The impact of technical change on income inequality in Vietnam

Journal of Economics and Development

329

Thu Kim Hoang
National Economics University, Hanoi, Vietnam, and
Quoc Hoi Le
Department of Economics, National Economics University, Hanoi, Vietnam

Received 5 March 2024
Revised 3 July 2024
Accepted 3 July 2024

Abstract

Purpose – The primary purpose of this study is to explore the effect of technical changes on provincial-level income inequality in Vietnam. The authors also investigate whether the quality of institutions and human capital level moderate this relationship.

Design/methodology/approach – This research applies the fixed-effect and random-effect models on a balanced panel data set of 63 Vietnamese provinces/cities from 2010 to 2020.

Findings – The study's empirical results show that technical improvement has a nonlinear influence on income disparity in Vietnamese localities. When the local level of technology is limited, technological change can mitigate income disparity. However, as local technological levels increase, inequality tends to rise. Moreover, the study also reveals that the quality of a province's institutions and the level of human resources are factors that moderate the correlation between technological change and income inequality. For provinces with better institutional quality and/or better human resources, inequality tends to decline under the impact of technological change.

Practical implications – The results of this study suggest that while encouraging technology advancement, localities should also ensure sustainable development, reduce income inequality and focus on improving institutional quality and human resources development.

Originality/value – There are increasing concerns about the impact of technical change on inequality in income distribution; however, empirical evidence on this relationship in developing countries remains scarce. This study is among the few attempts to examine this issue at the provincial level of a developing country considering the moderation effect of institutional quality and human capital level.

Keywords Income inequality, Technical changes, Institutional quality, Human capital, Vietnam

Paper type Research paper

1. Introduction

Global evidence suggests that high levels of income inequality may have a broad variety of negative consequences, such as hindering economic growth (Berg and Ostry, 2011) and slowing the rate of poverty alleviation (Klasen, 2016; Ravallion, 2004). One of the factors that affects income inequality is technical change (Moll *et al.*, 2022), which is a growing concern for a variety of reasons. Firstly, economic disparity has an adverse influence on growth (Cingano, 2014); therefore, while economic growth is crucial to alleviate poverty, its impact depends on income distribution (Bourguignon, 2004). Secondly, many scholars have emphasized that technological progress is an increasingly powerful engine of growth (Aghion *et al.*, 2023). Economic development will be constrained in the absence of ongoing technological advancement (Aghion and Howitt, 2009). Solow (1956) argues that all long-term growth per capita results from technical progress. Lastly, if technological progress raises income

Journal of Economics and Development
Vol. 26 No. 4, 2024
pp. 329-345
Emerald Publishing Limited
e-ISSN: 2632-5330
p-ISSN: 1859-0020
DOI 10.1108/JED-03-2024-0087

disparity, the benefits on economic development will be offset by a reduced rate of growth as well as other social negative impacts. Therefore, investigating the relationship between technological change and income inequality is critical for developing countries that can minimize economic disparities while also preparing the country for future technological advancements (Suphanachart, 2019).

Numerous theoretical studies have confirmed a negative effect of technical change on income inequality, but the empirical evidence on the direction and magnitude of income distribution due to technical change is not fully agreeable. Several empirical studies have found that countries experiencing greater income disparities are those with more advanced technological change (Katz and Murphy, 1992; Lindquist, 2005). However, other research has reported negative consequences (Suphanachart, 2019) or a non-linear association between technological change and income gap (Jaumotte and Tytell, 2007). Goldin and Katz (1998) and Card and DiNardo (2002) found that the income gap was stable despite improvements in technology. Thus, research conducted across various levels and facets demonstrates that technological advancements have an effect on the distribution of income; nevertheless, the precise mechanisms and extent of this influence vary across nations and are contingent upon the institutional and socioeconomic context of each nation. Hence, additional research is needed to examine the correlation between technical change and income distribution within particular contexts.

Vietnam provides an interesting case study for examining the effects of technical changes on income disparities. Over the past three decades, rapid economic growth and improvements in technology have brought Vietnam from a low – income to a middle – income country, improving the living standard for Vietnamese. Despite notable achievements in economic growth and alleviating poverty, the country has witnessed a rise in income disparity both among different regions and within its own communities. The Gini index in Vietnam ranged from 0.42–0.44 during the period 2010–2018 (Le *et al.*, 2021). This is relatively small in comparison with other middle-income countries in East Asia, yet there is still considerable income disparity between rural and urban regions, as well as across different demographic groups (Poole *et al.*, 2017). Nonetheless, the shift in Vietnam's growth model towards increased innovation and technology-intensive investments, aimed at sustaining economic expansion, has the potential to worsen inequality.

Although both technological improvement and income distribution are topics of interest in Vietnam, earlier studies have focused on either of them while few attempt has been conducted on discovering this relationship (Poole *et al.*, 2017). A systematic quantitative study on the impact of technological advancement on income inequality provides scientific evidence to help Vietnam achieve both technological advancement and income equality. As such, this study is critical and relevant in both theory and practice.

Furthermore, although both technology and institutional quality are separately recognized as drivers of growing inequality (Acemoglu, 2003; Jaumotte *et al.*, 2013; Sequeira *et al.*, 2017), what is lacking is a more thorough understanding of the moderating role of institutional quality in the technology–inequality relationship. Syverson (2011) points out that institutions and the political and administrative context encourage firms to engage more in research and development, enabling technical advancements, shortening the technology gap and promoting productivity convergence with top domestic firms through the incentive mechanisms. Adeleye (2024) posits that equitable and efficient income distribution relies on the presence of robust and effective institutions. In essence, income inequality can be influenced by the quality of institutional quality. Governance quality, therefore, can affect both enterprises' technical change decisions and the pay of workers; thus, it indirectly moderates the relationship. This research examines technical changes and income inequality correlation in Vietnam under the regulation of institutional quality. To the best of my knowledge, this is among the few attempts to examine this issue at a provincial level.

Additionally, this study adds a new dimension by demonstrating that human capital has a regulatory influence on the impact of technological advancements on income disparity. The role of human capital (often proxied by educational level) as a determinant of inequality has been confirmed in many research (Castelló-Climent and Doménech, 2021; Galor and Moav, 2004; Lee and Lee, 2018). On the other hand, the role of education in technology is emphasized by the Nelson–Phelps' hypothesis in the way that educated individuals make better innovators, so that education accelerates the process of technological diffusion (Nelson and Phelps, 1980). Human capital determines the level to which technology is adopted as well as leads to differences in productivity and then creates a wage gap according to the capital – skill complementarity hypothesis. Human capital is thus seen in the theory as a determinant of more technical change and higher inequality and therefore, able to moderate the technology – inequality nexus. This research aims to evaluate the extent to which the impact of technical change on income inequality is conditioned on human capital.

