

Article Type (Research article/Review article)**The Impact of ICT Use and Trade Openness on Youth Unemployment in ASEAN: Opportunity or Challenge?****Tripitono Adi Prabowo^{1*}, Alvin Sugeng Prasetyo²**¹ Faculty of Economics and Business, Universitas Trunojoyo Madura, Indonesia² Faculty of Economics and Business, Universitas Trunojoyo Madura, Indonesia*Corresponding email: tripitono.prabowo@trunojoyo.ac.id

Abstract: This study investigates the effects of Information and Communication Technology and trade openness on youth unemployment in ASEAN countries from 2000 to 2023. Using panel FMOLS, the results show internet usage and mobile subscriptions have significant negative effects on youth unemployment, indicating that ICT expansion offers substantial opportunities to reduce joblessness among the youth by enhancing access to labor markets, education, and entrepreneurship. Conversely, trade openness exhibits a small but statistically significant positive effect on youth unemployment, suggesting a structural challenge where trade liberalization may not benefit young job seekers equally, possibly due to skill mismatches or capital-intensive import patterns. Meanwhile, fixed broadband subscriptions show a strong positive association with unemployment, which may reflect a digital divide or unequal ICT infrastructure development. These findings imply that while ICT is an opportunity for inclusive youth employment, trade openness must be accompanied by labor market reforms and skill development to prevent exclusion.

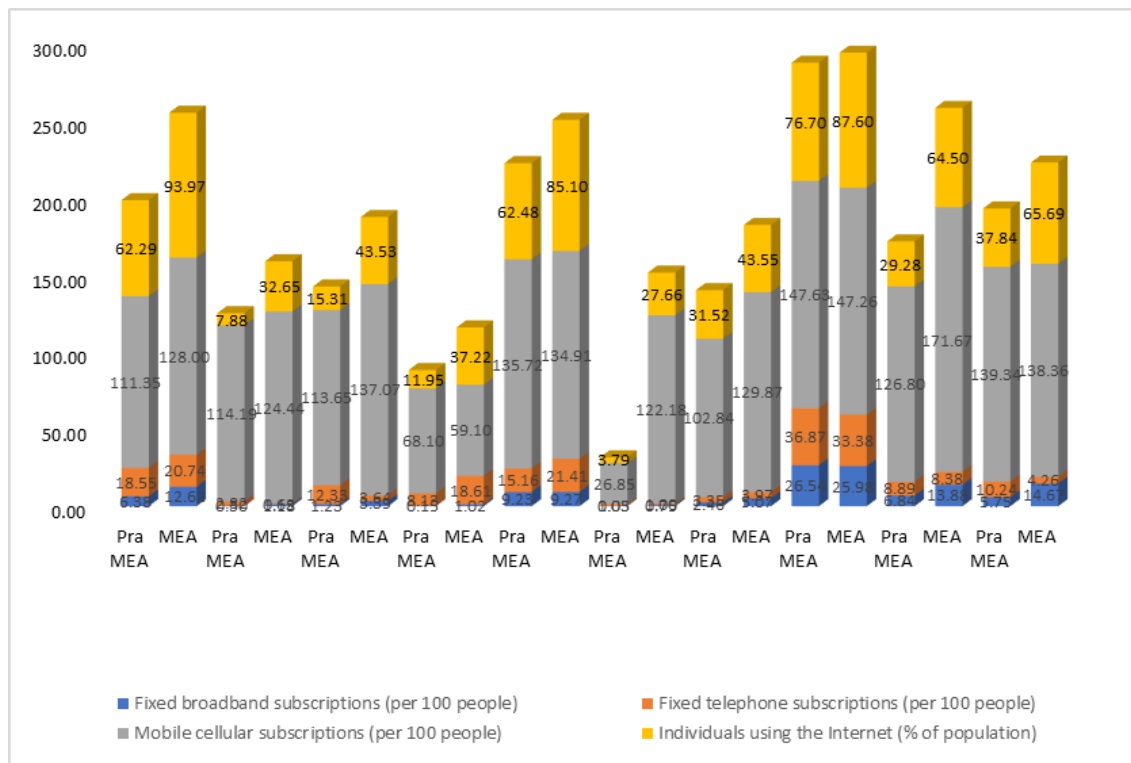
Keywords: ICT, Youth Unemployment, Trade Openness, Panel FMOLS

INTRODUCTION

The issue of the impact of Information and Communication Technology (ICT) on youth unemployment has been an interesting empirical research topic and has generated considerable debate in the literature. Several studies have shown that ICT adoption can expand youth access to employment opportunities through increased job search efficiency and digital skills development. For example, research in Cameroon found that ICT use significantly increased youth employment opportunities, particularly by expanding social networks and access to information (Njong & Mve, 2023). However, other studies have highlighted that without adequate digital skills, youth may be left behind in an increasingly digitalized labor market (Khatri & Poudel, 2025).

This condition reflects the ambivalence in the role of ICT, but on the one hand as an enabler that opens the way to new job opportunities, and on the other hand as a potential barrier for the workforce that does not yet have adequate digital access or competence. The differences in results in the literature indicate that the readiness of a country's digital infrastructure greatly influences the effectiveness of ICT in addressing youth unemployment. Therefore, it is important to analyze in more depth the interaction between ICT use and youth unemployment.

In the context of the ASEAN region, these dynamics become increasingly complex given the diversity of levels of digital economic development, the quality of ICT infrastructure, and disparities in access and digital literacy between member countries (Nguyen & Choi, 2025). This means that for the ASEAN region, advances in digital infrastructure and internet penetration open up new opportunities for young people to participate in the digital economy, however, a paradox arises when increased use of ICT does not automatically reduce the youth unemployment rate in the ASEAN region (Othman et al., 2024). Examples such as Singapore and Malaysia have shown significant progress in ICT integration so that young people can be interested in participating in the digital economy, and ultimately, can reduce youth unemployment. Other countries such as Cambodia, Laos, and Myanmar still face fundamental challenges in providing infrastructure and digital skills training for young people, so they have not been able to solve the problem of youth unemployment (Raza & Raza, 2024). Indonesia, the Philippines, and Vietnam show great potential as growing digital markets, but they are still grappling with the issue of inequality in access to and quality of vocational education that does not fully support the needs of the ICT-based industry. Therefore, the ability to reduce youth unemployment is not effective.



Source: World Bank, 2023

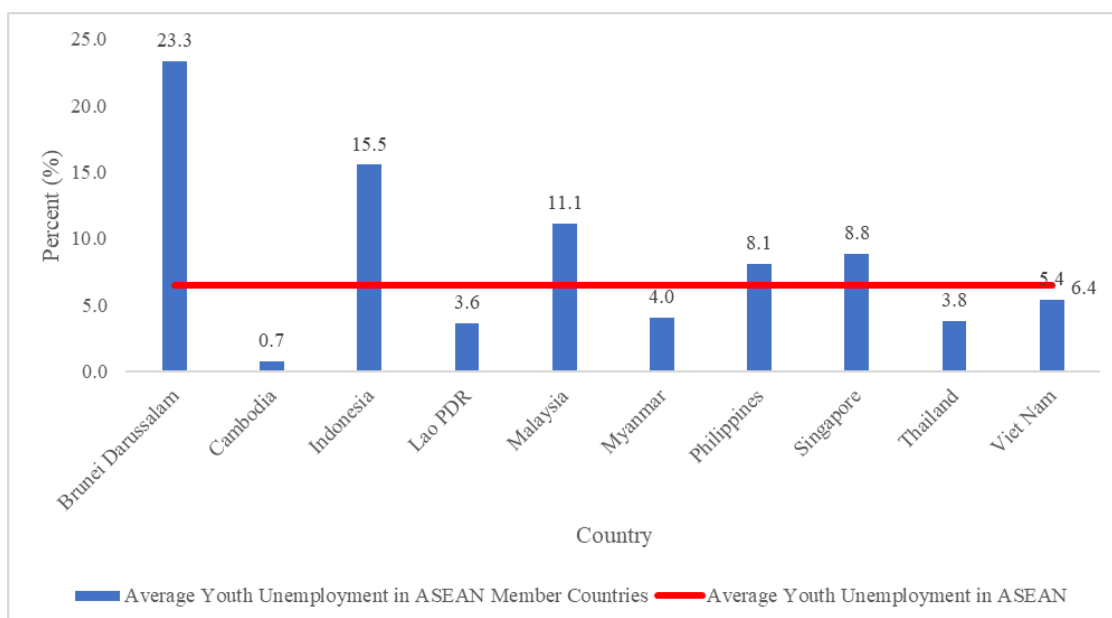
Figure 1
Digital Infrastructure Disparities 2010-2023 in ASEAN

Figure 1 shows a comparison of digital infrastructure in ASEAN member countries before the Pre-AEC (ASEAN Economic Community), namely the period 2010-2014, and the AEC (ASEAN Economic Community) period, namely 2015-2023.

