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The impact of digitalization and foreign direct investment on income inequality: Implications for human resource quality in the digital age

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Abstract

This paper examines the impact of digitalization and foreign direct investment (FDI) on income inequality in Vietnam with data collected from 46 provinces over the 2018-2022 period. Employing the OLS, FEM, REM, and GLS methods, the results show that while digitalization, FDI, and trade openness help to reduce income inequality, human capital could widen this gap across provinces. Based on the findings and analysis, recommendations are proposed to improve Vietnam's human capital quality in the digital age.

Keywords: digitalization, foreign direct investment, human capital, income inequality

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1. Introduction

The Fourth Industrial Revolution is rapidly unfolding globally and is having a direct impact on Vietnam. This presents a significant opportunity to accelerate the country's industrialization and modernization. According to the International Labour Organization, Vietnam is one of the countries most affected by the Fourth Industrial Revolution since the country has actively and deeply integrated into the global economy (Chu, 2018). Foreign direct investment (FDI) is not only a product of integration but also a driving force behind it. However, FDI has also contributed to inequality due to technology transfer and the demand for high-skilled labor (Nguyen & Tran, 2022).

Driven by the Fourth Industrial Revolution, digitalization is rapidly taking place across all sectors and industries of Vietnam, especially since the issuance of the Prime Minister's Decision No. 505/QĐ-TTg on the National Digital Transformation Day, issued on April 22, 2022, and Decision No. 58/QĐ-UBQGCĐS of the National Committee for Digital Transformation on the issuance of the 2024 Action Plan, promulgated on April 19, 2024, to accelerate national digitalization. According to Dinh (2020), digitalization is a global trend and an irreversible process. In this context, digitalization is accelerating the shift in FDI towards high-tech industries and provinces with well-developed digital infrastructure. This has increased the income gap between skilled and unskilled labor, leading to income inequality. Consequently, industries that rely heavily on unskilled labor are facing significant challenges and a high risk of unemployment due to the development of automation and artificial intelligence (Chu, 2018). This has resulted in increasing unemployment and income inequality. Therefore, to address these challenges, it is imperative to focus on improving the quality of the human capital.

In September 2015, the 2030 Agenda with 17 Sustainable Development Goals (SDGs) was adopted by the United Nations General Assembly to end poverty, protect the planet, and ensure prosperity for all. Vietnam has been actively working towards achieving these goals, including reducing inequality. Vietnam's Gini coefficient in 2022 was 0.375 (General Statistics Office, 2022), although inequality between provinces and cities is increasing.

Given these factors, this study aims to examine the impact of digitalization and FDI on income inequality, thereby influencing income distribution and contributing to social equality. Through this research, the authors focus on analyzing the impact of digitalization and FDI on income inequality in Vietnamese provinces and cities and thereafter provide recommendations to enhance income equality as well as human capital quality in the digital age, particularly in Vietnam affected by the Fourth Industrial Revolution.

2. Related Literature

2.1 Studies on the impact of Foreign Direct Investment on income inequality

Regarding the impact of FDI on income inequality, modernization theory and endogenous growth theory hypothesize a non-linear relationship between FDI and income inequality. Additionally, the H-O model of international trade suggests that FDI reduces income inequality. Endogenous growth theory focuses on technology but fails to explain what determines technological innovation (Aghion & Howitt, 1998). Lee et al. (2009) indicate that FDI initially reduces income inequality but increases it again when countries achieve financial growth, thus encouraging countries with low FDI to focus more on developing their financial sectors. Meanwhile, the General Purpose Technology (GPT) model, as proposed by Zulfiu Alili and Adnett (2018), suggests that wage inequality initially increases with FDI due to the increased demand for skilled labor but may

decrease afterward.

Conversely, dependency theory and the North-South model hypothesize that FDI increases income inequality. According to the North-South model, FDI often flows into capital-intensive and technology-intensive industries, requiring highly skilled labor. Feenstra et al. (1997) argue that this creates a high-income labor group, widening the income gap with the rest of the population. Consequently, FDI increases income inequality in a country but may decrease as the country develops and has a higher-skilled workforce (Huang, Sim, & Zhao, 2020). While FDI can increase income inequality, it can also be reduced under the regulation of education and institutions at the provincial level (Le et al., 2021).

