



DIGITAL ECONOMY AND INCOME INEQUALITY: AN EMPIRICAL STUDY FROM EMERGING ASIAN ECONOMIES

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Abstract

This research explores how the digital economy affects income inequality across emerging economies in Asia, utilizing panel data spanning from 2010 to 2022. Although digital transformation is widely seen as a catalyst for economic expansion and broader participation, its role in shaping income distribution remains uncertain. By applying the Quantile Regression for Panel Data (QRPD) technique, this study captures how digitalization influences inequality at different segments of the income distribution. Results reveal that digital advancements are most effective in reducing inequality in countries with relatively equal income distribution, particularly at lower quantiles, where the Digital Economy Index has the strongest negative coefficient (-0.235). However, the equalizing effect weakens in nations facing higher inequality levels. Gross Domestic Product (GDP) per capita also correlates negatively with inequality, albeit with a milder effect. These findings underscore the necessity of inclusive digital development strategies that are responsive to each country's income structure. This study enriches existing scholarship by demonstrating the value of a nuanced and underutilized methodological framework within the context of developing regions.

Keywords: Digital economy, income inequality, developing countries, quantile regression, Asia

INTRODUCTION

Over the past decade, the digital economy has emerged as a transformative force reshaping production systems, business models, and socio-economic structures worldwide. Rapid advances in information and communication technologies (ICT) have fundamentally altered how individuals work, interact, and access both public and private services. Emerging Asian economies such as Indonesia, Vietnam, the Philippines, and India have experienced an accelerated pace of digitalisation, driven by rising internet penetration, widespread mobile device usage, the expansion of e-commerce, and extensive digital transformation initiatives undertaken by both public and private sectors (World Bank, 2023). The proliferation of digital platforms, electronic payment systems, and the integration of smart technologies into global value chains indicate that the digital economy has evolved beyond a complementary phenomenon to become a central pillar of contemporary economic development.

Nevertheless, alongside the widespread optimism regarding the digital economy's potential to enhance efficiency, broaden market access, and promote financial and social inclusion, growing concerns have emerged regarding its implications for income distribution. Rather than narrowing economic disparities, digital technologies may exacerbate income inequality when access to and the capacity to utilise such technologies are unevenly distributed across society. High-skilled workers are more likely to capture disproportionate gains from digitalisation, benefiting from well-paid employment opportunities in technology-intensive and financial sectors. In contrast, low-skilled workers, informal labourers, and populations in lagging or remote regions face a heightened risk of marginalisation and economic exclusion (UNCTAD, 2022). Disparities in access to digital infrastructure, levels of technological literacy, and the capacity to adapt to evolving labour market conditions have given rise to a pronounced digital divide, which in turn deepens existing economic inequalities. According to the IMF (2023), while digitalisation has the potential to enhance aggregate productivity and income levels, the distribution of its gains is often uneven, disproportionately accruing to capital owners, large firms, and individuals who already possess the resources and capabilities to adopt digital technologies at an early stage.

Income inequality commonly measured using indicators such as the Gini index, the Theil index, and income quintile share ratios remains a persistent structural challenge undermining the achievement of sustainable and inclusive growth across emerging Asian economies. Economic digitalisation may generate new winners and losers within society, thereby raising a fundamental question: does the digital economy function as a force for economic democratisation, or does it instead intensify social stratification (ADB, 2022)? Consequently, a rigorous empirical assessment is required to determine whether digital transformation genuinely contributes to a more equitable income distribution or merely amplifies pre-existing socio-economic disparities.

| Country | Digital Economy Index (DEI) | Internet Penetration (%) | E-commerce Growth (%) | GDP per Capita (USD) | Gini Index (Income Inequality) |
|-------------|-----------------------------|--------------------------|-----------------------|----------------------|--------------------------------|
| India | 0.75 | 45.0 | 20.0 | 2100 | 0.35 |
| Vietnam | 0.68 | 55.0 | 18.0 | 2500 | 0.34 |
| Indonesia | 0.7 | 50.0 | 15.0 | 3500 | 0.38 |
| Philippines | 0.72 | 53.0 | 22.0 | 2900 | 0.42 |
| Thailand | 0.74 | 58.0 | 19.0 | 4300 | 0.36 |

The table presents a comparative overview of emerging Asian economies based on key indicators of digital development and income inequality. India records the highest Digital Economy Index (DEI) score (0.75), followed by Thailand and the Philippines with values of 0.74 and 0.72, respectively, indicating strong engagement in digital economy development. Thailand exhibits the highest level of internet penetration (58%), while the Philippines has experienced the fastest growth in e-commerce activities (22%). Despite these advances, India remains the economy with the lowest GDP per capita (USD 2,100). Meanwhile, Vietnam and the Philippines display relatively higher levels of income inequality, as reflected by Gini index values of 0.42 and 0.38, suggesting that substantial disparities persist even amid rapid digitalisation. Overall, these patterns highlight that, notwithstanding significant progress in digital transformation, emerging Asian economies continue to face considerable challenges in ensuring an equitable distribution of the benefits derived from the digital economy, with important implications for social and economic inequality across countries.