The four main indicators used are fixed broadband subscriptions, Fixed telephone subscriptions, Mobile cellular subscriptions, and Individuals using the Internet. This data

is presented in the form of a tiered bar chart for each ASEAN country, providing a clear picture of the digital disparity in the region. Mobile cellular subscriptions (grey bars) are the most evenly distributed and dominant form of digital infrastructure across ASEAN countries, both before and after the AEC. Almost all countries have more than 100 mobile subscriptions per 100 population, indicating high penetration and easy access to cellular networks. This reflects that mobile telecommunication have become the backbone of digital connectivity in Southeast Asia. However, significant disparities appear in the fixed broadband subscriptions and fixed telephone subscriptions (orange bars) indicators. Countries such as Singapore and Malaysia show much higher adoption rates of fixed broadband and fixed telephony compared to other countries such as Laos, Cambodia, and Myanmar. This indicates a gap in wired digital infrastructure, which is usually related to long-term infrastructure investment and national economic capacity.

The individuals using the Internet indicator presented in Figure 1 show a striking difference. Singapore, Brunei, and Malaysia recorded a very high percentage of internet users (approaching or exceeding 80 percent), while countries such as Laos, Myanmar, and Cambodia are still below 50 percent, even after the AEC. This indicates that, in addition to infrastructure, other factors such as digital literacy, purchasing power, and government policies also affect the level of internet adoption in the community. Overall, this graph reflects that although the AEC aims to promote integration and more equitable development, digital disparities are still evident in the ASEAN region. More economically advanced countries have shown significant improvements in all digital infrastructure indicators, while countries with limited resources and fiscal capacity are still lagging. To achieve the vision of inclusive ASEAN digital connectivity, a regional strategy is needed that emphasizes infrastructure investment, technology cooperation, and human resource capacity building.

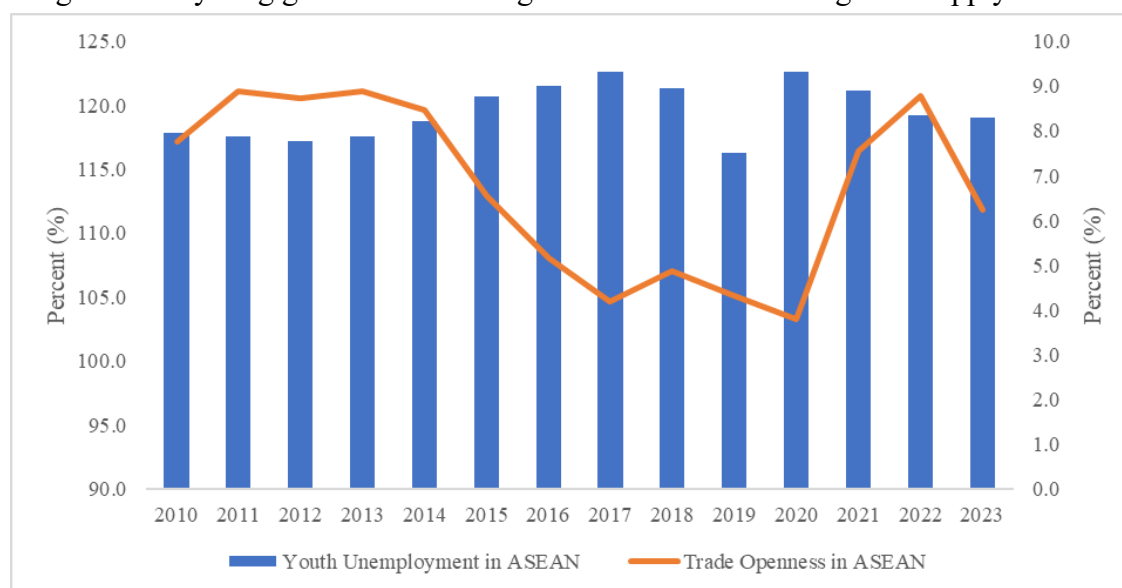


Source: World Bank, 2023

Figure 2
Average Youth Unemployment in ASEAN Member Countries 2010-2023

The apparent digital disparity also has direct implications for youth unemployment in the ASEAN region. Figure 2 presents the youth unemployment rate in ASEAN member countries, shown as blue bars for each country and a horizontal red line representing the ASEAN average youth unemployment of 6.4 percent. Strikingly, Brunei Darussalam recorded the highest youth unemployment rate in ASEAN at 23.3 percent, far exceeding the regional average. This is followed by Indonesia (15.5 percent) and Malaysia (11.1 percent), two countries with large populations and rapidly developing economic structures. The high youth unemployment rate in these countries is likely due to the mismatch between the skills of young graduates and industry needs, limited access to quality job training, and the slow transition to an inclusive digital economy. In contrast, countries such as Cambodia (0.7 percent), Lao PDR (3.6 percent), and Thailand (3.8 percent) recorded relatively low youth unemployment rates, although this needs to be viewed with caution as it may reflect the dominance of the informal sector and low participation in further education.

The youth unemployment rate in ASEAN is also inseparable from the dynamics of trade openness in the region. On the one hand, trade openness can create new job opportunities through increased foreign investment, expansion of the manufacturing industry, and growth of the service sector. However, on the other hand, if it is not balanced with strengthening the capacity of the young workforce, the benefits of free trade will be enjoyed more by skilled workers or foreign workers. This has the potential to worsen youth unemployment, especially in countries that have not been able to integrate their young graduates into the global labor market or regional supply chain.



Source: World Bank, 2023

Figure 3
Youth Unemployment and Trade Openness in ASEAN

Figure 3 presents the relationship between the youth unemployment rate in ASEAN and trade openness from 2010 to 2023. In the early years (2010–2014),

ASEAN trade openness was relatively high and stable, while youth unemployment remained at a high range of around 118%. This shows that high international trade does not necessarily automatically absorb young workers, especially

if they do not have the skills needed by the global industry. During this period, although export markets grew, the transformation of the production sector was not fully inclusive of young workers with minimal experience and digital skills. Entering the 2015–2020 period, there was a significant decline in trade openness, especially in 2019–2020, which was likely influenced by the global economic slowdown and the impact of the COVID-19 pandemic. At the same time, youth unemployment increased drastically, reaching its peak in 2017 and 2020. Limited mobility, job closures, and economic uncertainty make young people the group most vulnerable to the impacts of the crisis. These data strengthen the argument that when trade disruptions or economic contractions occur, young workers are often the main victims.

Figure 3 also explains the post-pandemic period, in 2021–2022, there was a significant recovery in trade openness, again touching above 8%. Interestingly, this was followed by a gradual decline in youth unemployment, indicating a positive correlation when trade began to recover and job opportunities reopened. However, in 2023, even though trade slowed down again, youth unemployment still did not experience a significant spike, indicating that structural adaptations may have occurred, such as an increase in the role of the digital economy, online work, or youth entrepreneurship initiatives.