The structure of this paper is as follows. The second section presents the theoretical framework and literature review. The third section provides an overview of technical change and income inequality in Vietnam. The fourth section describes the data and research methodology. Empirical results and discussions are presented in the fifth section. Finally, the sixth section draws conclusions.

2. Theory and literature review

The effect of technical change on income inequality can be explained by several theories. There have been three main strands of theory about the technical change–inequality nexus. The most famous one is the Skill-Biased Technical Changes (SBTC) and its related hypothesis with the main argument is that recent technological development is not factor-neutral but factor-biased (Acemoglu, 1998, 2002a, b). Most of the recent technological changes are skilled-biased (i.e. skill-technology complement), meaning that the movement of technology is in preference of more skilled employees such as those who are better educated, capable and experienced. Otherwise, it can substitute unskilled workers' activities; hence, it raises relative productivity as well as relative demand for those who are skilled. Hence, the skill premium, which reflects the productivity difference between sectors, rises (Acemoglu, 2002b). This means that the income gap is therefore widening. In their paper, Pi and Zhou (2013) call this effect between technical change and wage inequality *the multiplier effect*. Thanks to technological development, workers are more effective. This effectiveness will multiply with the marginal productivity of labor and raise the productivity of workers, leading to an increase in skilled workers' wages and hence, widening the income gap. Furthermore, they also argue that there is an opposite effect, which is called *competition effect*. This effect explains that high effective labour per worker, as a consequence of technical change, will raise the total amount of labour, making more intensive worker competition. This will reduce the wage of skilled workers and narrow the income gap. As a result, changes in the income gap depend on the interaction between the two effects.

A related hypothesis is the Capital–Skill Complementary hypothesis has been formalized by Griliches (1969) and developed by Krusell *et al.* (2000). It states that due to equipment-specific technical progress, the relative price of capital equipment decreases, hence encouraging investment in capital equipment. Because skilled workers complement equipment capital more than unskilled workers, expansion in the stock of equipment enhances skilled workers' marginal product but reduces unskilled workers' marginal product. As a result of the larger capital stock, skilled wages are pushed up comparatively higher than unskilled wages. Hence, the skill premium increases. The improvement of this hypothesis is that the rise in skill premium is not necessarily due to the rise in relative productivity. In case skilled workers' relative productivity stays static while relative supply of them grows, the skill premium may still increase if the equipment-skilled labour ratio increases quickly enough (Hornstein *et al.*, 2005).

Another way of approach is the Directed technical change. The central concept originates from Acemoglu's (1998) analysis of 20th-century US labour data, where, despite the rise in the supply of skilled labour there is a higher college premium. This phenomenon is explained by two effects. The first effect is the *traditional substitution effect*, where an increase in the supply of skilled labour leads to a rightward shift in the skilled labour supply curve, resulting in a new equilibrium with lower skill wages and, consequently, a reduction in the college premium. The second effect, *directed technical change*, suggests that technological advancements are intentionally designed to complement skills, rather than being naturally skill-replacing. With a larger market for skill-complementary technologies as the number of skilled workers grows, inventors find it profitable to focus on creating technologies that complement skills. Skill-complementary technologies, by expanding the demand for skilled labour, cause a significant rightward shift in the labour demand curve, leading to a long-term increase in the college premium. This implies that the wage gap will, in turn, expand over time.

Recently Moll *et al.* (2022) provided a framework on the theory of factor income to explain the mechanism of how technical change affects income distribution in the long run. The idea is that automation increases wealth and the return to wealth as productivity gains from automation accrue not only to workers but also to the owners of the capital. Given that capital ownership is highly concentrated at the top earner, the rise in capital income will tend to raise the income gap in the long run (Bengtsson and Waldenström, 2018).

To sum up, the influence of technical change on the distribution of factor income is primarily contingent on the nature or orientation of the technical change, which is not inherently neutral. In instances where the technical change favors capital augmentation or is capital-biased, it tends to stimulate increased investment in capital, displacing labour with machines and contributing to a rise in income inequality (Acemoglu, 2002a, 2003). Conversely, when there is a prevalence of labour-biased technological change, it results in a reduction of the income gap.

Based on those theoretical frameworks, the wide empirical literature on the link between technical change and income disparity yields mixed and inconclusive results. Some empirical research has shown that technical-led growth might face a trade-off of inequality due to the increase in productivity and wage of high-skilled workers, higher demand for highly educated labour (Autor *et al.*, 1998) as well as job replacement by automated devices and robots of low-skilled workers (Katz and Murphy, 1992; Acemoglu, 1998). Lindquist (2005) demonstrates that the growing income disparity in Sweden between high- and low-skilled workers is demand driven as a result of capital-skill complementarity in production. Research by Ferreira (2020) confirms that SBTC alone accounted for 42% of the overall increase in income inequality in the U.S during the period 1980–2010. This aligns with Almeida and Afonso's (2010) finding that SBTC has become the predominant explanation for inequality gap in wage ratio of college workers and lower-secondary workers in 25 OECD countries. Muzammil *et al.* (2018) analyze both fixed and random effects on panel data of 104 countries and find that transfer of technology has a positive impact on income inequality in developed countries but a negative impact on income gap in developing countries.

Contrarily, the research conducted by Suphanachart (2019) in Thailand demonstrates that Technical Change, represented by Total Factor Productivity (TFP), has a statistically significant adverse effect on the income difference over a long time. Nevertheless, the negative immediate consequences do not seem to have any major statistical impact. Research by Jaumotte and Tytell (2007) find that technical change, particularly in the information and communications sectors, appears to have a non-linear influence on the labour share of income. However, some other researchers found that the wage gap was stable despite improvements in technology (Goldin and Katz, 1998; Card and DiNardo, 2002) and that technological change is not significantly affect differences in income (Sequeira *et al.*, 2017). Alesina *et al.* (2018) propose that the rise of skill premiums, as well as technical changes in the US, can be a cause of labour market regulation. may be attributed to labour market regulations. Additionally, they suggest the possibility of a reverse causation, where increased income inequality leads to the adoption of technology that favors skilled workers, rather than the opposite. It is also argued that the influence of technological change on income share is dependent on the type of technical change, whether it is labour- or capital-augmentation (Acemoglu, 2002a).

Many previous studies have discussed the role of technical changes on income disparities; however, most of the empirical papers test the relationship using cross – national data (Barro, 2000; Van Reenen, 2011; Jaumotte *et al.*, 2013; Fuentes *et al.*, 2014; Jerzmanowski and Tamura, 2019). An important feature of inequality data is that it is country specific. This is a disadvantage of utilizing cross-country data since it may overlook key micro-effects. Exploring the variety of data on the drivers of inequality is critical, since the determinants of inequality might vary significantly among countries. Hence, research on drivers of inequality at the cross – national level is found to be ambiguous and may not support the theory in crucial aspects (Sequeira *et al.*, 2017). Additionally, the impact of technological progress may vary depending on whether the nation is technologically advanced or not.

