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TURNING POPULATION PRESSURE INTO PRODUCTIVITY THROUGH DIGITALISATION AND URBAN DENSITY IN ASEAN

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ABSTRACT

This study examines the impact of digitalisation on the economic performance of ASEAN countries from 2015 to 2024, focusing on GNI per capita as a measure of welfare and income. It highlights the growing role of digital platforms, online labor markets, and demographic changes in shaping ASEAN's economy. Using panel data and Two-Stage Least Squares (TSLS), the study addresses endogeneity by instrumenting variables like urban population, growth rates, and youth unemployment for population density, while controlling for demographic and labor factors. Findings indicate that higher population density and increased service-sector employment significantly boost GNI per capita. Internet access further raises income levels, emphasizing the importance of digital infrastructure. In contrast, mobile phone penetration correlates negatively with income, potentially because basic access supports low-wage gig work and informal competition. Inflation reduces welfare, whereas HDI has a positive impact. Overall, digitalisation plays a vital role in increasing income across ASEAN.

KEYWORDS: ECONOMY, DENSITY, POPULATION, DIGITALISATION, ASEAN

ABSTRAK

Kajian ini mengkaji kesan pendigitalan terhadap prestasi ekonomi negara-negara ASEAN dari tahun 2015 hingga 2024, dengan memberi tumpuan kepada PNK per kapita sebagai ukuran kebajikan dan pendapatan. Ia mengetengahkan peranan platform digital, pasaran buruh dalam talian dan perubahan demografi yang semakin meningkat dalam membentuk ekonomi ASEAN. Menggunakan data panel dan Dua Tahap Kuadrat Terkecil (TSLS), kajian ini menangani endogeniti dengan menginstrumentasikan pembolehubah seperti populasi bandar, kadar pertumbuhan dan pengangguran belia untuk kepadatan penduduk, sambil mengawal faktor demografi dan buruh. Penemuan menunjukkan bahawa kepadatan penduduk yang lebih tinggi dan peningkatan pekerjaan sektor perkhidmatan meningkatkan PNK per kapita dengan ketara. Akses internet meningkatkan lagi tahap pendapatan, menekankan kepentingan infrastruktur digital. Sebaliknya, penembusan telefon bimbit berkorelasi negatif dengan pendapatan, berpotensi kerana akses asas menyokong kerja gig bergaji rendah dan persaingan tidak formal. Inflasi mengurangkan kebajikan, manakala HDI mempunyai kesan positif. Secara keseluruhan, pendigitalan memainkan peranan penting dalam meningkatkan pendapatan di seluruh ASEAN.

KATA KUNCI: EKONOMI, KEPATUTAN, POPULASI, PENDIGITALAN, ASEAN

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1. INTRODUCTION

Digitalisation, defined by flexible work arrangements and driven by technological advancements, has undergone significant changes in the global employment landscape. This project-based, short-term, task-focused work model has become more prevalent due to advances in digital technology and increasing urban population density. Technology plays a crucial role in supporting economic growth by better matching supply and demand, reducing job search costs, and enhancing organisational efficiency (Brawley, 2017; Ma, 2024). Meanwhile, urban density creates ideal conditions for the growth of the platform economy, providing a large labor force and consumer base (Ghosh & Ramachandran, 2023). The synergy between digital technology and urban density has reshaped the labor market, presenting both new opportunities and challenges related to well-being and job stability (Talukder *et al*., 2024).

Furthermore, innovations like Shopee, Grab, Gojek, Uber, and Amazon Mechanical Turk have transformed gig work by directly and instantly connecting workers and employers. This expands opportunities for participation and enhances labor efficiency and simplicity (Brawley, 2017). The rise of internet technology has also reduced geographical and informational barriers, enabling more precise matching of workers' skills to user needs (Ma, 2024). Additionally, the deployment of advanced technologies, such as the Internet of Things (IoT) and 5G, in urban areas has enhanced flexible work options through real-time monitoring and decentralised transactions (Malik *et al*., 2024). Hence, technology serves not only as a means of production but also as an essential infrastructure within the economic ecosystem.