2.2 Studies on the impact of digitalization on income inequality.

Dinh (2020) highlights that digitalization has become a global and irreversible trend. This transformation is driving FDI toward high-tech sectors and regions with advanced digital infrastructure. As a result, the income gap between skilled and unskilled workers has widened, exacerbating income inequality. Additionally, industries dependent on unskilled labor are encountering substantial difficulties, including heightened unemployment risks, due to advancements in automation and artificial intelligence (Chu, 2018). These developments have resulted in unemployment and income inequality. Addressing these issues requires prioritizing efforts to enhance the quality of human capital.

Many previous studies have highlighted the influence of digitalization on income inequality. According to the Skill-Biased Technological Change (SBTC) theory, technological advancements tend to favor highly skilled workers, reducing the demand for low-skilled labor and exacerbating income inequality (Acemoglu, 2002). The theory identifies two main effects of new technology on the labor market. First, technology enables businesses to reduce the need for low-skilled workers while increasing demand for highly skilled labor directly related to technology. Second, in the capital market, investment flows tend to concentrate on sectors utilizing modern technology, equipping workers in these sectors with more capital, thus increasing their relative wages (Suphannachart, 2019).

In addition to SBTC, a stylized socio-ecological model by Mirza et al. (2019) revealed that the positive correlation between digitalization and asset accumulation could intensify local income inequality, subsequently increasing poverty and natural resource degradation. In developing societies, the positive relationship between assets and technology may lead to moderate inequality levels. However, if technology and productivity are unevenly distributed, particularly in a "long-tail" manner only a small elite group gains access to advanced technologies. This elite group accumulates wealth through technology, capital income, and resource control, widening the wealth gap. If left unchecked, this situation could lead to resource overexploitation and push more people into poverty.

Global research on the impact of digitalization on income inequality has yielded mixed results. A study by Xiao et al. (2024) found that digitalization exacerbates income inequality in both developed and developing countries, with developed nations being more severely affected. In contrast, Nguyen (2022) found that digitalization has a U-shaped effect on income inequality: it benefits developed economies but harms developing ones. Similarly, Hoàng (2023) asserted that technological advancements have an inverse effect on income inequality. A novel approach by Huang et al. (2024) produced differing results. Their research indicated that technological advancements, such as digitalization, AI, and the data economy, could have distinct impacts on labor supply, differentiating them from traditional technologies like automation. By incorporating the labor supply effects of digitalization into a growth model, Huang et al. (2024) demonstrated that both skilled and unskilled workers could benefit from the digital economy's development through easier access to new knowledge, reduced learning time, or lower education costs. This creates equal opportunities for unskilled labor to engage in e-commerce entrepreneurship. The labor supply effect can offset the traditional labor demand effect in the digital economy, leading to a declining or U-shaped trend in income inequality. Studies by Munandar et al.

(2023), Namazi (2020), and Tian, L., and Xiang, Y. (2024) also concluded that digitalization contributes to reducing income inequality gaps.

In this study, the research team aims to examine factors such as human capital, the extent of digital transformation, and FDI inflows across provinces and cities in Vietnam. Based on these considerations, the team formulated the following two hypotheses:

H1: Digitalization exaggerates income inequality

H2: FDI reduces income inequality

3. Methodology

In this study, income inequality is the dependent variable, measured by the Gini coefficient across provinces and cities in Vietnam based on data published by the General Statistics Office of Vietnam. The independent variable is the level of digitalization, measured by the DIG index. The DIG index is constructed based on three indicators: mobile phone user penetration rate (MPH), telecommunications service user penetration rate (TPH), and government science and technology expenditure (SCE). The method for calculating the DIG index applies the standardization process of the United Nations Human Development Index (HDI):

$$Dimension\ \ index = \frac{Actual\ \ value - Minimum\ \ value}{Maximum\ \ value - Minimum\ \ value} * 100$$