Against this background, the present study aims to provide an in-depth empirical analysis of the relationship between digital economy development and income inequality in emerging Asian economies. Employing cross-country panel data spanning the period from 2010 to 2022, the study applies a Quantile Regression for Panel Data (QRPD) framework to examine the effects of digital economy indicators such as internet penetration, e-commerce usage, and the contribution of the ICT sector to GDP across different points of the income inequality distribution. This approach enables the identification of heterogeneous impacts across income quantiles, thereby capturing differential effects on various segments of society. The study offers a substantive and novel contribution to the literature by elucidating how digital transformation reshapes income inequality structures and by providing robust empirical evidence to inform the design of inclusive, equitable, and sustainable digital policies in emerging Asian economies.

LITERATURE REVIEW

A. Digital Economy

The digital economy encompasses a broad range of economic activities enabled by digital technologies, including but not limited to e-commerce, mobile-based applications, digital financial technologies (FinTech), artificial intelligence (AI), the Internet of Things (IoT), and cloud computing. Bukht and Heeks (2018) conceptualise the digital economy as an economic system in

which digital inputs, processes, and outputs dominate, with data and information technologies functioning as core production factors that partially substitute for traditional capital and labour. In the Asian context, the rapid advancement of the digital economy has been facilitated by favourable demographic structures particularly a large, digitally literate young population the expansion of ICT infrastructure, and the implementation of pro-digital national strategies such as Digital India, Indonesia Digital 2025, and Vietnam's National Digital Transformation Programme. UNESCAP (2022) and Choi et al. (2023) document that the growth of the digital economy contributes significantly to national GDP and serves as a catalyst for cross-sectoral innovation. A prominent illustration can be observed in India, where the development of Digital Public Infrastructure (DPI), including Aadhaar and the Unified Payments Interface (UPI), has substantially expanded access to financial services, social transfers, and digital identity systems, thereby enhancing broad-based economic participation (Mehta et al., 2023). Despite these achievements, persistent digital gaps relating to access to devices, network quality, and levels of digital literacy remain major constraints on the equitable distribution of digital economy benefits, particularly in rural areas and among low-income populations. From a theoretical perspective, the relationship between the digital economy and income inequality can be explained through the lens of Digital Divide Theory, which posits that digital innovation generates a bifurcated society consisting of those with access to and the ability to leverage digital technologies (digital haves) and those who remain excluded (digital have-nots) (Norris, 2001). This framework aligns closely with the Skill-Biased Technological Change (SBTC) hypothesis, which argues that digital technologies disproportionately benefit high-skilled workers relative to low-skilled workers, thereby widening income disparities (Autor, 2014).

In addition, the theory of digital economic inclusiveness advanced by Banga and te Velde (2020) suggests that digital platforms can enhance productivity and market access for micro-enterprises and individuals, while simultaneously increasing the risk of market dominance by a small number of large technology firms (Big Tech). Such dynamics may foster monopolistic tendencies and contribute to wealth concentration. Consequently, the impact of the digital economy on social welfare is inherently dualistic. On the one hand, digitalisation holds the potential to promote economic inclusion; on the other hand, it may generate new forms of fragmentation and inequality. This duality underscores the importance of empirically assessing the extent to which the expansion of the digital economy influences equity-related outcomes particularly income distribution in emerging Asian economies undergoing rapid digital transformation. Consistent with this perspective, the digital economy can be broadly defined as encompassing all economic activities grounded in digital technologies such as e-commerce, mobile applications, FinTech, AI, IoT, and cloud computing that integrate digital inputs, processes, and outputs (Bukht & Heeks, 2018). Using a STIRPAT framework applied to BRICS countries over the period 2011–2021, Abu Karaki et al. (2023) find that the digital economy plays a critical role in shaping social, economic, and environmental outcomes, including carbon emissions, thereby highlighting the structural and sustainability implications of digitalisation. Complementary evidence from Indonesia, provided by Rosmika et al. (2022), demonstrates that improvements in ICT infrastructure exert a stronger effect on inter-island economic interactions than increases in electricity supply, particularly between regions such as Bali and Nusa Tenggara. These findings support the hypothesis that digitalisation fosters broader and more complex economic linkages across regions.