Issues and phenomena regarding youth unemployment, ICT, and trade openness have been outlined, so the next step is to review the relationship between these variables. Information and Communication Technology (ICT) emphasizes that increasing adoption and penetration of information technology can reduce unemployment, especially among young people, by creating new types of digital-based jobs and expanding access to online job opportunities. ICT acts as an enabler of the digital economy, which opens up pathways for youth entrepreneurship, gig economy platforms, and remote work models that are increasingly inclusive of workers without conventional industry experience (Raza & Raza, 2024). On the other hand, although information and communication technology (ICT) is often seen as a solution to expand employment opportunities, especially in the digital era, some evidence suggests that ICT can also deepen the challenges of youth unemployment. Irawan (2013) noted that low levels of ICT utilization and economic structures that do not yet support the technology sector have caused lower-middle-income countries to not gain maximum benefits from ICT developments, thus failing to reduce youth unemployment. Yong et al. (2019) not all individuals or groups have equal access and ability to utilize digital technology. In the context of the youth workforce, this inequality creates structural barriers because many young people, especially in developing countries, do not yet have the basic digital skills needed in a technology-based labor market. Haini & Loon, (2022) also stated that ICT tends to strengthen the demand for highly skilled workers, while eliminating conventional jobs that are generally filled by young workers with minimal experience. This causes young people who do not have technological competence to be excluded from the new production system, exacerbating youth unemployment.

Trade openness has the potential to reduce unemployment rates by opening access to a wider labor market and encouraging the expansion of labor-intensive sectors such as manufacturing and export services. However, its impact on young workers is highly dependent on the readiness and suitability of the skills possessed by this age group. If young workers do not have skills that match the needs of the global industry, then they will not be absorbed in the trade expansion process. In addition, free trade can

also trigger economic restructuring that leads to automation and production efficiency, which ironically can replace the role of young workers with technology. In situations like this, trade openness increases the risk of youth unemployment in countries that have not succeeded in aligning trade policies with strategies for improving the quality of human resources.

Trade openness can also be understood as a strategic opportunity to overcome youth unemployment, especially if supported by domestic policies that support skills development and innovation. In the classical and neoclassical economic perspective, international trade allows countries to allocate resources more efficiently and access wider global markets, thereby creating new demand for labor, including young people. As export sectors develop, especially in labor-intensive or medium-tech industries such as manufacturing, modern agribusiness, and digital services, job opportunities for young workers will increase. In addition, trade can encourage the transfer of technology and knowledge, which, if utilized through vocational training and education, can increase the competitiveness of young workers in the global market. In this context, trade openness catalyzes to encouragement of young workers' participation in the formal economy, especially if the country succeeds in creating an ecosystem that supports young entrepreneurs, industrial internships, and collaboration with the global private sector.

The research gap found from the results of the analysis of previous studies, namely, there are differences in empirical results that highlight the positive effects of ICT on youth unemployment, especially in countries with supporting digital infrastructure. However, challenges such as the digital infrastructure gap are still obstacles in several countries, especially developing countries. Likewise, trade openness can contribute to reducing youth unemployment, but on the other hand, without appropriate protection policies, trade openness also has the potential to worsen unemployment due to competitive pressures and industrial automation. The findings of previous studies still show mixed and contradictory results, some stating that ICT and trade reduce unemployment, while others emphasize the potential for increasing inequality due to inequality of access and digital skills. The differences in research results indicate the need for a more holistic approach in analyzing the impact of ICT and trade openness on youth unemployment. This study proposes an empirical approach based on panel data to examine the use of ICT and trade openness on youth unemployment in ASEAN countries over a period covering the period as well as before and after the implementation of the AEC. This study is important because analyzing how ICT and trade openness have a real impact on youth unemployment will not only enrich the scientific literature but also become a strong basis for formulating inclusive and evidence-based policies to accelerate the absorption of young workers in the digital economy era.

LITERATURE REVIEW

According to the Ricardian Theory, barrier-free foreign trade can reduce unemployment. This is because foreign trade will increase the domestic price of a product produced domestically, thereby increasing the marginal product of labor. The marginal product of labor has increased will create employment opportunities so as to reduce unemployment. The Heckscher-Ohlin theory assumes that there are two sectors and two factors (labor and capital). Conditions before conducting foreign trade, the relative prices of labor-intensive products will be lower than the relative prices of capitalintensive

products, but the existing labor force is absorbed more so youth unemployment decreases. Furthermore, a country carries out foreign trade freely, so there will be an increase in the relative price of capital-intensive products. This will lead to an increase in the demand for capital in return for labor, which in the end the average wage rate will decrease and unemployment will increase.

Several studies have suggested that increasing ICT adoption contributes positively to reducing youth unemployment through digital job creation, namely, Raza & Raza (2024) found that the ICT index significantly reduces unemployment in Asia, provided there is support for secondary education and pro-ICT policies. Wu (2023) noted that the digital economic transformation in China has succeeded in reducing youth unemployment, especially through strengthening the digital and e-commerce sectors. Hashim et al. (2024) in the Malaysian context found a strong long-term relationship between the contribution of the ICT sector to reducing youth unemployment.

Jimoh et al. (2023) developed an ICT-based framework for youth empowerment in Nigeria, focusing on digital training and youth entrepreneurship. However, several studies have shown the challenging side of ICT, namely, Alao et al. (2024) showed that the lack of ICT education exacerbates youth unemployment, especially among women in developing countries. Masavah et al. (2023) highlighted that limited digital literacy is a barrier to the use of ICT for job search among young people in South Africa

While ICT has an ambivalent role, trade openness also shows a dual effect, namely, Ali & Almula-Dhanoon (2021) showed that trade openness hurts youth unemployment in Arab countries, meaning that the more open an economy is, the lower its youth unemployment rate, when combined with FDI and macroeconomic stability. On the other hand, Wainaina (2025) stated that trade openness in Sub-Saharan countries hurts GDP, which risks worsening unemployment if not balanced with local sector protection policies and increasing workforce capabilities. Yaqin & Sulistyono (2024) showed that trade openness contributes to economic growth in ASEAN, which indirectly supports job creation, including for young workers. Azhar (2023) in a study in MENA stated that international trade has a positive impact on reducing youth unemployment, as long as it is accompanied by increased productivity and domestic investment. Choi (2024) stated that there is a phenomenon of "diminishing returns" where the impact of digital trade increases at the beginning but decreases in the next phase if it is not supported by continuous technological innovation. Queirós et al. (2025) found that high-tech products hurt employment in Brazil, mainly because automation replaces young workers with low skills.

METHOD

This study uses time series data for the research period from 2000 to 2023 in ASEAN countries. The early 2000s marked an important phase when ASEAN countries became increasingly active in trade liberalization and regional integration. This period allows for longitudinal analysis of the impact of trade openness on youth unemployment. Additionally, the 2000–2023 timeframe covers the phase of massive adoption of information technology in Southeast Asia, including internet penetration, mobile connectivity, and the digital economy. This period is appropriate for observing the relationship between digitalization and youth unemployment. With this coverage, the study can evaluate how the labor systems and digital sectors responded to economic

pressures and their impact on youth unemployment. ASEAN was chosen because it has a large youth population and high youth unemployment rates in many of its member countries. This makes the region relevant for examining the challenges and potential structural transformation in the labor market.

The data source used in this study is from the World Bank. The data utilized are secondary data systematically collected and processed by the World Bank in a reliable manner. Secondary data was chosen because it covers extensive and comprehensive information on economic and social indicators, and is available in a standardized format, facilitating analysis and comparison across countries. Using secondary data also allows for efficiency in time and cost in this research.