The composite DIG index by averaging the three dimensions:

$$DIG = \frac{MPH\ \ + TPH + SCE}{3}$$

The remaining explanatory variables are selected based on previous empirical research results. Based on theoretical foundations and data availability, the model for estimating and testing the impact of digitalization and FDI on income inequality is calculated for 46 provinces and cities in Vietnam. The period from 2018-2022 was chosen for research by the authors for the following reasons: *i*, In the context of global fluctuations during this period, Vietnam still attracted strong FDI inflows and positive growth; *ii*, The Covid-19 pandemic prompted businesses to switch to digitalization solutions to maintain operations. Investments in information technology, telecommunications, and e-commerce increased significantly, along with a strong digitalization context; *iii*, The scale for measuring the level of income inequality by province, Gini, used in this study, was collected and published in 2018, and the latest data was updated to 2022; therefore, 2022 was chosen as the end year of the study period; and *iv*, The period from 2018-2022 is long enough to consider the impact of digitalization and FDI on income inequality. Due to the effects of the COVID-19 pandemic, data was only collected from 46 provinces and cities during the 2018-2022 period. However, the balanced panel dataset still ensures quality, allowing for constructing a specific research model as follows:

$$Gini_{it} = \alpha_1 + \alpha_2 * Log\ HC_{it} + \alpha_3 * DIG/Gini_{it} + \alpha_4 * Log\ FDI_{it} + \alpha_5 * To_{it} + u_{ijt}$$

Where:

Table 1

Summary of Variables in the Model

Variable	Description	Expected Sign	Source
$Gini_{it}$	The Gini coefficient of province *i* in year *t*		General Statistics Office of Vietnam
To_{it}	The trade openness index of province *i* in year *t*	–	Vietnam's import-export reports
$DIG/Gini_{it}$	The index measuring the level of digitalization of province *i* in year *t* is constructed based on three indicators	+	the Statistical Yearbooks of each province
$LogFDI_{it}$	The index measuring foreign direct investment capital of province *i* in year *t*	–	the Statistical Yearbooks of each province

$LogHC_{it}$	The index measuring human capital, standardized using a method similar to DIG, with the aggregation by averaging two indicators: the proportion of the labor force aged 15 and over with certified training by locality and the number of students	+	the Statistical Yearbooks of each province

Source: Self-compiled by the authors, 2024

We will conduct the respective tests to choose amongst three possible models: The Pooled Ordinary Least Squares (POLS) model is employed when assuming that all coefficients remain constant across different spatial and temporal conditions. If the observations vary across both time and space, either Fixed Effects (FE) or Random Effects (RE) models can be utilized. In particular, the FE model inherently eliminates variables with time-invariant values, while the RE model assumes no correlation between the independent variables and the error term. Three respective tests will be used to identify the appropriate model. The F test to select between POLS and FE models with the Null hypothesis is that the POLS will be the preferred model. Breusch- Pagan (BP) test is used for choosing between POLS and RE models where the null hypothesis is that the POLS be the preferred model. Finally, the Hausman test will be used to choose between RE and FE models where the RE model is preferred be the null hypothesis. Whenever we identify the appropriate one, further diagnostic tests will be conducted to identify the problems of serial correlation and heteroscedasticity. If there exists any or both of them, the Generalised Least Square (GLS) will be used to correct them.

4. Results and Discussion

4.1 Descriptive analysis

Table 2
Descriptive analysis

Variables	Mean	Std. Dev.	Min	Max
GINI	0.3569652	0.0546812	0.203	0.525
LogHC	2.390876	1.118936	-2.21268	4.60517
DIG/Gini	102.8669	57.86811	-75.14176	396.2536
LogFDI	3.758852	2.730266	-4.710531	9.028579
To	5.66e+09	1.03e+10	6359514	4.75e+10

Source: Authors' analysis result, 2024

The Gini coefficient, a measure of inequality, averages 0.36 across the regions studied, with a maximum value of 0.525 and a minimum of 0.203. This suggests that the levels of inequality among various provinces and cities are relatively balanced. However, the data reveals significant disparities when examining the dimensions of digitalization and human capital. The standard deviation values for digital infrastructure and workforce capabilities across the country's provinces highlight significant disparities, measuring 57.87 and 1.11, respectively. These figures suggest a pronounced variation in the quality and accessibility of digital resources and workforce competencies in different regions.