B. Income Inequality

Income inequality constitutes one of the central challenges in economic development, particularly in developing and emerging economies. Commonly used indicators to measure income inequality include the Gini coefficient and income decile ratios, which capture disparities in income distribution across different segments of society. The Gini coefficient, for instance, provides a numerical representation of inequality, with values closer to one indicating a more unequal income distribution within a country. The level of income inequality is shaped by several key factors, including disparities in educational attainment, uneven regional development, labour market structures (formal versus informal employment), and the effectiveness of redistributive policies such as taxation systems and social transfers (ILO, 2021). Countries characterised by unequal access to quality education particularly among low-income populations tend to experience higher levels of

income inequality. Moreover, labour markets dominated by informal employment and low-wage jobs constitute a major structural source of persistent income disparities. Beyond its economic implications, income inequality can undermine social stability and weaken social cohesion over the long term. The OECD (2022) highlights that societies facing extreme levels of inequality often exhibit lower levels of social trust, heightened social tensions, and slower economic growth, largely due to underinvestment in human capital and limited social mobility. In emerging Asian economies, the dynamics of income inequality are further complicated by rapid digitalisation processes that do not necessarily yield uniform benefits. High-productivity and high-wage employment opportunities tend to be concentrated in metropolitan areas and technology hubs such as Jakarta, Ho Chi Minh City, Bengaluru, and Manila where digital infrastructure is more advanced. In contrast, rural and remote regions continue to face significant constraints, including inadequate digital infrastructure, low internet penetration, and limited digital literacy.

These disparities contribute to unequal economic opportunities between populations with access to digital technologies and those who remain excluded (ADB, 2022). Ravallion (2021) argues that two dominant forces currently shaping global income inequality are globalisation and technological transformation. While globalisation facilitates the expansion of large multinational firms, digital transformation accelerates automation and raises demand for high-skilled labour. As a result, workers with higher education levels and technological capabilities are better positioned to benefit, whereas low-skilled workers increasingly face marginalisation. Importantly, digitalisation does not automatically lead to reduced inequality. Structural constraints such as inadequate infrastructure, low-quality human capital, and weak regulatory frameworks can offset or even reverse the potential egalitarian effects of technology, particularly in low-income economies. This perspective is reinforced by Abdullah et al. (2024), published in the *International Journal of Energy Economics and Policy (IJEPP)*, who find that digital finance, as a core component of the digital economy, significantly promotes sustainable economic growth in Belt and Road Initiative (BRI) countries. However, the magnitude and direction of this effect are highly contingent upon the level of economic readiness and the robustness of national regulatory environments.

C. Digital Economy and Income Inequality Nexus

Empirical evidence on the relationship between the digital economy and income inequality remains mixed. Several studies, such as Zhuang and Zhang (2022), suggest that digital financial inclusion can mitigate income inequality by empowering marginalised groups and expanding access to financial services. In contrast, other research including Lee et al. (2022) finds that digital automation disproportionately displaces low-skilled labour, thereby widening income gaps. A key mediating factor in this relationship is the level of digital skills and access to technology. In economies characterised by high levels of digital inclusion, the benefits of technological advancement tend to be more broadly shared. Conversely, persistent digital divides result in uneven distribution of digital gains, reinforcing existing inequalities. Accordingly, policy interventions aimed at strengthening digital literacy, expanding affordable and reliable internet access, and fostering inclusive innovation ecosystems are critical to ensuring that digitalisation contributes to more equitable income outcomes (World Bank, 2023). Building on these insights, this paper extends the existing literature by providing empirical evidence from emerging Asian economies, examining how digitalisation influences income inequality across diverse socio-economic contexts.