Regarding the local context, prior research on the technology – inequality nexus has mostly been conducted in developed countries (Acemoglu and Restrepo, 2022; Krusell *et al.*, 2000; Lindquist, 2005), whereas empirical evidence on this relationship in developing countries remains scarce (Fuentes *et al.*, 2014; Singh and Dhumale, 2000; Suphanachart, 2019) and that there is insufficient empirical data to draw robust judgments about emerging nations (Singh and Dhumale, 2000). There are also mixed and inclusive results when research is done on developing countries. While Zhang *et al.* (2017) find that technological development has a negative influence on income inequality in China, taking both labour and capital income into account, Suphanachart (2019) verifies that technological improvements lower income disparity in Thailand. This is still a missing piece of empirical study. Therefore, this research aims to address the existing gap in knowledge by focusing on the dynamic between technical change and income inequality in Vietnam. This study has the potential to contribute valuable insights to the empirical literature, as no prior research has investigated this specific relationship in the context of Vietnam. The objective is to offer new empirical evidence and enhance our understanding of the relationship between technical change and income inequality in the Vietnamese context.

3. Income inequality and technical change in Vietnam

3.1 Income inequality

Data from General Statistics Office of Vietnam (GSO) shows that the Gini coefficient in Vietnam (Figure 1 in Online Appendix) remained relatively constant since 2002, ranging from 0.355 to 0.434, and maintained a safe, efficient and suitable threshold for high growth. Since the Covid period, the Gini coefficient in Vietnam is likely to be lower.

Based on the findings of NiNo-Zarazua *et al.* (2017), the relative Gini coefficient for the East Asia and the Pacific region spanned from 2005 to 2010, with values between 0.5 and 0.6. This value exceeds the national average of 0.4 for Vietnam, suggesting that relative income inequality estimates in Vietnam are slightly lower than those of the region encompassing East Asia and the Pacific.

Prior to 2010, there was a greater disparity in income in urban regions than in rural areas. But inequality in rural areas was evidently worse after 2010 and continued to rise between

2010 and 2018 (Figure 2 in Online Appendix). The urban rich-poor disparity decreased from 7.9 times in 2010 to 7 times in 2018 and 5.4 times in 2020. Oppositely, in rural areas, the income gap between the highest and poorest groups increases from 7.9 times in 2010 to 8.7 times in 2018 and falls to 8 times in 2020 due to the overall impact of the Covid-19 epidemic on the entire economy.

Although the overall pattern of income inequality throughout the whole country seems to be rather consistent over the past decade, there are clear differences in inequality levels between areas. Wider effects of income disparity are often seen in impoverished and underdeveloped areas such as the Northern Mountains and the Central Highlands.

3.2 Technical change

Over the last few decades, Vietnam has seen substantial technological advancement, especially since the "Doi Moi" economic reforms were implemented in 1986. Since then, the country has been experiencing a period of industrialization and modernization. Internet access was officially permitted in 1997 with initial users of just 0.25% of the population due to insufficient technological infrastructure and costly expenses (Poole *et al.*, 2017). However, the internet has currently become widely popular in Vietnam. The country has transitioned from an agricultural economy to a more industrialized one with the growth of the manufacturing sector. On the other hand, recent research by Cirera *et al.* (2021) on firm-level technology adoption in Vietnam reveals that the manufacturing sector in Vietnam remains behind, with the highest technological gap when compared to services and agricultural companies. The authors also suggest that the ordinary Vietnamese enterprises are far from the technology frontier, with a lack of readiness for the digital shift required by the pandemic shock. Additionally, Vietnam is still in the early stages of implementing Industry 4.0 technology.

One of the most popular measures of technical change is the level of Information and Communication Technology capital (ICT capital) (Hötte *et al.*, 2022). This data is not available in Vietnam. Nevertheless, there is an alternative resource is the ICT index, which has been published annually since 2005 by the Ministry of Information and Communication. This index offers information on the current status of ICT development and application in Vietnam, and also provides evaluations and rankings based on the readiness for ICT development. It consists of four primary components: technical infrastructure, human resources, internal applications and online public services. This is one of the most comprehensive assessment indices on the local technology development situation. The ICT index ranges from 0 to 1, where a value closer to 1 signifies a higher level of technological advancement.

The ICT index across Vietnam's six socioeconomic regions is depicted in Figure 3 in Online Appendix, with the mean ICT ranging from 0.314 to 0.517. Rural regions have a lower ICT index, particularly the Northern Mountains and Central Highlands. These regions are inhabited by numerous ethnic minority groups and have an exceptionally high poverty rate (Nguyen *et al.*, 2021). On the contrary, urban regions such as the Southeast and Red River Delta exhibit an above-average ICT index. Better infrastructure and human resources contribute to higher living standards in these regions, thereby providing provinces with a stronger foundation for technical infrastructure, human infrastructure and IT applications, contributing to a high ICT index.

Regarding provincial technology (Table I in Online Appendix), the top three cities with the highest level of technology development are typically developed cities characterized by high personal income and a low Gini coefficient. In contrast, provinces with the lowest level of ICT are those located in mountainous rural areas facing several difficulties. They experience low income per capita and high Gini coefficients, indicating significant inequality.

4. Research methodology

4.1 Model specification

To estimate the impact of provincial technical change on income inequality, we based our study on the theoretical model of Aghion and Howitt (2009), and the modelling strategy of (Muzammil *et al.*, 2018), with the following baseline model specifications:

$$\text{Gini}_{i,t} = \beta_0 + \beta_1 . \text{ICT}_{i,t} + \beta_j . \text{X}_{i,t} + \text{u}_i + \text{v}_{i,t} \quad (1)$$

In this model, i and t denote province *i* and year *t*, respectively. The dependent variable, income in equality is measured by $\text{Gini}_{i,t}$, the Gini coefficient of province i in year t income. The Gini index is the most common measure of income distribution (Nguyen *et al.*, 2021) and is widely used in research on income inequality.

There are a variety of proxies used in the literature to measure technical changes such as TFP, R&D intensity ratio, information and communication technology, robot-diffusion and innovation (Hötte *et al.*, 2022). This paper utilizes the Information and Communication Technology Index (ICT) as a proxied for provincial technical change. This index provides information on the current status of ICT development and application in Vietnam to ministries, branches and localities. It is compiled from 4 main components: technical infrastructure, human infrastructure, internal applications and online public services. In Vietnam, this is one of the most comprehensive assessment reports on the local technology development situation, including technical infrastructure and human resources.