Table 3
VIF analysis

Variables	VIF
LogHC	1.19
DIG/Gini	1.46
LogFDI	1.53
To	1.66

Source: Authors' analysis result, 2024

The results of the Variance Inflation Factor (VIF) analysis presented in Table 3 show that all VIF values

below 5. It means there is no multicollinearity in the model.

4.2 Regression results

The regression analysis using Stata software estimated the impact of digitalization and Foreign Direct Investment (FDI) on income inequality, represented by the Gini coefficient. The analysis employed Ordinary Least Squares (OLS), Fixed Effects Model (FEM), Random Effects Model (REM), and Generalized Least Squares (GLS) methods.

Table 4
Results of estimating the impact of digitalization and FDI on income inequality

Dependent variables	Regression models			
	OLS	REM	FEM	GLS
LogHC	0.00488*	0.00988***	0.0142***	0.00539**
DIG/Gini	-0.000289***	-0.000441***	-0.000467***	-0.000318***
LogFDI	-0.00788***	-0.00236*	0.000225	-0.00590***
To	-7.06e-14	-7.35e-13	-1.13e-12	-4.40e-13*
R-squared	0.329	0.272		

Significant levels are denoted by ***, **, and * for 1%, 5%, and 10% respectively.
Source: Authors' analysis result, 2024

To determine the most appropriate model for our analysis, the research team conducted tests for autocorrelation (Wooldridge test) and heteroskedasticity (White Heteroskedasticity test) to choose between the pooled Ordinary Least Squares (OLS) model and the Fixed Effects (FE) or Random Effects (RE) models. For choosing the appropriate model, p-values of F test and BP test are 0.0021 and 0.0095 respectively which imply that POLS model is not the appropriate one at 5% significant level (the null hypothesis is rejected).

Subsequently, we performed the Hausman test to identify which model, FE or RE,would be more appropriate for our data. The result of Hausman test has the P-value of 0.0000 which much smaller than 0.05, providing sufficient grounds to reject Ho. Therefore, we determined that the Fixed Effects Model (FEM) is more suitable for analyzing the data. Further testing for heteroskedasticity using the Breusch-Pagan Lagrangian Multiplier test revealed that our initial model exhibited heteroskedastic errors. To address this issue, we employed a Generalized Least Squares (GLS) model with panel selection (heteroskedasticity) and correlation (ar1). Based on this refined approach, we drew several conclusions:

Firstly, the adjusted model produced a regression coefficient for the variable DIG/Gini of -0.000318, which is statistically significant. Accordingly, the first hypothesis is rejected. Though this result is inconsistent with the research papers of Chu (2018), Mirza et al. (2019), Dinh (2020), Acemoglu (2002) and Xiao et al (2024), it is supported by Namazi (2020), Munandar et al. (2023), Huang et al. (2024) and Tian, L., and Xiang, Y. (2024). It also implies that a rapid and robust digitalization process can improve the problem of income inequality in Vietnam. In our opinion, digitalization can reduce income inequality by expanding employment opportunities, enhancing labor productivity and increasing access to education and job opportunities through online platforms. Moreover, transparency in public administration is likely to improve through electronic information systems, which can help reduce corruption and resource waste, thereby ensuring a fairer income distribution among different population groups. These factors suggest that digitalization is not merely a technological trend but an essential element in efforts to reduce income inequality in Vietnam.