Regarding population density, dense urban areas offer a strong market for the platform economy, driven by high interaction and transaction volumes. Population concentration increases demand for gig services, such as transportation, food delivery, and other digital offerings (Ghosh & Ramachandran, 2023). Therefore, population density is a significant driver of economic growth, as it facilitates market interactions and expands digital economic networks. Besides that, the temporary nature of gig work, heavily influenced by market demand, creates a dynamic economic environment for gig workers (Duggan *et al*., 2021; Singh, 2024). This reflects an economy that adapts to technological changes and market needs, emphasising the importance of responsive work management systems. As a result, technology and urban density are key factors shaping economic development and creating new socio-economic frameworks, which require policy adaptations to support sustainable and inclusive growth within the digital work ecosystem (Kumar & Verma, 2025).

As urbanisation and digital transformation continue to accelerate rapidly across the ASEAN region, it becomes increasingly important to gain a comprehensive understanding of how various factors—such as technology adoption, population density, and overall well-being—are intricately interconnected within the broader economic landscape. Analyzing these relationships in depth can yield valuable empirical insights that not only enhance our comprehension of current trends but also support the development of innovative digital work models. These models are crucial for promoting sustainable economic growth, fostering inclusivity among diverse communities, and ensuring equitable opportunities for all. In doing so, they contribute to the overarching goal of advancing sustainable development in ASEAN's rapidly evolving digital economy, paving the way for a more resilient and equitable future.

2. LITERATURE REVIEW

This research draws on Thomas Robert Malthus's foundational ideas, which view population as a central factor in economic dynamics. In his influential 1798 work, An Essay on the Principle of Population, Malthus argued that population increases geometrically while economic output, particularly food and resources, grows only arithmetically (Ramya *et al*., 2020). He warned that this imbalance would strain societal welfare, especially if population growth exceeds the economy's capacity to provide enough sustenance. His analysis emphasised that without technological advances or increased productivity, higher population density would lead to increased resource competition,

rising living costs, income instability, and decreased overall welfare (Montano & García-López, 2020). Although these ideas were conceived in an agrarian and pre-industrial context, their core principles remain relevant today for understanding the link between population growth and economic well-being. Currently, Malthus's theory serves as a foundation for examining how densely populated societies encounter structural challenges in meeting economic needs, particularly when production and distribution are not yet fully optimised.

Over time, as industrialisation and urbanisation advanced, modern economists reinterpreted Malthus's ideas through the lens of urban economics and agglomeration theory. Unlike Malthus's focus on the risks of population density, agglomeration theory, developed by Alfred Marshall and refined by Glaeser (Duranton & Puga, 2020). Posits that population clustering in specific areas can enhance productivity by enabling the concentration of economic activities, encouraging physical proximity, and increasing market interactions. Higher population densities facilitate quicker information exchange, foster innovation, support improved infrastructure, and generate more jobs in the service sector. Modern urban economics indicates that densely populated regions nurture large, flexible labor markets, expand production networks, provide substantial consumer bases, and create optimal conditions for growth in service industries (Lehmann, 2019). Thus, urban and agglomeration theories offer a new perspective: population density can act as a catalyst for economic growth, adding a new dimension to Malthus's original theory. The key distinction between Malthus and this modern view is that productivity depends not only on resource availability but also on social interactions and the density of economic activities (Brunt & García-Peñalosa, 2022).

Endogenous growth theory revolutionised our understanding of the factors that influence economic growth. It highlights technological progress, innovation, and improvements in human capital as key drivers of sustained growth (Schilirò, 2019). Unlike the Solow model, which treats technology as an external factor, this theory views technology as arising from investments in knowledge, education, and research. It shows that technology can bypass Malthusian resource limits by significantly increasing productivity and efficiency. Innovations such as the internet, cellular networks, digital systems, the Internet of Things (IoT), and 5G exemplify how innovation enables faster information exchange, quicker labor matching, and greater economic efficiency. Even in densely populated regions, technology can raise productivity without additional physical resources. Thus, endogenous growth theory suggests that a country's prosperity depends not just on population or resources but also on its ability to adopt, learn, and apply new technologies.

The shift to the digital era and platform economy offers a new perspective that reinterprets Malthus's ideas. In this digital economy, population density and technology no longer oppose each other; instead, they complement and reinforce one another through platform mechanisms (Tan, 2024). Examples such as Grab, Gojek, Shopee, Uber, and Amazon Mechanical Turk demonstrate that densely populated areas are ideal markets for flexible, app-based work models. Population density results in higher transaction volumes, enhances the efficiency of matching supply with demand, and promotes innovation (Nawawi *et al*., 2023).