Theoretically, this model contains a set of control variables $\text{X}_{i,t}$ to eliminate confounding effects and ensure the accuracy of the findings. $\text{X}_{i,t}$ includes economic growth, FDI, institutional quality, human capital, trade, urbanization and provincial transportation infrastructure.

This study analyzes economic growth in Vietnamese provinces using the natural logarithm of provincial GRDP per capita in real terms at a comparable 2010 price. Kuznets (1955) suggests an inverted-U relationship between economic growth and income inequality. Income inequality tends to increase in the early stages of economic development due to low-wage sectors like agriculture or manufacturing, reaching its peak at the middle stage. As the economy becomes more developed, income inequality begins to reduce due to improved education, healthcare and redistribution policies.

Foreign direct investment (FDI) is significant for Vietnam's economic growth and income disparity. FDI's impact on inequality can be positive or negative. According to Aghion and Howitt (2009), new technology from multinational companies increases demand and wages for skilled labour, initially widening income inequality. However, as skills improve and technology integrates, inequality reduces.

The impact of trade on income inequality has been extensively studied (Meschi and Vivarelli, 2009) with the Heckscher-Ohlin as the primary model. As trade helps the country or area to concentrate on its comparative advantage, demand for unskilled workers and their earning in developing nations/areas might rise due to their relatively high abundance of unskilled workers. Therefore, trade can help to close the wage gap. This research uses the province's ratio of total imports and exports to GDP to estimate the variable openness to international trade (referred to as "Trade").

The study measures transportation infrastructure development through the natural logarithm of passenger loads, following (Nguyen *et al.*, 2021) and urbanization via the share of urban permanent residents, following Bloom *et al.* (2010). The process of urbanization causes economic structural changes, with people and resources shifting from agricultural activities to industrial operations. This process is related to rising inequality, with higher earnings in urban compared to rural areas. As previously noted, this study investigates how human capital and institutional quality moderate the relationship between technical change and inequality. The variable 'HC' represents human capital and is calculated as the proportion of currently working individuals aged 15 and above who have received training in each province. To assess institutional quality, we utilize the Provincial Competitiveness Index (PCI) for each province in Vietnam.

Also, in the model, unobserved variables are decomposed into time-invariant component u_i, showing the specific characteristics of each province, and time-variant component $v_{i,t}$, is an unseen random component.

We also consider the existence of a non-linear relationship by adding the squared variable of the variable ICT (namely ICT2) to model (2)

$$Y_{i,t} = \beta_0 + \beta_1 . ICT + \beta_2 . ICT2 + \beta_{j.} X_{i,t} + v_{i,t} \tag{2}$$

As discussed above, the effect of increasing or narrowing the income inequality of technical change depends on the institutional quality and human capital level. This study tests these two binding factors on the impact of technical change and income inequality by adding two new interaction variables between ICT and institutions (ICT_PCI) and between ICT and Human capital (ICT_HC).

$$Y_{i,t} = \beta_0 + \beta_1 . ICT + \beta_2 . X_{i,t} ICT2 + \beta_3 . ICT\_PCI + \beta_{j.} X_{i,t} + v_{i,t} \tag{3}$$

$$Y_{i,t} = \beta_0 + \beta_1 . ICT + \beta_2 . ICT2 + \beta_3 . ICT\_HC + \beta_{j.} X_{i,t} + v_{i,t} \tag{4}$$

The control variables $X_{i,t}$ in models (2), (3) and (4) are the same as model (1).

4.2 Data

The Gini coefficients are computed by the GSO using the Vietnam Household Living Standard Survey (VHLSS) from 2010 to 2020. Since 2002, the GSO has conducted VHLSS of more than 30,000 households every even year. In this paper, the Gini coefficient is multiplied by 100, so it ranges from zero (the most equal income distribution) to 100 (the least equal of income distribution).

The ICT Index data, described earlier in this paper, has been collected from the website of the Ministry of Information and Communications since 2005. The data is collected for multiple levels of groups including Ministries, ministerial-level agencies, Government agencies; provinces; economic groups, corporations and commercial banks. In this paper, we used the ICT Index calculated for each province, which is built based on the United Nations' EGDI index system including 4 main components: technical infrastructure, human infrastructure, internal applications and online public services.

In this article, the components of the Provincial Competitiveness Index (PCI) in Vietnam represent the institutional quality. Data on the PCI Index are collected from Vietnam Chamber of Commerce and Industry (VCCI). The PCI evaluates the business climate, economic governance quality and government administrative reform efforts in Vietnamese provinces and cities in supporting the growth of the non-state economic sector. The PCI consists of 10 sub-indexes that represent various aspects of economic governance affecting private sector development, such as market entry costs, land access and stability in land use, transparency of business environment and business information, unofficial fees, inspection, examination and implementation of administrative regulations and procedures time, competitive environment, the pioneering and dynamism of provincial leaders, business support services, labour training policy and dispute resolution procedures. The index is ranked on a scale of 100 points, with higher points representing better institutional quality.

Other data are collected from Provincial Statistical Yearbooks issued by the Provincial Statistics Officers.

We will use the panel data of 63 provinces for all even years from 2010 to 2020 to estimate model (1) with a total of 378 observations. Table II in Online Appendix summarizes statistics of the data set in the model.

4.3 Methodology

Based on the theoretical review, we proposed a model to estimate the effect of technical changes on income inequality using panel data from 63 provinces in Vietnam from 2010 to 2020. The Pooled OLS will be used initially for the model; nevertheless, due to the time and cross-sectional variability of observations in panel data, it is advisable to incorporate the Fixed Effects Model (FEM) and Random Effects Model (REM). In contrast to the Pooled OLS, which disregards the panel structure and aggregates data from various sectors and time periods into a single large dataset, FEM takes into consideration individual-specific effects, thereby mitigating the influence of time-invariant unobserved factors that introduce bias. REM, on the other hand, permits correlations between the independent variables and the individual-specific effects, which can be especially beneficial when time-varying factors are correlated with the individual-specific effects. The optimal model is determined by applying pertinent tests to the three models.

In addition, the purpose of this paper is to investigate how human capital and government quality moderate the relationship. Specifically, in the estimation equation, the interaction variables are interacting variables between ICT with two variables, namely PCI and HC.

5. Empirical results and discussion

We start with a linear model of ICT and Gini coefficients in model (1); however, the association is not statistically significant at the conventional level except for the pooled OLS. Next, we apply a quadratic model, in which both ICT and ICT2 are included in the model (2). The estimation results show that both of ICT and ICT2 are statistically significant (Table 1). The coefficients are different for each model; however, there is a clear U-shape relationship between the ICT index and income inequality for all Pooled OLS, FEM, REM and GLS models. To choose a suitable model, we apply the Breusch – Pagan (xttest0) to choose between OLS and FEM/REM, and then the Hausman test to choose between FEM and REM. After the testing process, the FEM appeared to be the optimum. However, the FEM suffers from problems of autocorrelation and heteroskedasticity, so we apply the GLS to fix these problems. In this study, we use the results from GLS for interpretation.