Secondly, the two independent variables LogFDI and To produced regression coefficients of -0.00590 and −0.00000000000044, respectively, which are also statistically significant. It indicates that our second hypothesis

of FDI having the inverse relationship with income inequality is consistent with the H-O model of international trade and Huang, K., Sim, N., & Zhao, H. (2020). This could be explained that FDI creates numerous jobs and raises incomes for workers while promoting technology transfer and enhancing labor productivity. Additionally, trade openness increases competition, lowers prices for goods and services, and provides opportunities for domestic businesses. Furthermore, regions attracting FDI often benefit from increased tax revenues from foreign enterprises, allowing for income redistribution that supports infrastructure development and social services. In summary, FDI and trade openness create numerous economic opportunities and contribute to reducing income disparities within society.

Thirdly, the GLS method yielded a regression coefficient for the human capital of 0.00539, which is statistically significant. It means that higher levels of human capital having adverse impacts on reducing income inequality. In Vietnam, disparities in access to and application of knowledge and skills among different population groups can exacerbate income inequality. As the quality of human capital improves, individuals with higher educational attainment and skills typically earn higher incomes, while those with lower qualifications face challenges in increasing their earnings. Increased investment in education and training can lead to "uneven investment," where wealthier groups have better access to quality educational opportunities while poorer groups face resource and information limitations. This not only widens the income gap but also reinforces existing social structures, resulting in increased income inequality amidst Vietnam's rapid economic development. Thus, while high human capital can drive economic growth, it may deepen societal inequalities if not managed equitably.

Based on the regression model results applied to real-world contexts, our research team concludes that four factors: human capital, digitalization, FDI, and trade openness statistical significantly impact income inequality across provinces in Vietnam from 2018 to 2022. The regression equation derived from our analysis is as follows:

$$Gini = 0.405 + 0.00539*LogHC - 0.000318*DIG/Gini - 0.00590*LogFDI - 4.40e\text{-}13*To$$

5. Conclusions and Implications

This study examines the impact of digitalization and FDI on income inequality in Viet Nam. Based on the panel dataset about 46 provinces over the 2018-2022 period, our results find that the development of digitalization, FDI, and trade openness reduce income inequality, while human capital increases it across provinces. This indicates that digitalization, FDI flow, and trade openness are essential elements in efforts to shorten the income gap in Vietnam. The results also imply that individuals with higher education and advanced skills generally earn higher incomes, whereas those with lower qualifications struggle to enhance their earnings. Although human capital may increase inequality, it does not mean that improving the quality of human resources should be neglected. Efforts also should be made focusing on enhancing the positive impacts of digitalization. While foreign direct investment facilitates equality, attention must be paid to the quality of capital inflows. Income levels may rise, but caution is needed regarding other aspects of life, such as the environment and health.

This article mainly suggests some necessary implications for governments in formulating and enforcing policies and regulations relating to human capital so that progress contributes to solving the income inequality challenge. The implication is that wealthier groups have better access to high-quality educational resources, while disadvantaged groups encounter barriers due to limited resources and information. The disparities and differences in human capital development across regions have led to income inequality among provinces. Therefore, to promote equal human capital development across provinces in Vietnam, the government should prioritize several key measures. Policy adjustments are crucial to maximize these initiatives' effectiveness and reduce inequalities.

Firstly, it is essential to formulate a comprehensive human resource development strategy while focusing on enhancing workforce capacity across all levels and qualifications to meet the evolving demands of digital labor at different stages and periods. Currently, the proportion of workers with high technical expertise in Vietnam