METHOD

This study initially acknowledges the use of conventional econometric approaches, such as Ordinary Least Squares (OLS) and fixed-effects models, which primarily estimate the average impact of independent variables on the dependent variable. However, these approaches become inadequate when the effects of digitalisation on income inequality are heterogeneous that is, when the magnitude and direction of the impact vary across different points of the income distribution. To address this limitation, the present study adopts the Quantile Regression for Panel Data (QRPD) framework developed by Koenker (2004). This method enables the analysis of heterogeneous effects across multiple quantiles of the dependent variable, rather than focusing solely on conditional mean

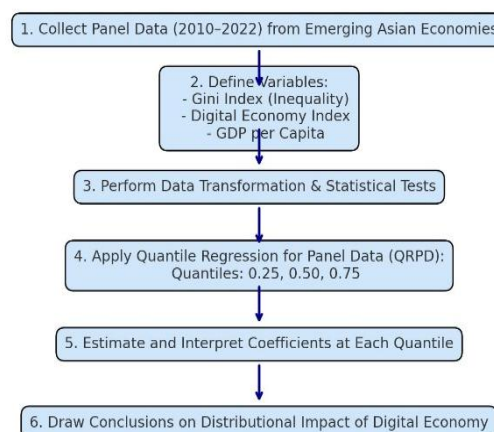
estimates. QRPD is specifically designed to examine how independent variables such as digitalisation indicators or internet penetration affect different quantiles of the dependent variable, for example, the Gini index. This approach allows for an assessment of whether digitalisation exerts a stronger influence on lower-income segments of society (represented by lower quantiles) relative to higher-income segments (upper quantiles). Such differentiation is particularly important, as QRPD has been widely employed in panel econometric literature to detect non-uniform effects across both extreme and intermediate quantiles of the distribution. Furthermore, recent empirical work by Kuziboev et al. (2024) underscores the methodological advantages of quantile-based approaches in uncovering complex relationships within panel data settings. For instance, quantitative studies examining energy consumption and environmental quality using panel quantile regression demonstrate that the effects of independent variables can differ substantially between countries or regions located in lower versus higher quantiles of the distribution.

Formally, the empirical model can be expressed as follows:

$$Q\tau(\text{GINI}_{it} | X_{it}) = \alpha_i(\tau) + \beta_1(\tau) * \text{DEI}_{it} + \beta_2(\tau) * \text{GDP}_{it} + \varepsilon_{it}(\tau)$$

By employing the QRPD framework, this analysis is able to capture how the relationship between digitalisation and income inequality varies significantly across countries characterised by low, moderate, and high levels of inequality. This approach offers a more nuanced and context-sensitive analytical advantage in understanding the distributional dynamics of the digital economy in emerging Asian economies.

QRPD Methodology Flowchart

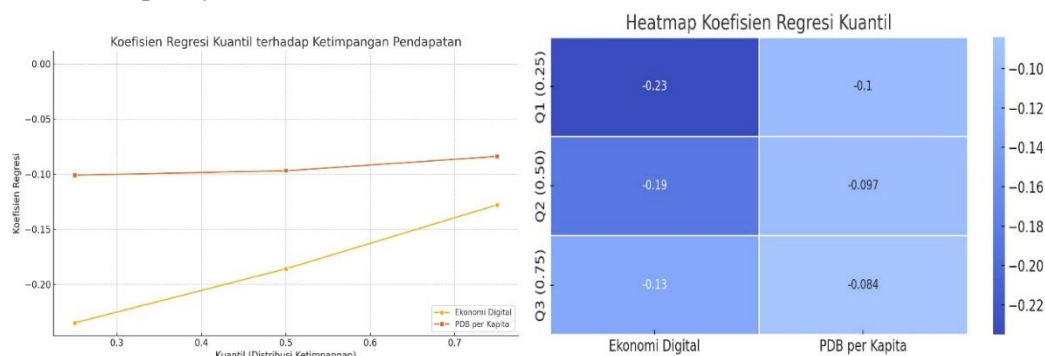


RESULTS AND DISCUSSION

| Kuantil | Koefisien DEI | Std. Error | Koefisien GDP | Std. Error | R ² |
|---------|---------------|------------|---------------|------------|----------------|
| 0.25 | -0.235 | 0.043 | -0.101 | 0.031 | 0.69 |
| 0.50 | -0.186 | 0.038 | -0.097 | 0.028 | 0.72 |
| 0.75 | -0.128 | 0.051 | -0.084 | 0.035 | 0.67 |

The table reports the results of the quantile regression estimations across three points of the income inequality distribution (Q1, Q2, and Q3). The coefficient of the Digital Economy Index (DEI) is consistently negative across all quantiles, with the largest magnitude observed at the lower quantile (-0.235 at Q1). This finding indicates that digitalisation is most effective in reducing income inequality in countries characterised by relatively more equal income distributions. Similarly, GDP per capita exhibits a negative coefficient across all quantiles, suggesting that higher income levels are associated with lower inequality; however, its effect is comparatively weaker than that of the DEI. The highest R² value is recorded at the median quantile (Q2 = 0.72), implying that the model explains variations in income inequality most accurately at intermediate levels of the distribution. Overall, these results confirm that the inequality-reducing impact of digitalisation is stronger in

countries with low to moderate levels of inequality and diminishes in economies with relatively high income inequality.