The data used in this study include youth unemployment, male youth unemployment, and female youth unemployment as the dependent variable, while ICT and trade openness serve as independent variables. Control variables consist of economic growth, FDI, and birth rate. Economic growth and FDI are not the primary focus of this study on ICT and trade openness; therefore, they need to be controlled to avoid influencing the estimated effects of ICT and trade openness on youth unemployment. The birth rate affects the size of the youth labor force in the medium and long term. It is important to control for this variable to ensure that the relationship between ICT and youth unemployment is not biased by demographic pressure. Proxy of ICT is variables such as Internet users (% of population), Mobile Cellular Subscriptions per 100 People, and Fixed Broadband Subscriptions per 100 People. Variables Mobile Cellular Subscriptions per 100 People, and Fixed Broadband Subscriptions per 100 People and Crude Birth Rate (per 1,000 people) were transformed using the natural logarithm (ln). Log transformation helps reduce the influence of extreme or large outlier data, making the analysis more robust. Below is an explanation related to the variables used:

Table 1 Operational Definition

Variable Type	Variable Name	Indicator / Proxy	Operational Definition	Academic Justification
Dependent Variable	Youth Unemployment	Youth Unemployment Rate (ages 15–24)	Percentage of population aged 15–24 actively seeking work but currently unemployed.	Represents the most vulnerable age group in the labor market; indicates mismatch between the education system and labor demand.
Independent Variables	ICT (Digitalization)	Internet Users (% of population)	Percentage of individuals who have used the internet from any location in the past three months.	Reflects digital access and readiness; can create or replace jobs depending on human resource preparedness.
		Mobile Cellular Subscriptions (per 100 people)	Number of active mobile cellular subscriptions (postpaid and active prepaid accounts used within the last 3 months) per 100 people in a country.	Measures mobile phone penetration; reflects access to modern communication technology and infrastructure progress influencing productivity and inclusion.
		Fixed Broadband Subscriptions (per 100 people)	Number of active fixed broadband subscriptions per 100 people in a country or region at a given time.	Measures access to fixed broadband infrastructure supporting economic, educational, and governmental activities; fosters innovation and productivity.
	Trade Openness	(Exports + Imports) / GDP	Ratio of total exports and imports of goods	Trade can create employment but may also

			and services to Gross Domestic Product.	increase competition and drive labor market shifts.
Control Variables	Economic Growth	GDP Growth (% annual)	Annual percentage change in real GDP as an indicator of national economic growth.	According to Okun's Law, economic growth typically reduces unemployment by increasing labor demand.
	Foreign Direct Investment	FDI Net Inflows (% of GDP)	Net inflows of foreign direct investment as a percentage of GDP.	FDI can create jobs and transfer technology; impact varies depending on whether investments are labor-intensive or capital-intensive.
	Fertility	Crude Birth Rate (per 1,000 people)	Number of live births per 1,000 population in a given year.	Indicates demographic pressure; a youth bulge can lead to higher youth unemployment if not accompanied by sufficient job creation.

The analytical technique used in this study is Panel FMOLS. Pedroni (2001) extended the concept of Fully Modified OLS (FMOLS), originally introduced by Phillips & Hansen (1990) in the context of time series data, into panel data analysis. Panel FMOLS is particularly suitable when the variables analyzed are non-stationary but exhibit a long-term relationship (cointegration). The stages in Panel Fully Modified Ordinary Least Squares (FMOLS) begin with stationarity testing on the panel data using unit root tests such as Levin, Lin & Chu (LLC) to ensure that the variables are non-stationary at the level and become stationary after the first differentiation. Following this, a cointegration test is conducted to determine whether a long-term relationship exists between the variables, typically using methods such as the Kao Cointegration Test. If cointegration is detected, the next step is Panel FMOLS estimation, which aims to address issues of endogeneity and autocorrelation in standard OLS regression using non-parametric adjustments.

Panel Data Stationarity Test

In panel data analysis, the stationarity test is crucial before running regression, especially when using long-term models such as Panel FMOLS or Panel Cointegration. The purpose of this test is to determine whether a variable follows a fixed time trend (stationary) or contains a unit root (non-stationary), which can lead to spurious (false/invalid) regression results. A dataset is considered stationary if it has a constant mean over time, constant variance, and stable covariance across time periods. If these criteria are not met, the data is classified as non-stationary ($I(1)$), requiring differentiation or transformation to make it stationary.

Levin, Lin & Chu (LLC) (2002) developed a unit root test method for panel data under the assumption of homogeneity of unit roots across individuals in the panel. This means that the test assumes the same level of stationarity in each cross-section unit (e.g., each country in an ASEAN panel). Homogeneity of unit roots, the LLC test assumes that all cross-sectional units (e.g., countries, firms) share a common unit root process, meaning the autoregressive coefficient (ρ) is identical across units. Individual Fixed Effects, the model allows for individual-specific intercepts, acknowledging that each cross-sectional unit may have its own average level. Cross-sectional Independence, the standard LLC test assumes that cross-sectional units are independent of each other. In

the presence of cross-sectional dependence, the test statistics may be biased unless adjustments are made. Identical Lag Structure (Optional), while lags of the differenced terms can vary by unit, in practice LLC sometimes assumes a common lag length across units to simplify estimation. Large Time Dimension ($T > N$), the test performs better when the number of time periods (T) is larger than the number of cross-sectional units (N), as it relies on asymptotic properties. Below is the ADF model introduced by Levin, Lin & Chu (2002):

$$\Delta y_{it} = \alpha_i + \rho y_{it-1} + \sum_{j=1}^p \beta_{ij} \Delta y_{it-j} + \varepsilon_{it} \dots \dots \dots (1)$$

In this equation, y_{it} represents the variable being tested for stationarity, where i indexes the cross-sectional units (such as countries) and t denotes the time periods. The operator Δ indicates the first difference, capturing changes from one period to the next. The key parameter of interest is ρ , which determines whether the data series contains a unit root. If $\rho=0$ the variable is considered non-stationary (i.e., it contains a unit root), whereas if $\rho < 0$, the variable is stationary. The model allows for individual-specific intercepts (α_i) and includes lagged differences to account for serial correlation in the error term. A critical assumption of the LLC model is the homogeneity of the autoregressive coefficient ρ across all cross-sectional units, although intercepts and error structures may vary. This test is particularly suitable for panel data with a large time dimension ($T > N$) and provides more robust results than individual time-series unit root tests when the homogeneity assumption holds.

KAO Cointegration Test

The Kao Cointegration Test is a statistical method used to determine whether there is a long-term equilibrium relationship between variables in panel data. It is an extension of traditional cointegration tests applied to time series data but adapted for panel settings. The test was developed by Kao (1999) and is widely used in econometrics. The Kao test examines whether the residuals of a panel regression model are stationary. If the residuals are stationary, the variables are considered cointegrated, meaning there is a stable long-term relationship between them. This test adopts the residual-based cointegration approach introduced by Engle-Granger, which has been modified for panel data. The main assumption is that the cointegration coefficients are homogeneous across all cross-sectional units. The residuals are tested for stationarity

using the Augmented Dickey-Fuller (ADF) test, under the assumption of independence among units or weak dependence. The hypothesis test follows:

H_0 (Null Hypothesis) : No cointegration (residuals contain a unit root/non-stationary).

H_1 (Alternative Hypothesis) : Cointegration exists (residuals are stationary).

If the residuals are found to be stationary (p -value of the test $<$ significance level), it indicates that the dependent and independent variables share a long-term relationship (cointegrated).

Cointegration testing aims to determine whether there is a long-term relationship between independent variables, even if they are non-stationary, but their linear combination can be stationary. The cointegration test used in this study is the Kao Residual Cointegration Test. Kao & Chang (2000) stated that there are two types of cointegration tests, namely the Dickey-Fuller (DF) test and the Augmented Dickey-Fuller (ADF) test. Kao (1999) applied DF and ADF to test cointegration in panel data,

following a standard approach adopted from the Engle-Granger procedure. Kao (1999) developed the DF and ADF statistical tests, which are used to examine cointegration in panel data.

$$\text{ADF } t = \frac{t_{\text{ADF}} + \frac{\sqrt{6N}\hat{\sigma}_\nu}{2\hat{\omega}_\nu}}{\sqrt{\frac{\hat{\omega}_\nu^2}{2\hat{\sigma}_\nu^2} + \frac{3\hat{\sigma}_\nu^2}{10\hat{\omega}_\nu^2}}} \dots\dots\dots(2)$$

Panel FMOLS

Created by Phillips & Hansen (1990), the panel Fully Modified Ordinary Least Squares (FMOLS) method is an analytical tool designed to provide optimal results for models exhibiting cointegration in regression analysis. By addressing endogeneity—a critical component in cointegrated relationships—and serial correlation, this method modifies the conventional Ordinary Least Squares (OLS) approach. The presence of serial correlation in a model can affect the estimates produced by OLS, making them no longer the Best Linear Unbiased Estimator (BLUE), as required by the Gauss-Markov theorem. The panel FMOLS approach accounts for endogeneity, serial correlation, and heterogeneity across individuals, thereby producing consistent and reliable estimates (Pedroni, 2000).