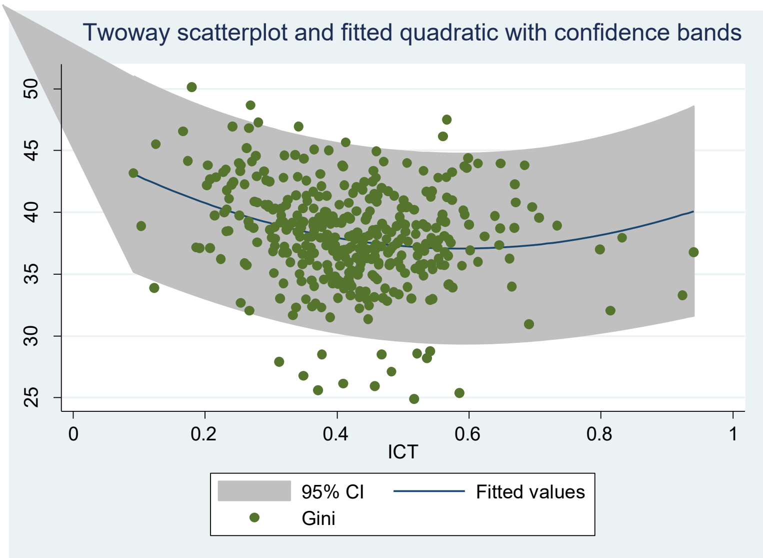
Gini coefficients initially fall as the ICT index rises. When the ICT score is approximately 0.44 (which is equal to $14.72/(2 \times 16.67)$), the effect of the ICT index on income inequality is equal to zero. Later, when the ICT score is above 0.44, its effect on income gap is negative. This result suggests that technical change appears to have a non-linear influence on income disparity in Vietnam. Figure 1 presents the quadratic correlation between the Gini index and ICT with 95% confidence bands. This result is consistent with a research by Jaumotte and Tytell (2007), who found that technical advancement, as measured by ICT capital, seems to have a nonlinear influence on the labour share of income using panel data from 18 advanced OECD nations from 1982 to 2002. The notion that technological advancements might decrease income disparity in less-developed regions and exacerbate economic inequalities in rich regions is supported by a study conducted by Muzammil *et al.* (2018).

One possible explanation is that when a province has low levels of technology, advancements in general-purpose technologies like computers and the internet have the potential to boost overall labour productivity, which in turn might elevate living standards, and narrow economic disparities. This, in turn, could lead to higher living standards and lower economic inequality. As technology advances and becomes increasingly skilled-biased,

Dependent Variable	(1) Pooled OLS	(2) FEM	(3) REM	(4) GLS
ICT	−19.26***	−12.64*	−16.47**	−14.72***
	(7.277)	(7.008)	(6.739)	(4.953)
ICT2	18.90**	17.73**	21.20***	16.67***
	(8.161)	(7.830)	(7.529)	(6.035)
HC	−0.0766**	−0.241***	−0.157***	−0.114***
	(0.0368)	(0.0716)	(0.0483)	(0.0366)
lnGRDPPC	−0.638	−1.046	−0.539	−1.308**
	(0.483)	(1.368)	(0.733)	(0.624)
FDI	−0.967	−1.322	−1.395	−0.659
	(1.448)	(1.235)	(1.233)	(0.729)
Trade	−0.428**	−0.164	−0.296	−0.528**
	(0.184)	(0.240)	(0.211)	(0.211)
PCI	−0.0509	0.00767	−0.0178	0.0253
	(0.0536)	(0.0522)	(0.0488)	(0.0384)
passengers	−0.513***	2.589***	−0.0221	−0.347*
	(0.193)	(0.818)	(0.325)	(0.208)
Urban	4.491**	−14.50***	−1.049	1.984
	(1.905)	(4.899)	(2.692)	(2.066)
_cons	49.69***	44.20***	47.21***	46.38***
	(3.234)	(3.646)	(3.040)	(2.500)
N	378	378	378	378
Adjusted R^2	0.142	0.155	0.1191	
Wald test		p-value = 0.0000 < 0.05		
Hausman test		p-value = 0.0041 < 0.05		

Note(s): Numbers in bracket indicate standard errors, and asterisk marks with *, ** and *** indicate the estimated coefficients are statistically significant at level of 10, 5 and 1%, respectively
Source(s): Authors' estimation

Table 1.
Regression results of ICT and ICT2 on Gini coefficient



Source(s): Authors' estimation

Figure 1.
Gini index and ICT index with 95% confidence intervals

as suggested by the Directed technical change hypothesis, only skilled workers are able to adapt to new technologies and enhance their productivity, whereas low-skilled workers may struggle to keep up, leading to a widening income disparity, as suggested, by the SBTC hypothesis. Furthermore, this explanation can be attributed to the fact that Vietnam's ICT development is concurrent with its modernization, transitioning from an agriculture to a manufacturing economy. Provinces with low ICT levels are primarily rural areas where agriculture dominates. Technological advancements in these provinces generally support agricultural activities, enhancing the productivity of low-skilled workers. In contrast, major cities that have made significant progress in ICT are mostly large cities that have a predominant focus on manufacturing operations. So that technological changes here are more complex and skill-intensive, increasing the productivity and demand for skilled labour, thereby widening the income gap.

All of the four models show a negative and statistically significant relationship between Human capital and Gini. This indicates that improvement in the skilled labour rate can help reduce income inequality. This finding is consistent with the human capital model of income distribution by Mincer (1958) and other research by Castelló-Climent and Doménech (2021) and Barro (2000) that the more educated, the lower the level of income disparity. It can be explained that education is a kind of investment in workers' skills. Therefore, an increase in the supply of skilled labour can satisfy the extra demand of skilled workers, helping to maintain the wage of the skills (Pan, 2014). Therefore, the premium for educated workers will eventually diminish and the wage gap between skilled and unskilled workers begins to fall (Knight and Sabot, 1983).

The regression model also suggests that trade openness has a negative impact on income inequality, implying that provinces with a higher proportion of overall trade contributing to GRDP have a narrower difference between rich and poor. This discovery aligns with Heckscher – Ohlin trade theory, which posited that an increase in trade in nations with a predominantly unskilled labour force leads to a reduction in inequality. Trade liberalization will drive provinces and cities to concentrate on producing goods and services in which they have a comparative advantage. Increased trade openness can generate various opportunities for many economic sectors and affect the income of the population.

