusalim, L., Anggraeni, L., & Pasaribu, S. H. (2022). The economy of Indonesia: Driven by physical or human capital? *Jejak, 15*(1), 10–28. https://doi.org/10.15294/jejak.v15i1.34418

Badri, A. K., Badri, P. K., & Cham, M. (2019). R&D spending and economic growth in selected OECD countries. *International Journal of Applied Economics, Finance and Accounting, 5*(2), 48–54. https://doi.org/10.33094/8.2017.2019.52.48.54

Boeing, P., Eberle, J., & Howell, A. (2022). The impact of China's R&D subsidies on R&D investment, technological upgrading and economic growth. *Technological Forecasting and Social Change, 174*, 121212. https://doi.org/10.1016/j.techfore.2021.121212

Boujelbene, T. (2021). Nonlinearity relationship of inflation and economic growth: Role of institutions quality. *Romanian Journal of Economic Forecasting, 24*(1), 165–179. http://www.ipe.ro/rjef/rjef1_21/rjef1_2021p166-179.pdf

Choi, C., & Yi, M. H. (2018). The Internet, R&D expenditure and economic growth. *Applied Economics Letters, 25*(4), 264–267. https://doi.org/10.1080/13504851.2017.1316819

Didya, M. (2024). Determinants of economic growth of Nepal. *Bagiswori Journal, 3*(1), 42–58. https://doi.org/10.3126/bagisworij.v3i01.62014

Ding, R., & Huang, M. (2021). The spatial difference of "internet plus tourism" in promoting economic growth. *Sustainability, 13*(21), 11788. https://doi.org/10.3390/su132111788

Duong, V. A. N. (2023). Impacts of information and communication technologies infrastructure development on economic growth: An empirical study of Southeast Asian countries. *Science & Technology Development Journal: Economics - Law and Management, 7*(2), 4331–4340. https://doi.org/10.32508/stdjelm.v7i2.1178

Fadli, F., Hongbing, O., & Liu, Y. (2019). Earmarking tax for Indonesia's economic growth through the education and health sector in the long and short term period. *Business and Economic Research, 10*(1), 1. https://doi.org/10.5296/ber.v10i1.15889

Fazaalloh, A. M. (2024). FDI and economic growth in Indonesia: A provincial and sectoral analysis. *Journal of Economic Structures, 13*(1). https://doi.org/10.1186/s40008-023-00323-w

Güler, H., Haykır, Ö., & Öz, S. (2022). Does the electricity consumption and economic growth nexus alter during COVID-19 pandemic? Evidence from European countries. *The Electricity Journal, 35*(6), 107144. https://doi.org/10.1016/j.tej.2022.107144

Hong, J. P. (2017). Causal relationship between ICT R&D investment and economic growth in Korea. *Technological Forecasting and Social Change, 116*, 70–75. https://doi.org/10.1016/j.techfore.2016.11.005

Kantar, E., Aslan, A., Deviren, B., & Keskin, M. (2016). Hierarchical structure of the countries based on electricity consumption and economic growth. *Physica A: Statistical Mechanics and Its Applications, 454*, 1–10. https://doi.org/10.1016/j.physa.2016.01.075

Khan, A. M., & Khan, U. (2021). The stimulus of export and import performance on economic growth in Oman. *Montenegrin Journal of Economics, 17*(3), 71–86. https://doi.org/10.14254/1800-5845/2021.17-3.6

Kumar, R. R., Stauvermann, P. J., & Samitas, A. (2016). The effects of ICT on output per worker: A study of the Chinese economy. *Telecommunications Policy, 40*(2–3), 102–115. https://doi.org/10.1016/j.telpol.2015.06.004

Kunwar, S., Timilsina, S., Nepal, S., Shrestha, P., Shrestha, A., & Gahatraj, M. (2023). Impact of money supply and inflation on economic growth in Nepal. *The Lumbini Journal of Business and Economics, 11*(1), 381–396. https://doi.org/10.3126/ljbe.v11i1.54343

Lu, Y. S., Thye, G. L., Muhairah, S. S., & Kumar, S. S. (2023). Applying the pooled mean group panel ARDL technique to analyse the impact of uncertainty on economic growth in the ASEAN-5. *International Journal of Economics and Management, 17*(1), 125–137. https://doi.org/10.47836/ijeam.17.1.09