The panel FMOLS method adjusts the OLS estimation process to accommodate cointegration. Since OLS estimators are known to be biased and inconsistent in the presence of cointegration, several alternative estimation techniques have been proposed (Nasreen & Anwar, 2014). While OLS is useful for basic linear regression analysis when the classical assumptions are met (e.g., residuals free from autocorrelation, cointegration, or endogeneity), it is faster and simpler. However, if the data exhibit cointegration, OLS results may become biased and inconsistent. In contrast, the panel FMOLS method is specifically developed to address cointegration issues in panel data. By correcting for endogeneity and autocorrelation, FMOLS provides more accurate and unbiased estimations. In this study, the long-run equilibrium relationship is estimated using the FMOLS method.

The estimated parameter values of FMOLS and OLS differ because FMOLS uses the covariance factor as a “bias correction.” A general model of the panel FMOLS is as follows:

$$y_{it} = a_i + \alpha_i X_{it} + \hat{L}_{it} \text{ dengan } X_{it} = X_{it-1} + \varepsilon_{it} \dots\dots\dots(3)$$

Where a_i represents the intercept and α_i is the vector of cointegration coefficients, under the condition that there is cointegration between y_{it} and X_{it} , and L_{it} is the error term. In this study, FMOLS is used to provide estimates that account for heterogeneity by using cross-section-specific estimates of long-run covariance prior to conducting the FMOLS estimation.

Long-run covariance refers to the correlation or relationship between two variables in a regression model. In panel data analysis, it is important to account for the covariance between the observed variables, especially in situations where these variables may have a long-term relationship or cointegration (Pedroni, 1999). The estimation results will be discussed based on theory to demonstrate the magnitude and interpretation of the findings. The following is the panel FMOLS analytical model used:

$$Yun_{it} = \alpha_{11} + \alpha_{12}ICT1_{it} + \alpha_{13}Ln(ICT2)_{it} + \alpha_{14}Ln(ICT3)_{it} + \alpha_{15}TO_{it} + \alpha_{16}FDI_{it} + \alpha_{17}EG_{it} + \alpha_{18}Ln(BR)_{it} + e_{1it} \dots \dots \dots (4)$$

Yun is youth unemployment the dependent variable. ICT1, ICT2, dan ICT3 adalah Internet users (% of population), Mobile Cellular Subscriptions per 100 People, and Fixed Broadband Subscriptions per 100 People. TO adalah *trade openness*. FDI adalah Net inflows of foreign direct investment as a percentage of GDP. EG refers to economic growth, while BR represents the birth rate. The subscript i denotes ASEAN member countries, and t represents the years 2000–2023. The variable e is the error term, while Ln indicates the natural logarithm. The terms α_{11} to α_{31} represent the constants, while α_{13} to α_{38} denote the coefficients of each variable and control variable.

Robustness Check

The primary purpose of a robustness check is to ensure that the relationships identified in the main model are not coincidental or dependent on a specific model specification. This procedure is carried out by re-estimating the panel FMOLS model with the inclusion of a dummy variable. If the estimation results remain consistent in terms of direction and statistical significance despite the model modification, the findings can be considered robust. Thus, the robustness check serves as a validation tool to enhance the empirical credibility and validity of the econometric research conducted. This study chooses to modify the control variables.

$$Yun_{it} = \beta_{11} + \beta_{12}ICT1_{it} + \beta_{13}Ln(ICT2)_{it} + \beta_{14}Ln(ICT3)_{it} + \beta_{15}TO_{it} + \beta_{16}FDI_{it} + \beta_{17}EG_{it} + \beta_{18}Ln(BR)_{it} + \beta_{19}D_{MEA} + e_{1it} \dots \dots \dots (5)$$

The D_{MEA} variable represents a dummy variable. It takes the value of 0 for the period before the ASEAN Economic Community (AEC) implementation (2000–2014), and the value of 1 for the AEC period (2015–2023).

RESULTS

Table 1 presents the descriptive statistics in this study. Based on the descriptive statistics from 240 observations, the average youth unemployment rate (YUN) is 8.55 percent, with considerable variation (a standard deviation of 6.77), where the minimum value is only 0.38 percent and the maximum reaches 30.81 percent. Economic growth (EG) has an average rate of 5.04 percent, but with a high standard deviation of 3.86, reflecting considerable fluctuations in growth across observations. Notably, there is a negative minimum value of -12.02 percent, indicating economic contraction in certain countries or periods. Meanwhile, foreign direct investment (FDI) shows a negative average of -3.23 percent of GDP, with a similar standard deviation (3.86). The minimum value of -18.66 percent suggests that most countries in the sample experienced FDI outflows, indicating an unstable foreign investment climate. In terms of trade openness (TO), the average is remarkably high at 118.85 percent of GDP, with significant variation (standard deviation of 95.55). The maximum value reaches 437.33 percent, indicating that some countries are highly dependent on international trade. Fertility rate (FER) is relatively moderate, with an average of 2.27 births per 1,000 women of reproductive age

and a standard deviation of 0.70, reflecting an ongoing demographic transition in most countries.

Technology use and digital access also show considerable disparities. The average mobile phone ownership is 87.05 per 100 people, but with a high standard deviation of 53.53 and a maximum of 181.77, indicating multiple device ownership in some countries. On the other hand, fixed broadband subscriptions (FBS) remain low, with an average of only 5.50 per 100 people and a maximum of 28.54, highlighting limited digital infrastructure. Meanwhile, average internet usage (INTRNT) stands at 36.96 percent of the population, with a standard deviation of 31.01 and a minimum of 0 percent, indicating a substantial digital divide across countries.

Table 1 Descriptive Statistic

Variabel	Mean	Std. Dev.	Min	Max	Observations (N)
yun (%)	8.547	6.768	0.375	30.809	240
eg (%)	5.036	3.863	-12.016	14.520	240
fdi (%)	-3.233	3.863	-18.656	4.576	240
to (%)	118.848	95.554	0.000	437.327	240
fer (per 1,000 people)	2.267	0.699	0.970	4.429	240
mobile (per 100 People)	87.052	53.527	0.029	181.767	240
fbs (per 100 People)	5.503	7.663	0.000	28.539	240
Intrnt (%)	36.961	31.013	0.000	99.000	240

Note: yun, eg, fdi, to, fer, mobile, fbs, intrnt adalah Youth Unemployment Rate (ages 15–24), Male Youth Unemployment Rate (ages 15–24), Female Youth Unemployment Rate (ages 15–24), GDP Growth (% annual), FDI Net (% of GDP), (Exports + Imports) / GDP, Crude Birth Rate (per 1,000 people), Mobile Cellular Subscriptions per 100 People, Fixed Broadband Subscriptions per 100 People, Internet users (% of population)

Table 2 shows that the youth unemployment rate slightly increased from an average of 8.446% before the ASEAN Economic Community (AEC) to 8.708% during the AEC period, with the standard deviation remaining relatively stable. Although the increase is not substantial, it suggests that economic liberalization under the AEC framework has not significantly reduced youth unemployment and may have even slightly worsened it. Secondly, the economic growth variable experienced a sharp decline. Before the AEC, the average economic growth rate was 5.917%, but it dropped to 3.385% during the AEC period. This indicates that the implementation of the AEC has not provided a significant boost to domestic economic growth, and may even have introduced disruptions due to increased competition within the free market among ASEAN member countries.

Thirdly, foreign direct investment flows declined further from -2.776% to -4.029%. The negative FDI values indicate capital outflows, which may signal low investor confidence during the AEC period or a high dependency on sectors that are not attractive enough to foreign investors post-regional integration. Fourthly, trade openness also decreased from 124.156% to 109.632%. This is somewhat ironic, considering that the AEC aims to open markets among countries. The decline could be due to competitive imbalances, where countries with weaker competitiveness experienced a relative decrease in trade volume as a share of GDP. Fifth, the fertility rate (FER) declined from 2.429 to 1.974 births per 1,000 population, which is consistent with global and regional trends of declining birth rates. However, this may have implications for the future availability of young labor.