It appears that income disparity is negatively impacted by per capita income, suggesting that provinces/cities experiencing greater economic growth may exhibit reduced levels of inequality. Vietnam may have already reached its peak of the Kuznets curve, given its transition to a middle-income nation. The income disparity may be mitigated by policies that prioritize education and healthcare development, as well as redistribution, as the economy continues to develop.

As indicated by the negative correlation between FDI inflow and income gap in the estimation results, the presence of the foreign direct investment sector contributes to the reduction of income inequality. Although the majority of coefficients lack statistical significance, numerous prior studies have confirmed the contribution of the FDI sector in Vietnam towards poverty reduction and income gap narrowing (Le *et al.*, 2022).

The correlation between the income disparity and additional variables, such as urbanisation, passenger loads and PCI, remains unconfirmed and requires additional research.

Columns (1) and (2) in Table 2 display the estimation findings of Model (3), which examines how ICT and ICT squared affect income inequality when institutional quality is taken into account. The interaction variable between ICT and institutions, given by the variable ICT_PCI, is the major variable to be considered in this model. The coefficients of the interaction variables are negative and statistically significant at the 1% level in both linear and quadratic models. This finding suggests that in provinces with higher standards of governance and administrative efforts, technological progress will have a lessening effect on income disparities. Put another way, technical advancement will result in a reduction in Vietnam's

Table 2.
Regression results of ICT and ICT2 with interaction variables on the Gini coefficient

Dependent variables	(1) Model (3) Gini	(2) Model (3) Gini	(3) Model (4) Gini	(4) Model (4) Gini
ICT	70.54***	68.68***	3.544	−14.63**
	(17.84)	(17.43)	(4.282)	(7.011)
ICT2		31.80***		33.20***
		(8.030)		(10.24)
HC	−0.176**	−0.154**	−0.212*	0.0606
	(0.0724)	(0.0709)	(0.124)	(0.148)
lnGRDPPC	−1.032	−1.911	−0.662	−1.659
	(1.340)	(1.328)	(1.370)	(1.384)
FDI	−1.450	−1.515	−1.308	−1.263
	(1.217)	(1.189)	(1.245)	(1.226)
Trade	−0.189	−0.136	−0.196	−0.181
	(0.236)	(0.231)	(0.242)	(0.239)
PCI	0.452***	0.611***	0.0105	0.00370
	(0.126)	(0.129)	(0.0526)	(0.0518)
passengers	2.364***	2.543***	2.456***	2.574***
	(0.805)	(0.787)	(0.824)	(0.813)
Urban	−14.88***	−14.24***	−14.79***	−13.39***
	(4.823)	(4.714)	(4.944)	(4.888)
ICT_PCI	−1.110***	−1.523***		
	(0.289)	(0.301)		
ICT_HC			−0.0557	−0.605**
			(0.201)	(0.260)
_cons	13.81*	11.26	39.77***	43.55***
	(7.543)	(7.397)	(3.492)	(3.631)
N	378	378	378	378
R^2	0.203	0.242	0.165	0.192

Note(s): Numbers in bracket indicate standard errors, and asterisk marks with *, ** and *** indicate the estimated coefficients are statistically significant at level of 10, 5 and 1%, respectively
Source(s): Authors' calculation by STATA

wealth disparity due to the influence of high-quality regulations. Higher quality institutions and a conductive political and administrative environment motivate companies to increase their involvement in research and development. This leads to technological progress and fosters productivity alignment with leading local companies through incentivization. Improved governance and public administration, achieved by reducing market entry costs and unofficial fees, can enhance democratic processes, reduce corruption and ultimately make public investment and income-redistribution programs more efficient and beneficial for the poor.

The results of Model (4), which examined the moderating effects of human capital on the ICT and income inequality nexus, are displayed in Columns (3) and (4) of Table 2. The finding shows that the interaction variables between ICT and Human capital (ICT_HC) are negative and statistically significant at 5% in quadratic models. This outcome validates that the technical change has favorable impacts on decreasing income disparity through the influence of human capital. Technological development seems to have a greater impact on reducing inequality in provinces with a higher proportion of skilled people. It is clear from this moderating role of human capital that education plays a crucial role in jobs that need employees to be able to adjust to technological change. As a result, learning to keep up with and comprehend new technology advancements is essential. Therefore, provinces with a greater degree of human capital can more effectively adjust to changes in new technologies and provide higher income for workers.

6. Conclusion

In this study, we examine the influence of technology developments on income disparities in Vietnam. To begin, we provide a theoretical model that describes the effect of technological advances on income disparity. Then, we use statistical estimation methods with panel data from 63 Vietnamese provinces from 2010 to 2020 to uncover the linear and non-linear correlations. In addition, we analyze this relationship under the moderating effects of institutional quality and human capital.

This study provides two main valuable insights into how technology advancements impact income disparity, adding to existing literature on the subject. First, we present empirical evidence of a non-linear correlation between technological advancements and income inequality at the provincial level in a developing country, a departure from earlier research which mostly focuses on rich nations or cross-country comparisons. This suggests that for developing nations, initially, from a low starting point, enhanced technology can narrow the economic gap, but over time, more advanced technology may exacerbate income disparity. Furthermore, this research introduces a novel perspective: the quality of institutions and human capital has a regulatory influence on the relationship between technological developments and economic disparity. Specifically, the estimated coefficients of interacting variables between the quality of institutions, human capital and Gini coefficient are negative and statistically significant. This implies that in the provinces/cities with better institutional quality and/or higher skilled rate of labour, technical change can reduce income disparity.

The findings of this study have various policy implications. Firstly, advancements in technology are crucial for economic development, but it is essential to carefully evaluate their impact on income disparity. Secondly, this finding supports the idea that the quality of institutions is associated with both income distribution and technical advancement. All provinces can benefit from reducing income inequality by working to improve the institutional quality of their governments through anti-corruption measures, increased transparency and the establishment of an effective legal framework. Additionally, the country can also profit from integrating technology into public administration activities such as e-government initiatives. Thirdly, the educational system in developing countries such as Vietnam needs additional reforms, as human capital is an essential factor in how technological progress impacts inequality. Therefore, aiming for high-quality human resources might boost the country's technical progress while also decreasing the economic gap. A report from the World Bank (2014) shows that there is still a skills gap in the Vietnamese labour market despite notable basic literacy and numeracy achievements as many businesses report a scarcity of individuals with the required technical expertise. In addition, corporations are increasingly seeking cognitive abilities, such as problem solving and critical thinking, as well as behavioral skills in non-manual activities. As a result, policymakers should prioritize investments in public education and training. One approach is to provide a strong applied educational foundation and adequate technical education, which will assist in providing more skilled workers to the labour force. Finally, trade openness may be a solution to income equality. Local governments may implement particular strategies to identify the province's competitive advantage and promote provincial commerce. Vietnam, being a tropical nation with a diverse range of agricultural goods, has implemented a successful agricultural product trading strategy known as OCOP (One Country One Product). Each province should identify and cultivate its unique items that offer a competitive edge, thus enhancing its trade capabilities. Better commerce may not only serve to boost a province's GDP and expand job opportunities for both skilled and unskilled workers as suggested by Poole *et al.* (2017), but it may also facilitate the transfer of knowledge and new technological adoption.