3. METHODOLOGY

This study employs a quantitative, econometric approach to investigate the impact of population density and digital technology on economic well-being in the ASEAN region within the digitalisation framework. The chosen method focuses on empirically establishing causal links between variables, rather than merely observing correlations (Wooldridge, 2016; Greene, 2018). As the economy grows alongside urbanisation and digitalisation, understanding how demographic and technological factors influence macro-level economic well-being has become increasingly important (ILO, 2021).

The research model was developed to address potential endogeneity in several variables, notably population density. Higher economic well-being can drive urbanisation and population growth in cities, subsequently raising population density. To address this potential simultaneity bias, the Two-Stage Least Squares (TSLS) method was employed (Staiger & Stock, 1997). This approach provides

a more precise analysis of the relationships among demographic factors, digital technology use, and economic well-being, using relevant external variables as instruments for the endogenous variables. This model is estimated using the Two-Stage Least Squares (TSLS) method to address simultaneity bias and ensure instrument validity (Gujarati & Porter, 2020). This study's fundamental model is defined as follows:

$$lgni\_pc_{it} = \alpha + \beta_1 density_{it} + \beta_2 employ\_services_{it} + \beta_3 cellular_{it} + \beta_4 individu\_internet_{it} + \gamma Z_{it} + \varepsilon_{it}$$

Because density is believed to be endogenous to GNI per capita, the following instrument is employed:

$$density_{it} = \pi_0 + \pi_1 urban\_pop_{it} + \pi_2 pop\_growth_{it} + \pi_3 youth\_unemp_{it} + v_{it}$$

This study utilises secondary cross-country panel data from ten ASEAN nations: Indonesia, Malaysia, Thailand, the Philippines, Vietnam, Cambodia, Laos, Myanmar, Singapore, and Brunei Darussalam. ASEAN was selected due to its rapid digital transformation in recent years and its demographic diversity, ranging from Indonesia's high population density to Singapore's high income. This variation offers valuable insights into the relationships between population density, digital technology, and economic status (OECD, 2021). Data was gathered from reputable official sources. The primary source is the World Development Indicators (World Bank), which includes data on GNI per capita, population density, population growth, mobile phone usage, and internet usage. Additionally, information on the Human Development Index (HDI) was collected from the United Nations Development Programme (UNDP). The study spans the period from 2015 to 2024, chosen to capture the rapid adoption of digital technologies in the ASEAN region (Baltagi, 2021).

TABLE 1: RESEARCH VARIABLES

No	Variables	Symbol	Operational Definition
Dependent Variable			
1	Gross National Income per Capita (log)	lgni_pc	A measure of a society's economic health, expressed by the natural logarithm of GNI per capita (US$).
Interest Variables			
1	Population Density	density	The number of residents per square kilometer of land area is used as a measure of economic agglomeration.
2	Employment in Services	employ_service	Proportion of the workforce employed in the service sector relative to the total workforce.
3	Individuals using the Internet	individu_internet	Proportion of Individuals who use the internet
4	Mobile Cellular Subscriptions	cellular	Number of mobile cellular subscriptions per 100 people
Endogenous Variables			

No	Variables	Symbol	Operational Definition
1	Urban Population	urban_pop	The proportion of the population living in urban areas to the total population of a country
2	Population Growth	pop_growth	The annual population growth rate (in percent) is calculated based on the change in total population from the previous year.
3	Youth Unemployment	youth_unemp	The percentage of the young population (15–24 years) who are in the workforce but are not currently working.
Control Variables			
1	Inflation	inf	Inflation, consumer prices (annual %)
2	GDP Growth	gdp_growth	GDP per capita growth (annual %)
3	Dependency Ratio	dependency	Age dependency ratio (% of working-age population)
4	Human Development Index	hdi	Human development index as a proxy for human resource quality

Source: Table by Authors

4. FINDINGS

This study employs the Two-Stage Least Squares (TSLS) method to examine how population density, the service sector (employment_services), and digital technology factors (cellular and individual_internet) influence economic welfare in the ASEAN region, using Gross National Income per capita (GNI per capita) as a measure. To ensure the validity of the TSLS model, tests were performed to evaluate endogeneity, the robustness of instruments, and the consistency of model identification. The key tests included the Durbin-Wu-Hausman test, the First-stage regression test, and the Overidentification test.