Sixth, in terms of technology and digital infrastructure, there has been a very significant increase. Mobile phone ownership rose sharply from an average of 62.522 to 129.058 per 100 people, indicating rapid technological penetration. Likewise, fixed broadband subscriptions increased from 3.287 to 9.509 per 100 people, and internet usage surged from 21.776% to 65.053%. This increase reflects strong digital adoption during the AEC period and represents a major opportunity for digital economic growth, although it has not yet been fully reflected in overall economic growth figures. Overall, despite progress in technology and digital connectivity during the AEC period, significant challenges remain in the areas of youth employment, foreign investment, and economic growth. Regional integration appears to have not yet fully optimized economic fundamentals, particularly in terms of creating productive employment and attracting foreign capital inflows. Therefore, more adaptive policies are needed to align the benefits of the AEC with the domestic strengths of each country.

Table 2 Descriptive Statistic of Before AEC and AEC Period

Variabel	Sebelum MEA				Masa MEA			
	Mean (N=150)	Std. Dev.	Min	Max	Mean (N=80)	Std. Dev.	Min	Max
yun (%)	8.446	6.828	0.598	26.301	8.708	6.612	0.375	30.809
eg (%)	5.917	3.433	-3.901	14.520	3.385	4.240	-12.016	9.691
fdi (%)	-2.776	3.278	-13.647	4.431	-4.029	4.747	-18.656	4.576
to (%)	124.156	99.040	0.000	437.327	109.632	89.929	0.000	332.981
fer (per 1,000)	2.429	0.749	1.150	4.429	1.974	0.498	0.970	2.744
mobile (per 100)	62.522	49.582	0.029	154.035	129.058	29.463	51.546	181.767
fbs (per 100)	3.287	6.160	0.0001	27.730	9.509	8.534	0.000	28.539
intrnt (%)	21.776	23.228	0.000	80.900	65.053	23.975	0.000	99.000

Note: yun, eg, fdi, to, fer, mobile, fbs, intrnt adalah Youth Unemployment Rate (ages 15–24), Male Youth Unemployment Rate (ages 15–24), Female Youth Unemployment Rate (ages 15–24), GDP Growth (% annual), FDI Net (% of GDP), (Exports + Imports) / GDP, Crude Birth Rate (per 1,000 people), Mobile Cellular Subscriptions per 100 People, Fixed Broadband Subscriptions per 100 People, Internet users (% of population)

Based on the panel stationarity test results using the Levin-Lin-Chu (LLC) method, all variables in the model—both the dependent variables and the independent variables such as fdi, eg, to, lnfer, lnmobile, intrnt, and lnfbs were found to be non-stationary at level. This is indicated by p-values all above 0.1, meaning there is insufficient evidence to reject the null hypothesis that the variables contain a unit root. This non-stationarity issue can be addressed through first differencing. After transforming the variables into their first differences, all variables consistently became significantly stationary, with p-values of 0.0000 for most variables and 0.0001 for the

variable d.intrnt. This indicates that each variable only needed to be differenced once to achieve stationarity, or in econometric terms, they are integrated of order one, I(1).

Table 3 LLC Test (Panel Stationary Test)

Variable	Form	p-value	Description	Variable	Form	p-value	Description
yun	Level	0.6591	Non-stationary	D.yun	First Diff.	0.0000** *	Stationary
fdi	Level	0.7934	Non-stationary	D.fdi	First Diff.	0.0000** *	Stationary
eg	Level	0.9885	Non-stationary	D.eg	First Diff.	0.0000** *	Stationary
to	Level	0.8850	Non-stationary	D.to	First Diff.	0.0000** *	Stationary
Infer	Level	0.9876	Non-stationary	D.Infer	First Diff.	0.0000** *	Stationary
Inmobile	Level	0.9463	Non-stationary	D.Inmobile	First Diff.	0.0000** *	Stationary
intrnt	Level	0.9969	Non-stationary	D.intrnt	First Diff.	0.0001** *	Stationary
lnfbs	Level	0.7499	Non-stationary	D.lnfbs	First Diff.	0.0000** *	Stationary

Note: yun, eg, fdi, to, fer, mobile, fbs, intrnt adalah Youth Unemployment Rate (ages 15–24), Male Youth Unemployment Rate (ages 15–24), Female Youth Unemployment Rate (ages 15–24), GDP Growth (% annual), FDI Net (% of GDP), (Exports + Imports) / GDP, Crude Birth Rate (per 1,000 people), Mobile Cellular Subscriptions per 100 People, Fixed Broadband Subscriptions per 100 People, Internet users (% of population)

Based on the results of the panel cointegration test (Table 4) using the Pedroni method, there is strong evidence of a long-run relationship or cointegration among the variables analyzed across all three models. Table 4 shows that all types of test statistics indicate high significance: the Modified Phillips-Perron t-statistic is 2.6615 with a p-value of 0.0039, the Phillips-Perron t-statistic is -7.6029 with a p-value of 0.0000, and the Augmented Dickey-Fuller (ADF) t-statistic is -4.8878 with a p-value of 0.0000. This indicates that a stable long-run relationship exists between the dependent and independent variables in the model. These results demonstrate that the long-run relationship among the variables is strong and valid, meaning that long-term estimations are appropriate for use in further analysis.

Table 4 Kointegration Test

Jenis Statistik	Statistik	p-value	Keterangan
Modified Phillips-Perron t	2.6615	0.0039	Kointegrasi
Phillips-Perron t	-7.6029	0.0000	Kointegrasi
Augmented Dickey-Fuller t (KAO test)	-4.8878	0.0000	Kointegrasi

Based on the panel regression estimation results in Table 5, it is found that economic growth and foreign direct investment (FDI) have negative coefficients of -0.07 each, indicating that increases in these two variables contribute to a reduction in youth unemployment. This means that a 1% increase in economic growth or FDI is associated with a 0.07% decrease in the youth unemployment rate. Conversely, the variable trade openness has a positive coefficient of 0.01, indicating that increased trade may actually lead to higher youth unemployment. A 1% increase in the trade openness ratio, *ceteris paribus*, will increase the youth unemployment rate by 0.01%. Digitalization shows mixed effects. Internet usage (% of the population) and mobile subscriptions both have negative coefficients of -0.01, meaning that a 1% increase in the proportion of the population using the internet will reduce youth unemployment by 0.01%, *ceteris paribus*. The coefficient for mobile subscriptions is -2.73, which means that a 1% increase in the number of mobile subscriptions will reduce the youth unemployment rate by 0.0273 percentage points, *ceteris paribus*. Furthermore, the fertility rate also has a positive effect on youth unemployment, with a coefficient of 0.83. This indicates that a 1% increase in the fertility rate will raise the youth unemployment rate by 0.0083 percentage points, *ceteris paribus*.

Table 5. FMOLS Result (Dependent Variable is Youth Unemployment)

Independent Variable	Coefficient	t-Statistic	Standard Error	t-Table	Significance
Economic Growth	-0.07	-12.43	0.00563	1.96	Significant
Foreign Direct Investment	-0.07	-8.49	0.00824	1.96	Significant
Trade Openness	0.01	-21.47	0.00047	1.96	Significant
Internet Usage	-0.01	5.88	0.00170	1.96	Significant
Log of Fixed Broadband Subscriptions	1.31	17.03	0.07694	1.96	Significant
Log of Fertility Rate	0.83	9.69	0.08565	1.96	Significant
Log of Mobile Subscriptions	-2.73	-28.37	0.09623	1.96	Significant

The coefficient of 0.62 on Table 6 indicates that the average youth unemployment rate was 0.62 percentage points higher during the AEC (ASEAN Economic Community) period compared to the pre-AEC period. This may suggest that regional integration through the AEC has not fully benefited youth employment absorption, possibly due to increased labor competition or a lack of preparedness among the domestic workforce. With the inclusion of the AEC dummy, economic growth has a negative and significant impact on youth unemployment. A 1% increase in economic growth is associated with a 0.001 percentage point decrease in youth unemployment, indicating that economic growth helps reduce unemployment, although the effect is relatively small. Each 1% increase in FDI leads to a 0.03 percentage point decrease in youth unemployment. However, its effect has declined compared to the model without the dummy, suggesting that FDI during the AEC era has not optimally absorbed young labor directly.