References

Acemoglu, D. (1998), "Why do new technologies complement skills? Directed technical change and wage inequality", *Quarterly Journal of Economics*, Vol. 113 No. 4, pp. 1055-1089, doi: 10.1162/003355398555838.

Acemoglu, D. (2002a), "Technical change, inequality, and the labor market", *Journal of Economic Literature*, Vol. 40 No. 1, pp. 7-72, doi: 10.1257/jel.40.1.7.

Acemoglu, D. (2002b), "Technology and inequality", NBER Reporter Online Provided, Winter 200, pp. 12-16.

Acemoglu, D. (2003), "Labor-and capital-augmenting technical change", *Journal of the European Economic Association*, Vol. 1 No. 1, pp. 1-37, doi: 10.1162/154247603322256756.

Aghion, P. and Howitt, P. (2009), *The Economics of Growth*, The MIT Press, Cambridge, Massachusetts, London.

Acemoglu, D. and Restrepo, P. (2022), "Tasks, automation, and the rise in U.S. wage inequality", *Econometrica*, Vol. 90 No. 5, pp. 1973-2016, doi: 10.3982/ecta19815.

Adeleye, B.N. (2024), "Does institutional quality moderate the human capital–inequality dynamics? Comparative evidence from LAC and SSA countries", *African Development Review*, Vol. 35 No. 1, pp. 153-169, doi: 10.1111/1467-8268.12740.

Aghion, P., Bergeaud, A., Boppart, T., Klenow, P.J. and Li, H. (2023), "A theory of falling growth and rising rents", *The Review of Economics Studies*, Vol. 90 No. 6, pp. 2675-2702, doi: 10.1093/restud/rdad016.

Alesina, A., Battisti, M. and Zeira, J. (2018), "Technology and labor regulations: theory and evidence", *Journal of Economic Growth*, Vol. 23 No. 1, pp. 41-78, doi: 10.1007/s10887-017-9146-y.

Almeida, A. and Afonso, Ò. (2010), "SBTC versus trade: testing skill-premia evidence across 25 OECD countries", *Applied Economics Letters*, Vol. 17 No. 15, pp. 1497-1501, doi: 10.1080/13504850903049601.

Autor, D.H., Katz, L.F. and Krueger, A.B. (1998), "Computing inequality have computers changed the labor market?", *The Quarterly Journal of Economics*, Vol. 113 No. 4, pp. 1169-1213, doi: 10.1162/003355398555874.

Barro, R.J. (2000), "Inequality and growth in a panel of countries", *Harvard University*, Vol. 5, June, pp. 2-48.

Bengtsson, E. and Waldenström, D. (2018), "Capital shares and income inequality: evidence from the long run", *Journal of Economic History*, Vol. 78 No. 3, pp. 712-743, doi: 10.1017/S0022050718000347.

Berg, A.G. and Ostry, J.D. (2011), "Inequality and unsustainable growth: two sides of the same coin?", *IMF Economic Review*, Vol. 65 No. 4, pp. 792-815, doi: 10.1057/s41308-017-0030-8.

Bloom, D.E., Canning, D., Fink, G., Khanna, T. and Salyer, P. (2010), "Urban settlement: data, measures, and trends" (2010/12; WIDER Working Paper).

Bourguignon, F. (2004), "The poverty growth inequality triangle", March.

Card, D. and DiNardo, J.E. (2002), "Skill-biased technological change and rising wage inequality: some problems and puzzles", *Journal of Labor Economics*, Vol. 20 No. 4, pp. 733-783, doi: 10.1086/342055.

Castelló-Climent, A. and Doménech, R. (2021), "Human capital and income inequality revisited", *Education Economics*, Vol. 29 No. 2, pp. 194-212, doi: 10.1080/09645292.2020.1870936.

Cingano, F. (2014), "Trends in income inequality and its impact on economic growth", (163; OECD Social, Employment and Migration Working Papers).

Cirera, X., Comin, D., Cruz, M., Lee, K.M. and Martins-Neto, A.S. (2021), "Firm-level technology adoption in Vietnam", Policy Research Working Paper (Issue March).

Ferreira, A. (2020), "Skill-biased technological change and inequality in the U.S.", *Notas Economicas*, Vol. 51, pp. 91-107.

Fuentes, R., Mishra, T., Scavia, J. and Parhi, M. (2014), "On optimal long-term relationship between TFP, institutions, and income inequality under embodied technical progress", *Structural Change and Economic Dynamics*, Vol. 31, pp. 89-100, doi: 10.1016/j.strueco.2014.08.003.

Galor, O. and Moav, O. (2004), "From physical to human capital accumulation: inequality and the process of development", *Review of Economic Studies*, Vol. 71 No. 4, pp. 1001-1026, doi: 10.1111/0034-6527.00312.

Goldin, C. and Katz, L.F. (1998), "The origins of technology - skill complementary", *The Quarterly Journal of Economics*, Vol. 113 No. 3, pp. 693-732, doi: 10.1162/003355398555720.

Griliches, Z. (1969), "Capital-skill complementarity", *The Review of Economics and Statistics*, Vol. 51 No. 4, pp. 465-468, doi: 10.2307/1926439.

Hornstein, A., Krusell, P. and Violante, G.L. (2005), "Chapter 20 the effects of technical change on labor market inequalities", in *Handbook of Economic Growth*, Vol. 1, Issue Suppl. Part B, Elsevier Masson SAS, doi: 10.1016/S1574-0684(05)01020-8.

Hötte, K., Somers, M. and Theodorakopoulos, A. (2022), "Technology and jobs: a systematic literature review", (2022-2).

Jaumotte, F. and Tytell, I. (2007), "How has the globalization of labor affected the labor income share in advanced countries?", IMF Working Papers, Vol. 07 No. 298, p. 1, doi: 10.5089/9781451868616.001.

Jaumotte, F., Lall, S. and Papageorgiou, C. (2013), "Rising income inequality: technology, or trade and financial globalization?", *IMF Economic Review*, Vol. 61 No. 2, pp. 271-309, doi: 10.1057/imfer.2013.7.

Jerzmanowski, M. and Tamura, R. (2019), "Directed technological change & cross-country income differences: a quantitative analysis", *Journal of Development Economics*, Vol. 141 August, 102372, doi: 10.1016/j.jdeveco.2019.102372.