Result of Endogenceity Test

TABLE 2: ENDOGENCEITY TEST

Information	Result	*p*-value
Durbin (score) chi2(1)	3.6527	0.0560*
Wu-Hausman F(1,90)	3.4121	0.0680*

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Source: Table by Authors

This test aimed to determine whether the density variable is endogenous with respect to the dependent variable, log GNI per capita. The null hypothesis (H_0) states that the variable is exogenous, indicating no correlation with the error term. The test results show p-values of 0.0560 in the Durbin test and 0.0680 in the Wu-Hausman test, both just below the 10% significance level ($\alpha = 0.1$). This suggests that the density variable is significantly endogenous, although the endogeneity remains strong. Therefore, using the Two-Stage Least Squares (TSLS) method is appropriate, as it provides more consistent parameter estimates and avoids simultaneity bias, unlike ordinary least squares (OLS) regression.

Result of First-Stage Regression Summary Statistics

TABLE 3: FIRST-STAGE REGRESSION

Variable	R-sq.	Adjusted R-sq.	Partial R-sq.	F(3,89)	*p*-value
density	0.7482	0.7199	0.5073	30.5498	0.000***

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Source: Table by Authors

The initial testing phase assessed the instrument's ability to estimate the endogenous density variable. Results showed an F-statistic of 30.55, well above the recommended minimum of 10 by Staiger and Stock (1997), indicating the instrument's strong explanatory ability for density changes. The Partial R^2 of 0.5073 implies that about 50.7% of the variation in density is explained by the instruments: urban_pop, pop_growth, and youth_unemp. The Prob > F value of 0.0000 confirms the relationship's statistical significance. Consequently, the model is free from weak instruments, and these three variables are suitable for the first stage of Two-Stage Least Squares (TSLS) estimation.

Result of Overidentifying Test

TABLE 4: OVERIDENTIFICATION TEST

Information	Result	*p*-value
Sargan (score) chi2(2)	.536167	0.7648
Basmann chi2(2)	.479761	0.7867

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Source: Table by Authors

The Sargan and Basmann tests evaluated the validity of the instruments, mainly to confirm they are genuinely exogenous or uncorrelated with the error term in the main equation. The results showed p-values of 0.7648 for the Sargan test and 0.7867 for the Basmann test—both well above 1%, 5%, and 10% significance levels. This indicates there is not enough evidence to reject the null hypothesis (H_0), which states that all instruments are valid and uncorrelated with the error term. Therefore, the three instruments (urban population, population growth, and youth unemployment) are considered valid and exogenous. These findings support the proper identification of the Two-Stage Least Squares (TSLS) model, and the estimated results are reliable and interpretable with high confidence.

Result of Two-Stage Regression

TABLE 5: TWO-STAGES REGRESSION

Variables	(1) lgni_pc
density	0.000113***

Variables	(1) lgni_pc
	(2.96e-05)
employ_services	0.0208***
	(0.00380)
cellular	-0.00901***
	(0.00162)
individu_internet	0.0100**
	(0.00390)
inf	-0.0160**
	(0.00812)
gdp_growth	0.00127
	(0.00752)
dependency	-0.00697
	(0.0103)
hdi	4.914***
	(1.099)
Constant	4.733***
	(1.047)
R-squared	0.955

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
Source: Table by Authors

The results from the Two-Stage Least Squares (TSLS) model indicate that both population density and digital technology development play significant roles in enhancing economic welfare in the ASEAN region within the digitalisation framework. The dependent variable, log GNI per capita (lgni_pc), serves as an indicator of economic well-being. The analysis shows that population density, service-sector employment, and internet usage each have a significant positive effect on GNI per capita, whereas mobile phone usage has a significant negative effect. This suggests that the impact of the digital economy is largely influenced by the quality of technology use and the socio-demographic characteristics of each ASEAN country (ILO, 2021; World Bank, 2023).