Trade openness has a positive coefficient, meaning that every 1% increase in trade openness raises youth unemployment by 0.02 percentage points. This may indicate that trade liberalization, without adequate readiness of the domestic workforce, increases labor market competition and unemployment. Internet usage contributes to reducing youth unemployment. Each 1% increase in internet penetration lowers youth

unemployment by 0.01 percentage points, reflecting the benefits of digitalization in supporting job opportunities for young people. Each 1% increase in fixed broadband subscriptions is associated with a 0.0125 percentage point increase in youth unemployment, *ceteris paribus*. The fertility rate has a strongly positive effect. A 1% increase in fertility rate raises youth unemployment by 0.0357 percentage points, suggesting that a rise in birth rates increases the number of young job seekers without a corresponding increase in job availability. An increase in mobile phone subscriptions is negatively correlated with youth unemployment. Each 1% rise in mobile subscriptions reduces youth unemployment by 0.0262 percentage points, indicating that access to mobile technology potentially enhances productivity, access to labor market information, and opportunities in informal or digital employment.

Table 6. Robustness Check

Variabel	No Dummy			With Dummy			t-Table	Significance
	Coefficient (yun)	t-Statistic (yun)	Standar Error (yun)	Coefficient (yun_mea)	t-Statistic (yun_mea)	Standar Error (yun_mea)		
MEA (dummy)	-	-	-	0.62	7.19	0.08627	1.96	Significant
Economic Growth (eg)	-0.07	-12.43	0.00563	-0.10	-16.30	0.00613	1.96	Significant
Foreign Direct Investment	-0.07	-8.49	0.00824	-0.03	-4.27	0.00703	1.96	Significant
Trade Openness (to)	0.01	-21.47	0.00047	0.02	-12.85	0.00156	1.96	Significant
Internet Usage (intrnt)	-0.01	5.88	0.00170	-0.01	-4.45	0.00225	1.96	Significant
Log Fixed Broadband (lnfbs)	1.31	17.03	0.07694	1.25	19.02	0.06572	1.96	Significant
Log Fertility Rate (lnfer)	0.83	9.69	0.08565	3.57	8.00	0.44625	1.96	Significant
Log Mobile Subs (lnmobile)	-2.73	-28.37	0.09623	-2.62	-27.52	0.09521	1.96	Significant

The robustness check was performed by incorporating a dummy variable (DMEA) into the panel FMOLS model to test whether the core findings remain consistent under a modified model specification. The results confirm that most coefficients retain their direction and statistical significance, suggesting that the main relationships in the baseline model are robust. The DMEA variable, which captures the implementation of the ASEAN Economic Community (AEC), has a positive and statistically significant coefficient (0.62), indicating that youth unemployment was on average 0.62 percentage points higher during the AEC period (2015–2023) compared to the pre-AEC period (2000–2014). This could reflect challenges in labor market readiness amid regional integration. Economic growth continues to exhibit a negative and significant association with youth unemployment, confirming its role in alleviating joblessness, although the effect remains relatively small. Foreign Direct Investment (FDI) maintains a negative influence but with a reduced magnitude, implying that FDI during the AEC period may have been less effective in absorbing young labor, possibly due to capital-intensive investment patterns. Trade openness, which was initially negative, turns positive in the robustness model, suggesting that increased trade without

adequate domestic workforce preparedness may have intensified labor market competition, worsening youth unemployment. Technological variables such as internet usage and mobile subscriptions continue to demonstrate negative and significant effects, highlighting the positive role of digital access in expanding youth employment opportunities. Notably, the fertility rate shows a larger and still significant coefficient, suggesting that rising birth rates, especially during the AEC period, may have added pressure to the youth labor market. Overall, the robustness check confirms that the empirical findings are stable and credible, even when the model specification is altered.

DISCUSSION

The estimated coefficient of -0.07 indicates that a 1% increase in economic growth is associated with a 0.07 percentage-point decrease in youth unemployment, holding other variables constant. This finding aligns with the theoretical foundation of Okun's Law, which predicts that higher GDP growth reduces unemployment. Although the effect appears modest, it is statistically significant and confirms that economic expansion contributes, albeit incrementally, to reducing youth joblessness. Support for this relationship comes from youth unemployment in ASEAN-5. They report that GDP growth exerts a significant negative long-term effect on youth unemployment, while foreign direct investment and population growth had no significant direct impact. However, Hasan & Sasana (2020) in *Okun's Law and Youth Unemployment in ASEAN* found that while economic growth is negatively associated with youth unemployment, the effect size varies across countries due to structural issues such as skill mismatch, informality, and insufficient vocational training systems. They argue that growth alone is not enough unless supported by labor market reforms and improved human capital. In conclusion, your estimated coefficient of -0.07 is empirically consistent with regional and national studies, affirming that economic growth helps reduce youth unemployment in ASEAN, though the impact is constrained by structural factors. Policymakers should not rely solely on growth, but must complement it with interventions such as vocational training, education-industry alignment, labor market reforms, and youth-targeted productivity enhancement to convert GDP gains into meaningful employment outcomes.

Coefficient of -0.07 for FDI, implies that a 1% increase in FDI inflows is associated with a 0.07 percentage point reduction in youth unemployment, *ceteris paribus*. This outcome supports the neoclassical perspective where FDI brings capital,

technology transfer, and organizational practices, which should generate employment opportunities, especially when directed toward labor-intensive industries. In the context of broader Asian economies, Nguyen (2022) examines FDI's effect on unemployment, and finds that while FDI directly reduces overall unemployment, digitalization interacts with FDI to further enhance job creation. Notably, in countries where youth digital skills are higher, FDI's negative impact on youth unemployment is more pronounced. Setyanti & Wahyudi (2021) investigate Granger-causal links between FDI inflows and youth employment in ASEAN-5. They find that in Indonesia, Malaysia, the Philippines, and Singapore, FDI inflows lead youth employment improvements, while in Thailand the direction is reversed. Overall, they detect no bidirectional causality implying FDI tends to precede job creation, rather than respond to it. A coefficient of 0.01 for trade openness, meaning a 1% increase in trade openness (exports + imports relative to GDP) is associated with a 0.01 percentage-point increase in youth unemployment, *ceteris paribus*. Although relatively small, the positive sign suggests that greater openness in ASEAN economies may exacerbate youth joblessness rather than reduce it, particularly if young workers are not prepared to compete in open markets. Prasetyo & Amar M. (2022) in Relationship of Trade Openness, Financial Openness, and Unemployment Rate in ASEAN, found that while economic growth and inflation significantly reduce unemployment, trade openness significantly increases overall unemployment in ASEAN, including youth groups. Rashidi (2023), shows that trade openness tends to reduce total unemployment rates in high trade economies like Singapore and Malaysia. This implies that the youth unemployment effect may diverge from aggregate unemployment trends, possibly due to sectoral and skill-level mismatches.

CONCLUSION

Based on the results of research, field observations, and data analysis conducted during the internship period at Bank Syariah Indonesia KCP Mojokerto Gajah Mada, it shows that the Cicil

Emas product is one of the sharia-based investment instruments that is very attractive to the public. It is especially attractive to people of productive age and middle income. The main attractions of this product are the compliance with sharia principles, the gold price that is locked in at the beginning, and the flexible financing scheme. In addition, digital support through the Byond BSI app makes investing more convenient and easier for customers. Data shows that most customers use Cicil Emas as a long-term investment and to preserve the value of their wealth in times of economic instability. The growing number of customers also shows that external variables such as global gold prices, socio-religious events and promotional tactics play a big role in increasing customer interest. Compared to other digital platforms or social media, education provided by bank employees has proven to be the most common source of information. However, to make more people understand and believe in the investment mechanism there are still challenges to overcome, namely the lack of knowledge about Islamic finance. Therefore, more intensive, sustainable and adaptive efforts are needed to advance and educate digital development. If used correctly, the Cicil Emas product has the potential to become one of the catalysts for sharia-based economic growth at both the local and national levels. Coefficient of -0.01 for internet usage indicates that a 1% increase in the proportion of the population using the internet is associated with a 0.01 percentage-point reduction in youth unemployment, *ceteris paribus*. Though modest, this negative association aligns with the theoretical view that digital access empowers youth to connect with job opportunities, engage in online education, and participate in the gig economy. Similarly, research examining public employment services (PES) in the Asia-Pacific region conducted by the International Labour Organization (ILO) emphasizes that digital platforms assist youth jobseekers via remoter registration, skill-matching, and outreach. The study highlights that digitally transformed PES can substantially improve youth access to labor markets, particularly in countries including Indonesia, Philippines, Singapore, and Viet Nam. These findings support negative coefficient for internet usage.