Masserini, L., Bini, M., Zeli, A., & Forciniti, A. (2024). Measuring the impact of the 2008 and 2011 financial crises and the 2015 recovery on the unemployment rate in Italy. *Socio-Economic Planning Sciences, 95*, 102032. https://doi.org/10.1016/j.seps.2024.102032

Maurseth, P. B. (2018). The effect of the Internet on economic growth: Counter-evidence from cross-country panel data. *Economics Letters, 172*, 74–77. https://doi.org/10.1016/j.econlet.2018.08.034

Mehmetaj, N., & Xhindi, N. (2022). Public expenses in education and youth unemployment rates—A vector error correction model approach. *Economies, 10*(12), 293. https://doi.org/10.3390/economies10120293

Metzger, N., & Shenai, V. (2021). Economic growth and human development in OECD countries: A twenty-year study of data 2000–2019. *Journal of European Economy, 20*(4), 585–631. https://doi.org/10.35774/jee2021.04.585

Miao, M., Borojo, D. G., Yushi, J., & Desalegn, T. A. (2021). The impacts of Chinese FDI on domestic investment and economic growth for Africa. *Cogent Business & Management, 8*(1), 1886472. https://doi.org/10.1080/23311975.2021.1886472

Muhammad, B., & Khan, S. (2019). Effect of bilateral FDI, energy consumption, CO2 emission and capital on economic growth of Asia countries. *Energy Reports, 5*, 1305–1315. https://doi.org/10.1016/j.egyr.2019.09.004

Muye, I. M., & Hassan, A. F. S. (2016). Does Islamic insurance development promote economic growth? A panel data analysis. *Procedia Economics and Finance, 35*, 368–373. https://doi.org/10.1016/S2212-5671(16)00045-9

Nomaler, Ö., Spinola, D., & Verspagen, B. (2021). R&D-based economic growth in a supermultiplier model. *Structural Change and Economic Dynamics, 59*, 1–19. https://doi.org/10.1016/j.strueco.2021.07.002

Papík, M., Mihaľová, P., & Papíková, L. (2022). Determinants of youth unemployment rate: Case of Slovakia. *Equilibrium. Quarterly Journal of Economics and Economic Policy, 17*(2), 391–414. https://doi.org/10.24136/eq.2022.013

Phadkantha, R., & Yamaka, W. (2022). The nonlinear impact of electricity consumption on economic growth: Evidence from Thailand. *Energy Reports, 8*, 1315–1321. https://doi.org/10.1016/j.egyr.2022.03.025

Phale, K., Fanglin, L., Mensah, I. A., Omari-Sasu, A. Y., & Musah, M. (2021). Knowledge-based economy capacity building for developing countries: A panel analysis in Southern African Development Community. *Sustainability, 13*(5), 2890. https://doi.org/10.3390/su13052890

Rao, D. T., Sethi, N., Dash, D. P., & Bhujabal, P. (2023). Foreign aid, FDI and economic growth in South-East Asia and South Asia. *Global Business Review, 24*(1), 31–47. https://doi.org/10.1177/0972150919890957

Raza, S. A., Jawaid, S. T., & Siddiqui, M. H. (2016). Electricity consumption and economic growth in South Asia. *South Asia Economic Journal, 17*(2), 200–215. https://doi.org/10.1177/1391561416649721

Rosnawintang, Tajuddin, Adam, P., Pasrun, Y. P., & Saidi, L. O. (2021). Effects of crude oil prices volatility, the Internet and inflation on economic growth in ASEAN-5 countries: A panel autoregressive distributed lag approach. *International Journal of Energy Economics and Policy, 11*(1), 15–21. https://doi.org/10.32479/ijeep.10395

Rumbia, W. A., Muthalib, A. A., Adam, P., Jabani, A., Pasrun, Y. P., & Muthalib, D. A. (2022). The effect of crude oil prices and Internet on economic growth in Timor-Leste. *International Journal of Energy Economics and Policy, 12*(1), 275–280. https://doi.org/10.32479/ijeep.11992

Sahoo, D., Nayak, S., & Behera, J. (2021). Digitalization and economic performance of two fast-growing. *Asian Development Bank Institute (Issue 1243)*. https://www.adb.org/publications/digitalization-economic-performance-fast-growing-asian-economies-india-prc

Saidi, K., & Mongi, C. (2018). The effect of education, R&D and ICT on economic growth in high-income countries. *Economics Bulletin, 38*(2), 810–825. http://www.accessecon.com/Pubs/EB/2018/Volume38/EB-18-V38-I2-P80.pdf