To reinforce the quantitative findings, two visualisations are incorporated into the analysis. The first is a line graph illustrating the regression coefficients of the digital economy and GDP per capita across three quantiles of income inequality (Q1, Q2, and Q3). The graph reveals that the impact of the digital economy is strongest at the lower quantile (Q1), indicating that in countries with relatively low levels of inequality, digitalisation exerts the most pronounced effect in reducing income disparities. However, at the upper quantile (Q3), the effect of digitalisation weakens, suggesting that in highly unequal economies, the benefits of digital transformation do not automatically diffuse evenly across society.

The second visualisation is a heatmap depicting the magnitude and direction of the regression coefficients at each quantile. Darker red shades represent larger negative coefficients, corresponding to stronger inequality-reducing effects, while lighter shades indicate weaker impacts. The heatmap clearly confirms that the contribution of the digital economy to inequality reduction is strongest at the lower quantile and gradually diminishes at higher quantiles. A similar pattern is observed for GDP per capita, although its effects are notably weaker than those associated with digital economy indicators. Taken together, these visualisations consistently demonstrate that digital transformation holds substantial potential as an effective instrument for reducing income inequality, particularly when accompanied by equitable access and supportive policy frameworks. Accordingly, policymakers should tailor digitalisation strategies to the specific income distribution contexts of their respective countries to maximise inclusive economic outcomes.

CLOSING

Conclusion

This study provides up-to-date empirical evidence on the role of the digital economy in reducing income inequality across emerging Asian economies by applying a relatively underutilised quantitative approach, namely Quantile Regression for Panel Data (QRPD). Unlike conventional methods such as Ordinary Least Squares (OLS) or fixed-effects models which capture only average effects QRPD enables the estimation of the impact of independent variables, in this case digitalisation indicators, at different points along the distribution of the dependent variable, measured by the Gini index as an indicator of income inequality. The findings demonstrate that digitalisation exerts a statistically significant inequality-reducing effect, particularly among societies located in the lower and middle quantiles of the income distribution. This suggests that low- to middle-income groups benefit disproportionately from digital economy expansion, as access to digital financial services, online markets, and information technologies becomes increasingly widespread. These results carry important implications for public policy in Asia, a region characterised by substantial social and economic heterogeneity. In economies with relatively low levels of inequality, digitalisation can reinforce inclusive growth with minimal structural constraints. By contrast, in highly unequal economies, technology-driven interventions must be complemented by supportive policies such as digital literacy programmes, the expansion of digital infrastructure in lagging regions, and digitally enabled redistributive mechanisms to ensure that the benefits of the digital economy are more evenly shared. Community-based training initiatives and targeted support for technology-oriented micro,

small, and medium-sized enterprises (MSMEs) are particularly critical for narrowing the gap between urban and rural areas, as well as between digitally connected and digitally excluded populations. The study further indicates that generic, one-size-fits-all digitalisation policies may be insufficient, underscoring the need for policy designs that explicitly account for country- or region-specific income distribution characteristics.

From a methodological standpoint, this research contributes to the literature by demonstrating the analytical value of QRPD in uncovering distributional effects of digitalisation that remain hidden in mean-based models. This distribution-sensitive perspective offers policymakers a more precise evidence base for designing targeted interventions that go beyond aggregate outcomes. Future research is encouraged to incorporate additional structural variables such as labour market informality, inequality in access to education, and participation in digital entrepreneurship to further refine the analysis. Moreover, the application of long-run quantile effect models could enhance understanding of the dynamic causal relationship between digitalisation and income inequality over extended time horizons. The inclusion of spatial and multilevel approaches would also be valuable in identifying subnational disparities in the impacts of digital transformation. Overall, the digital economy presents a promising strategic pathway for reducing income inequality, provided that its growth is managed in an inclusive and context-specific manner. Through a quantile-based perspective, this study demonstrates that the effects of digitalisation on income inequality are heterogeneous and complex, necessitating adaptive, evidence-based policy responses. Digital transformation should therefore be directed not only towards economic growth, but also towards the equitable expansion of access, participation, and shared economic benefits across all segments of society.

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