Research Discussion

In Table 5, population density has been shown to significantly and positively influence GNI per capita. These results support Krugman's (1991) theory of economic agglomeration, which suggests that clustering economic activities in densely populated areas improves efficiency, expands markets, and accelerates the exchange of information and innovation. In the gig economy, higher population density enhances the potential of the digital labor market and strengthens platform networks such as Gojek, Grab, and Shopee. Densely populated regions often become hubs for digital activity due to the high demand for and supply of tech-based services (Ghosh & Ramachandran, 2023). Additionally, factors such as urbanisation, population growth, and youth unemployment—used as proxies for density—fuel the growth of the gig economy, particularly among working-age populations (Ma, 2024). Additionally, the variable employment_services (employ_services) shows a strong positive impact on economic well-being. This supports the idea that the gig economy mainly exists within the service sector, including ride-hailing, delivery, and digital creative services (Brawley, 2017; ILO, 2021). The growing share of the workforce in services drives economic growth because this sector is quicker to adopt technological innovations (Kässi & Lehdonvirta, 2018). Overall, these results indicate that the digital transformation of the economy in ASEAN economy is broadening the service sector's role in generating flexible employment and boosting productivity.

Then, variable individual internet users (individual_internet) significantly boost GNI per capita. Internet access is a crucial pillar of digital economic growth, enabling people to participate in

platform-based activities such as freelancing, remote work, and e-commerce (Manyika *et al*., 2016; Malik *et al*., 2024). It not only creates new economic opportunities but also broadens employment prospects, especially for youth and workers with medium- to high-skills (OECD, 2021). This highlights the need to invest in expanding digital infrastructure and enhancing technological literacy to promote digital economic inclusion across ASEAN. Unlike other variables, mobile phone usage (cellular) shows a significant negative effect on economic well-being. Although mobile phone ownership is high in ASEAN, this suggests that the devices are not yet fully leveraged for productive uses. This aligns with the digital divide concept, in which owning technology does not necessarily mean it is used effectively to achieve economic gains (van Dijk, 2020). In digitalisation, this also indicates an oversupply of informal digital labor, often earning low wages and facing intense competition (ILO, 2021; Duggan *et al*., 2021). Thus, technological access without the development of relevant skills can pose income challenges for gig workers.

From a macroeconomic standpoint, inflation (inf) significantly harms GNI per capita, aligning with the purchasing power theory, which states that inflation diminishes the real value of incomes. For gig workers, inflation increases operational expenses, such as fuel and transportation, leading to lower net income (Rani & Furrer, 2021). In contrast, the Human Development Index (HDI) has a strong, positive, and significant impact on GNI per capita, underscoring the importance of human resources for leveraging digital economic opportunities. These findings support human capital theory (Becker, 1964), which emphasises that higher education and skills underpin sustainable economic growth. Countries with high HDI scores tend to have more adaptable and efficient digital workers, enabling them to better capitalise on the gig economy to enhance well-being (OECD, 2021).

6. CONCLUSION AND POLICY IMPLICATION

This research suggests that population density and advancements in digital technology are key drivers of economic prosperity in the ASEAN region, particularly in the gig economy. The TSLS analysis shows that areas with higher population density and improved internet connectivity tend to have greater per capita incomes. It emphasises the need for policymakers to focus on urban development and expand digital infrastructure to boost economic well-being, especially in gig-related sectors. Investing in internet access and digital skills training can raise income levels and support platform-based employment. Moreover, strengthening human resources through education and development, as indicated by the Human Development Index (HDI), is essential for effective technology use. Policies aimed at inclusive growth, such as enhancing workforce skills, ensuring fair access to digital resources, and maintaining macroeconomic stability, will help the digital economy foster sustainable development. This study adds to the existing literature in several ways. First, it offers instrumental variable (IV) evidence to address potential endogeneity in the link between digitalisation, urban density, and income. Second, it utilises a panel dataset of ASEAN countries, providing region-specific insights that are often lacking in research on digital transformation and economic growth in developing areas. Third, it explicitly explores the interaction between urban density and digitalisation, showing how spatial concentration influences the effectiveness of digital infrastructure in boosting productivity and income. Finally, the results indicate a negative relationship between cellular subscriptions and Gross National Income (GNI), suggesting that the growth of basic mobile connectivity may reflect consumption-driven digital access rather than actual productivity improvements.

Nevertheless, the study has limitations. First, the data, aggregated across countries and limited to 2015–2024, does not fully capture individual dynamics or long-term structural changes in the digitalisation. Second, the variables primarily address broad demographic and technological factors, lacking detail on institutional and social factors such as digital labor regulations and social protections for workers. Future research should expand the analysis by using longitudinal microdata, examining regional differences within countries, and incorporating institutional and policy factors to achieve a more comprehensive understanding of the digitalisation economy’s sustainability in the digital age.

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