Katz, L.F. and Murphy, K.M. (1992), "Changes in relative wages, 1963-1987: supply and demand factors", *The Quarterly Journal of Economics*, Vol. 107 No. 1, pp. 35-78, doi: 10.2307/2118323.

Klasen, S. (2016), "What to do about rising inequality in developing countries?", PEGNet Policy Brief (5; PEGNet Policy Brief, Issue 5).

Knight, J.B. and Sabot, R.H. (1983), "Educational expansion and the Kuznets effect", *The New Palgrave Dictionary of Economics*, Vol. 73 No. 5, pp. 1132-1136, doi: 10.1057/9780230226203.0037.

Krusell, P., Ohanian, L.E., Rios-Rull, J.V. and Violante, G.L. (2000), "Capital-skill complementarity and inequality: a macroeconomic analysis", *Econometrica*, Vol. 68 No. 5, pp. 1029-1053, doi: 10.1111/1468-0262.00150.

Kuznets, S. (1955), "Kuznets 1955.pdf", *The American Economic Review*, Vol. 1, p. 30.

Le, Q.H., Do, Q.A., Pham, H.C. and Nguyen, T.D. (2021), "The impact of foreign direct investment on income inequality in Vietnam", *Economies*, Vol. 9 No. 1, pp. 1-15, doi: 10.3390/economies9010027.

Le, Q.H., Quach, M.H. and Tran, H.L. (2022), "Credit composition and income inequality in Vietnam: an empirical analysis", *Journal of Economics and Development*, Vol. 24 No. 4, pp. 365-377, doi: 10.1108/jed-08-2020-0110.

Lee, J.W. and Lee, H. (2018), "Human capital and income inequality*", *Journal of the Asia Pacific Economy*, Vol. 23 No. 4, pp. 554-583, doi: 10.1080/13547860.2018.1515002.

Lindquist, M.J. (2005), "Capital-skill complementarity and inequality in Sweden", *Scandinavian Journal of Economics*, Vol. 107 No. 4, pp. 711-735, doi: 10.1111/j.1467-9442.2005.00425.x.

Meschi, E. and Vivarelli, M. (2009), "Trade and income inequality in developing countries", *World Development*, Vol. 37 No. 2, pp. 287-302, doi: 10.1016/j.worlddev.2008.06.002.

Mincer, J. (1958), "Investment in human capital and personal income distribution", *Journal of Political Economy*, Vol. 66 No. 4, pp. 281-302, doi: 10.1086/258055.

Moll, B., Rachel, L. and Restrepo, P. (2022), "Uneven growth: automation's impact on income and wealth inequality", *Econometrica*, Vol. 90 No. 6, pp. 2645-2683, doi: 10.3982/ecta19417.

Muzammil, M., Amir-Ud-Din, R., Ejaz, R. and Khan, A. (2018), "How do the technology transfer and trade openness affect income inequality: a panel data analysis?", *Kashmir Economic Review*, Vol. 27 No. 2, p. 2018.

Nelson, R.R. and Phelps, E.S. (1980), "Investment in humans, technological diffusion, and economic growth", *Studies in Macroeconomic Theory*, Vol. 56 No. 1, pp. 133-139, doi: 10.1016/b978-0-12-554002-5.50015-7.

Nguyen, C.V., Giang, L.T., Tran, A.N. and Do, H.T. (2021), "Do good governance and public administration improve economic growth and poverty reduction? The case of Vietnam", *International Public Management Journal*, Vol. 24 No. 1, pp. 131-161, doi: 10.1080/10967494.2019.1592793.

NiNo-Zarazua, M., Roope, L. and Tarp, F. (2017), "Global inequality: relatively lower, absolutely higher", *Review of Income and Wealth*, Vol. 63 No. 4, pp. 661-684, doi: 10.1111/roiw.12240.

Pan, L. (2014), "The impacts of education investment on skilled-unskilled wage inequality and economic development in developing countries", *Economic Modelling*, Vol. 39, pp. 174-181, doi: 10.1016/j.econmod.2014.02.040.

Pi, J. and Zhou, Y. (2013), "Institutional quality and skilled-unskilled wage inequality", *Economic Modelling*, Vol. 35, pp. 356-363, doi: 10.1016/j.econmod.2013.07.029.

Poole, J.P., Santos-Paulino, A.U., Sokolova, M.V. and DiCaprio, A. (2017), "The impact of trade and technology on skills in Viet Nam" (770; ADBI Working Paper 770, Issue 770), doi: 10.1007/978-1-349-67278-3_116.

Ravallion, M. (2004), "Pro-poor growth: a primer", World Bank Policy Research Working Paper (World Bank Policy Research Working Paper, Vol. 3242).

Sequeira, T.N., Santos, M. and Ferreira-Lopes, A. (2017), "Income inequality, TFP, and human capital", *Economic Record*, Vol. 93 No. 300, pp. 89-111, doi: 10.1111/1475-4932.12316.

Singh, A. and Dhumale, R. (2000), "Globalization, technology, and income inequality: a critical analysis", in *Inequality Growth and Poverty in an Era of Liberalization and Globalization*, Vol. 210, doi: 10.1093/0199271410.003.0006.

Solow, R.M. (1956), "A contribution to the theory of economic growth", *The Quarterly Journal of Economics*, Vol. 70 No. 1, pp. 65-94, doi: 10.2307/1884513.

Suphanachart, W. (2019), "Effects of technological change on income inequality in Thailand", *Southeast Asian Journal of Economics*, Vol. 7 No. 2, pp. 85-106.

Syverson, C. (2011), "What determines productivity", *Journal of Economic Literature*, Vol. 49 No. 2, pp. 326-365, doi: 10.1257/jel.49.2.326.

Van Reenen, J. (2011), "Wage inequality, technology and trade: 21st century evidence", *Labour Economics*, Vol. 18 No. 6, pp. 730-741, doi: 10.1016/j.labeco.2011.05.006.

World Bank (2014), "Stock: an update on Vietnam's recent economic developments", Key Findings, available at: https://www.worldbank.org/en/news/feature/2014/07/08/key-findings-of-taking-stock-an-update-on-vietnams-recent-economic-developments-july-2014 (accessed 5 May 2023).

Zhang, X., Wan, G., Wang, C. and Luo, Z. (2017), "Technical change and income inequality in China", *World Economy*, Vol. 40 No. 11, pp. 2378-2402, doi: 10.1111/twec.12531.

Further reading

Violante, G.L. (2020), "Skill-biased technical change", in *The New Palgrave Dictionary of Economics*, Vols 1-6, doi: 10.1057/978-1-349-95121-5.

Online appendix

The supplementary material for this article can be found online.

Corresponding author

Thu Kim Hoang can be contacted at: thuhoangkim@gmail.com