stands at only 28.5% (General Statistics Office, 2024). While the country does not face a labor shortage, it suffers from a significant deficit in highly skilled digital professionals. The proportion of IT personnel relative to the national workforce is estimated at just 1.1% of Vietnam's 51 million workers (Hoang, 2023), which is modest compared to the actual demand for digital talent. According to the Ministry of Information and Communications, Vietnam needs to add at least 500,000 technology workers by 2025. This highlights the state of human resources in Vietnam's IT sector, which is growing rapidly and diversifying into areas such as hardware and electronics, software, digital content industries, and IT services. Despite increasing job opportunities in the field, the labor supply remains critically insufficient. Therefore, efforts must focus on implementing Decision No. 146/QD-TTg dated January 28, 2022 issued by the Prime Minister, regarding the "Program to Raise Awareness, Universalize Skills, and Develop Human Resources for National Digital Transformation by 2025 with Orientation to 2030." The program aims to create a significant shift in awareness and action to promote digital transformation, universalize digital skills among participants in the national digital transformation process, and improve the quality and efficiency of training and developing digital transformation human resources across industries, sectors, and localities. Additionally, policies should be established to attract IT professionals through competitive salary mechanisms, personal income tax incentives, and initiatives to bring overseas Vietnamese and foreign digital technology experts to work in Vietnam, especially in state agencies, as stipulated in Articles 44 and 45 of the Information Technology Law regarding policies for developing IT human resources. Moreover, Vietnam should strengthen international cooperation in its digital workforce development strategy by establishing global networks that connect with cutting-edge technology worldwide. This can be achieved by importing advanced technologies, inviting foreign experts for training, and conducting joint ventures in education, research, and development activities.

Secondly, prioritizing the development of digital human resources through improved education and training quality is essential. According to a report on Vietnam's IT market (TopDev, 2021), the country has a substantial number of IT training institutions, including 158 universities and 422 vocational schools. However, the quality of these institutions is inconsistent. Many schools remain small-scale with limited capabilities, inadequate infrastructure, and insufficient research staff in both quantity and quality, resulting in subpar training outcomes. Graduates often fail to meet industry requirements, necessitating retraining or career shifts, which leads to significant societal resource waste. Furthermore, the number of training institutions meeting international standards in capacity, facilities, and teaching methods remains minimal. Teaching practices often lack practical application, leading to training outcomes that fall short of market demands. To address these issues, it is imperative to establish an education system aligned with the development of the digital economy and society at both macro and micro levels. This alignment will bridge the gap between the supply and demand for digital talent in the economy and labor market, encompassing educational attainment, technical expertise, workforce structure, skills, and qualities. It will also foster the development of digital habits and culture grounded in real-world applications. Implementing "research-development-application" programs within educational institutions and government agencies can serve as a bridge between universities, colleges, training centers, and businesses. This approach aims to design training programs tailored to industry needs and enhance career exposure for students. Additionally, integrating STEM/STEAM-based digital education into primary and secondary schools is vital, with an emphasis on teacher training and equipping classrooms with necessary resources. Training structures must adapt to the demands of the digital economy, focusing on IT workforce development. Programs should accelerate the socialization of IT education, particularly in emerging fields such as IoT, AI, and robotics, enabling students to access these programs early. Strengthening collaboration between educational institutions and businesses in IT application training and practice is equally critical. Furthermore, extensive communication and education programs on IT should be established to raise awareness and improve skills among learners.

Thirdly, collaboration with reputable domestic and international organizations specializing in digital skill training is essential for designing specialized training programs. These programs should be regularly updated to align with international standards, including methods, measurement criteria for digital skills, and assessments of

the digital divide. Annual evaluations and publications should be conducted to ensure progress and transparency. Currently, Vietnam employs the Global Innovation Index (GII) to assess innovation capacity, with skills being a crucial component. Under Decision No. 176/QĐ-TTg issued by the Prime Minister, Vietnam aims to rank among the top 60 in the GII for professional labor by 2025 and the top 55 by 2030, with 90% of workers possessing IT skills by 2030, highlighting the focus on building a skilled workforce for the digital economy.

Fourthly, implementing training, retraining, short-term courses, and workshops on digital transformation and digital skills for officials, civil servants, public employees, and workers across all levels from central to local governments, state-owned enterprises, and media organizations is essential. Integrating content on raising awareness of digital transformation into state management training programs, leadership and management development programs, and job-specific training for public sector employees aligns with Decision No. 146/QĐ-TTg issued by the Prime Minister. Private organizations and enterprises are encouraged to initiate short-term training and skill development programs on digital transformation for their employees. Additionally, policies linking training with incentives, such as financial support for education, salary and bonus schemes, career planning, and promotions, should be established. Investments in resources and financial support for education and training, professional and vocational education systems, teacher development, and educational infrastructure and equipment are also critical to creating a robust ecosystem for digital skill development.

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