Fixed broadband subscriptions coefficient of 1.31 suggests that a 1% increase in fixed broadband subscriptions is associated with a 0.0131 percentage-point increase in youth unemployment, *ceteris paribus*. This positive relationship may reflect mismatches between digital infrastructure expansion and actual labor market benefits for youth. Briglauer (2024), finds that while broadband infrastructure has positive economic potential, its employment effects depend heavily on complementary skills, policy, and digital uptake strategies. Lukito (2024), finds that fixed broadband subscriptions are positively and significantly associated with employment-to-population ratio, but only insofar as corresponding digital skills and productivity levels are present. Broadband investment increases employment at the aggregate level, yet lacks clear youth-specific employment spill-over when digital readiness is low.

Mobile subscriptions ($\ln \text{mobile}$) has a coefficient of -2.73 , suggesting that a 1% increase in mobile subscriptions reduces youth unemployment by 0.0273 percentage points. This substantial negative effect underscores the role of mobile connectivity in supporting youth access to job markets and entrepreneurship. In African countries, Ogbonna et al. (2022) find that increased mobile phone subscriptions significantly reduce youth unemployment, highlighting ICT diffusion as an important channel for youth employment. Ebaidalla (2015) finds that while, mobile phone subscriptions also correlate negatively, although sometimes insignificantly, with youth joblessness in MENA region. These findings align with your ASEAN result, suggesting the importance of mobile reach even beyond internet penetration. Ahuru et al., (2024) demonstrates that in ECOWAS countries, mobile phone technology significantly reduces youth unemployment, especially when combined with educational attainment and show robust negative relationships between mobile diffusion and youth unemployment. Research by Klonner & Nolen (2010) in rural South Africa shows that moving from no mobile network to full coverage increased overall employment, with even larger gains in female employment highlighting that mobile adoption has transformative socioeconomic effects beyond just telecom growth. Coefficient of -2.73 , reinforcing that greater mobile connectivity is strongly linked with reductions in youth unemployment due to improved labor market access, entrepreneurial opportunities, and democratized access to job information. Coefficient of 0.83 for log fertility rate ($\ln \text{fer}$) indicates a positive association: a 1% increase in fertility corresponds to a 0.0083 percentage-point rise in youth unemployment, *ceteris paribus*. In demographic terms, this

effect reflects the “youth bulge” phenomenon—when rising birth rates lead to large cohorts entering working age simultaneously, creating added pressure on job markets. If labor demand and structural capacity do not expand in tandem, youth joblessness increases. Bloom & Williamson (1998) emphasize that countries experiencing demographic transitions must convert excess labor supply into productive employment, otherwise high fertility can become a liability. A World Bank report (UNFPA and World Bank, 2023) notes that in countries where fertility remains high and growth fails to absorb youth cohorts, youth unemployment tends to rise, especially if digital or service sectors haven’t matured sufficiently. Countries like the Philippines, Indonesia, and Laos with fertility above replacement yet limited high-skilled job creation—exhibit elevated youth unemployment compared to peers like Singapore or Malaysia. This empirical analysis reveals a complex interaction between economic, technological, and demographic factors influencing youth unemployment in ASEAN. The negative coefficient for economic growth confirms the applicability of Okun’s Law, indicating that GDP expansion reduces youth unemployment, although the impact is moderate and constrained by structural challenges like skill mismatch. Similarly, the role of foreign direct investment (FDI) is significant, supporting the view that FDI can enhance youth employment, particularly when coupled with digital readiness and favorable labor market conditions. Internet usage and mobile subscriptions both exhibit statistically significant negative effects on youth unemployment, emphasizing the role of digital connectivity in job creation, access to gig work, and entrepreneurship. The particularly strong influence of mobile technology underlines its accessibility and effectiveness in reaching underserved youth segments. However, fixed broadband’s positive coefficient indicates that infrastructure alone may not translate into employment gains without corresponding digital skills and workforce readiness.

The trade openness coefficient suggests a counterintuitive increase in youth unemployment, indicating that liberalization may harm unprepared youth segments, particularly when job competition intensifies and local industries lack adaptability. Lastly, the positive fertility coefficient (0.83) underscores the demographic burden of high youth population growth on job markets. Without adequate employment expansion, rising fertility exacerbates youth joblessness, consistent with the “youth bulge” theory. In conclusion, youth unemployment in ASEAN is influenced by a blend of economic

growth, digital access, trade dynamics, and demographic pressure. Policy responses must therefore be multidimensional focusing on human capital development, digital inclusion, investment alignment, and fertility management to convert macroeconomic gains into inclusive labor market outcomes for the youth.

Implication

Based on the empirical analysis, economic growth is found to have a negative relationship with youth unemployment, although the effect is relatively moderate. This implies that GDP growth should be directed toward inclusive and labor-intensive sectors to effectively absorb young workers. ASEAN governments need to design development strategies that not only focus on macroeconomic figures but also ensure that youth have access to productive employment, particularly by empowering MSMEs and the informal sector, which often serve as the primary entry point into the labor market. Furthermore, foreign direct investment (FDI) plays a significant role in reducing youth unemployment. However, the benefits of FDI cannot be fully realized without a local workforce that is adequately skilled to meet industry demands. Therefore, improving human capital through vocational training, technical skills development, and strong education–industry linkages is crucial. Governments should also encourage FDI in sectors with high employment potential and that are youth-friendly.

The findings also indicate that increased internet penetration and mobile phone usage significantly reduce youth unemployment, affirming the importance of digitalization as a tool for youth economic empowerment. As such, expanding digital infrastructure, enhancing digital literacy, and supporting the platform-based economy (gig economy) should be key policy priorities. These efforts will not only create new jobs but also foster digital entrepreneurship among youth, especially in rural or remote areas previously underserved by the formal labor market. On the other hand, trade openness, which is often expected to create jobs, is shown to have a positive correlation with youth unemployment, suggesting that trade liberalization has not fully benefited the younger population. This may be due to the low competitiveness of youth labor amid rising global competition. Therefore, trade policy must be complemented by protective measures for sectors that employ a large number of young workers, as well as initiatives to empower young entrepreneurs to compete in regional and global markets. Lastly, the positive correlation between high fertility rates and youth unemployment highlights the need to integrate population and labor market policies. The demographic dividend can be both an opportunity and a challenge. Without proper planning, a surge in the youth population may worsen unemployment rates. Hence, governments should expand access to reproductive health services, quality education, and accelerate the creation of youth-oriented jobs so that this demographic potential can truly be harnessed as a driver of regional economic growth.

Limitation and Future Direction

This study, while providing valuable insights into the macroeconomic and digital determinants of youth unemployment in ASEAN, has several limitations. First, the analysis is based on aggregate panel data, which may mask country-specific heterogeneity in policy implementation, labor market structures, and institutional quality. Future research could conduct country-level studies or employ multi-level modeling to better capture these differences. Second, the study focuses primarily on quantitative

variables and does not incorporate institutional, behavioral, or policy variables such as minimum wage laws, labor protections, or the quality of education and training systems, which are likely to influence youth unemployment dynamics. Integrating such qualitative indicators in future models may yield a more holistic understanding. Third, the data used may not fully capture informal employment and underemployment, which are prevalent among youth in developing ASEAN economies. Future research should consider alternative labor market indicators, including youth inactivity rates, discouraged jobseekers, and time-related underemployment. Additionally, the role of emerging factors such as the platform economy, automation, and climate-related labor displacement warrants further exploration, especially in shaping future youth employment patterns. Finally, longitudinal studies that track cohorts of young individuals over time could provide richer insights into the long-term effects of digital inclusion, FDI, and demographic change on employment outcomes.

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