Septrila, N., & Kurniasih, E. P. (2022). The effect of inflation and economic growth on unemployment rate in ASEAN countries. *International Journal of Business, Technology and Organizational Behavior, 2*(6), 580–594. https://doi.org/10.52218/ijbtob.v2i6.226

Singh, A., Singh, M., Karn, A. A., Kanti, T., & Shirolla, K. (2024). Bihar's human development journey: A post-1991 exploration. *International Journal of Research Publication and Reviews, 5*(1), 1593–1599. https://doi.org/10.55248/gengpi.5.0124.0217

Sultanuzzaman, M. R., Fan, H., Akash, M., Wang, B., & Shakij, U. S. M. (2018). The role of FDI inflows and export on economic growth in Sri Lanka: An ARDL approach. *Cogent Economics & Finance, 6*(1), 1518116. https://doi.org/10.1080/23322039.2018.1518116

Sultanuzzaman, M. R., Fan, H., Mohamued, E. A., Hossain, M. I., & Islam, M. A. (2019). Effects of export and technology on economic growth: Selected emerging Asian economies. *Economic Research-Ekonomska Istraživanja, 32*(1), 2515–2531. https://doi.org/10.1080/1331677X.2019.1650656

Sunde, T., Tafirenyka, B., & Adeyanju, A. (2023). Testing the impact of exports, imports, and trade openness on economic growth in Namibia: Assessment using the ARDL

cointegration method. *Economies, 11*(3), 86. https://doi.org/10.3390/economies11030086

Thoyibah, Q. A. P., & Sugiharti, L. (2022). The effect of telecommunication infrastructure on economic growth in the six ASEAN countries. *Media Trend, 17*(1), 156–167. https://doi.org/10.21107/mediatrend.v17i1.13640

Tumanoska, D. (2020). The relationship between economic growth and unemployment rates: Validation of Okun's law in panel context. *Review of Applied Economics, 12*(1). https://doi.org/10.5296/rae.v12i1.16665

Ullah, S., Luo, R., Ali, K., & Irfan, M. (2023). How does the sectoral composition of FDI induce economic growth in developing countries? The key role of business regulations. *Economic Research-Ekonomska Istraživanja, 36*(2). https://doi.org/10.1080/1331677X.2022.2129406

Worldbank. (2023). *The World Bank In Thailand*. https://www.worldbank.org/en/country/thailand/overview

Wulandari, P. N., Badriah, L. S., & Kadarwati, N. (2019). Determinants of economic growth in East Nusa Tenggara Province. *Eko-Regional: Jurnal Pengembangan Ekonomi Wilayah, 14*(1), 36–46. https://doi.org/10.20884/1.erjpe.2019.14.1.1246

Zhang, C., Zhou, K., Yang, S., & Shao, Z. (2017). On electricity consumption and economic growth in China. *Renewable and Sustainable Energy Reviews, 76*, 353–368. https://doi.org/10.1016/j.rser.2017.03.071

Zhu, W., Ahmad, F., Draz, M. U., Ozturk, I., & Rehman, A. (2022). Revisiting the nexus between exchange rate, exports and economic growth: Further evidence from Asia. *Economic Research-Ekonomska Istraživanja, 35*(1), 7128–7146. https://doi.org/10.1080/1331677X.2022.2059696

Biographies of Authors

Shedriko, Department of Informatics Engineering, Faculty of Technology and Computer Science, Universitas Indraprasta PGRI, West Jakarta, Special Capital Region of Jakarta 12530, Indonesia.

- Email: shedriko@gmail.com
- ORCID: 0000-0002-9360-2240
- Web of Science ResearcherID: N/A
- Scopus Author ID: N/A
- Homepage: N/A

Heru Subiyantoro, Graduate School of Economics, Universitas Borobudur, East Jakarta, Special Capital Region of Jakarta 13620, Indonesia.

- Email: herusubiyantoro@borobudur.ac.id
- ORCID: 0000-0002-0992-7414
- Web of Science ResearcherID: N/A
- Scopus Author ID: N/A
- Homepage: N/A

Muhammad Rozali, Graduate School of Economics, Universitas Borobudur, East Jakarta, Special Capital Region of Jakarta 13620, Indonesia.

- Email: m.rozali@borobudur.ac.id
- ORCID: N/A
- Web of Science ResearcherID: N/A
- Scopus Author ID: N/A
- Homepage: N/A