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THE ROLE OF INNOVATION IN THE RELATIONSHIP BETWEEN FDI AND INCOME INEQUALITY: EVIDENCE FROM A TRANSITION ECONOMY

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ABSTRACT

This study explores the impact of innovation and foreign direct investment (FDI) on income inequality, emphasizing the moderating role of innovation in the relationship between FDI and income inequality, using panel data from 63 Vietnamese provinces from 2005 to 2020. As economic expansion raises concerns about income inequality in Vietnam, understanding the distributional effects of innovation and FDI is essential. While innovation fosters technological progress and job creation, its benefits primarily accrue to skilled labor and capital-intensive sectors, potentially widening income inequality. Similarly, FDI promotes economic expansion, but its effects on inequality depend on absorptive capacity and investment composition, which may exacerbate income gaps. Using the system generalized method of moments (GMM) method on 1,008 observations, the findings reveal a U-shaped relationship between innovation and income inequality, whereas FDI exhibits an inverted U-shaped relationship. Specifically, innovation exacerbates inequality beyond a threshold of 27.63, while FDI reduces inequality once it exceeds 0.76. Moreover, the negative coefficient of the interaction variable between innovation and FDI suggests that innovation weakens the impact of FDI on income inequality. These findings remain robust when substituting the Human Development Index as an inequality proxy and align with modernization and endogenous growth theories. This study contributes novel empirical insights and policy implications for promoting inclusive innovation and sustainable investment, advancing Sustainable Development Goal 10 on inequality reduction.

Keywords: System generalized method of moments (GMM); foreign direct investment (FDI); innovation; income inequality; Vietnam.

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1. INTRODUCTION

Income inequality substantially impacts global economic development, increasing economic insecurity and the number of individuals facing poverty (Ongo et al., 2024; Suhrab et al., 2024). Furthermore, rising income inequality can impair social development and slow human progress (Law et al., 2020). Economic, political, cultural, and social factors influencing income inequality remain central to research (Lee et al., 2022).

Innovation and foreign direct investment (FDI) inflows are essential factors in achieving sustained economic development and reducing income inequality in a country (Antonelli & Gehringer, 2017; Yuldashev et al., 2023). According to the skill-biased technical change framework, innovation advantages high-skilled workers but disadvantages low-skilled workers. Low-skilled work, often involving routine tasks, is increasingly replaced by machines, while high-skilled labor remains relatively stable, exacerbating existing inequalities. Empirical studies on inequality show that innovation benefits the wealthy more than the poor, increasing inequality (Cetin et al., 2021; Law et al., 2020; Ongo et al., 2024; Permana et al., 2018). However, other empirical studies propose that innovation produces more job opportunities and improves workers' abilities, lowering inequality (Biurrun, 2022; Suhrab et al., 2024).

The relationship between FDI and income inequality is also inconsistent. Dependency theory asserts that, while FDI initially provides jobs in developing nations, its tendency to engage in capital-intensive production reduces employment and increases income inequality in the long term (Girling, 1973). Thus, dependency theory consistently views FDI as increasing income inequality. However, modernization and endogenous growth theories contend that, early in a country's development, FDI increases demand for high-skilled labor relative to low-skilled labor through industry-specific technological spillover. These spillover effects spread, narrowing the labor demand–supply gap and increasing demand for low-skilled labor, ultimately reducing income inequality below its starting point (Teixeira & Loureiro, 2019). Some empirical studies demonstrate that FDI exacerbates income inequality (Huynh, 2021; Nguyen, 2021), while others find the opposite (Soto et al., 2024; Ofori et al., 2023; Xu et al., 2021), or that the relationship between FDI and inequality is nonlinear (Kaulihowa & Adjasi, 2018; Pan-Long, 1995).

Vietnam's economy has experienced robust growth, with an average annual GDP increase of 6.56% from 2005 to 2019. Despite the adverse effects of the COVID-19 pandemic, the country achieved a remarkable growth rate of 2.91% in 2020, among the highest globally (World Bank, 2021). However, income inequality remains a persistent and pressing socio-economic issue. The Gini coefficient fluctuated between 0.34 and 0.43 during this period, reflecting limited progress in narrowing income disparities (GSO, 2021; Van Le & Tran, 2022). Between 2005 and 2008, a marginal decline in the Gini coefficient from 0.36 to 0.35 suggested a temporary narrowing of income gaps. However, this trend reversed sharply in 2010, likely due to the global financial crisis. In subsequent years, income inequality exhibited volatility, followed by a gradual decline between 2016 and 2020, as indicated by a reduction in the Gini coefficient from 0.43 to 0.37 (GSO, 2021). Nevertheless, rural areas consistently exhibited higher levels of inequality than urban areas, largely driven by disparities in education access, skill development, and economic opportunities (Minh Ho et al., 2020; Van Le & Tran, 2022). Additionally, regional disparities in infrastructure, industrial

capacity, and resource allocation further widen income inequality across different population groups (Hoang & Le, 2024; Suhrab et al., 2024).

Although the Gini coefficient remains relatively moderate in Vietnam, absolute income inequality has been rising (Do et al., 2024). This trend raises concerns regarding its potential to hinder economic growth, weaken social cohesion, and exacerbate poverty disparities (Van Le & Tran, 2022). As a developing economy, Vietnam has relied heavily on FDI as a key driver of economic growth (Cao, 2019). However, the broader socio-economic implications of FDI, particularly its effects on income distribution, remain an increasingly pertinent issue. Simultaneously, technological innovation is widely recognized as a fundamental driver of long-term economic development (Aghion et al., 2015). While both FDI and innovation are pivotal to Vietnam's economic growth, existing studies largely examine these factors in isolation, with their potential interaction on income distribution remaining underexplored (Do et al., 2024; Hoang & Le, 2024). This relationship is inherently complex, as FDI and technological progress can either mitigate or exacerbate income inequality, depending on institutional quality, labor market structures, and regional economic dynamics (Do et al., 2024; Hoang & Le, 2024). This study addresses this research gap by investigating the moderating effect of innovation on the relationship between FDI and income inequality across Vietnamese provinces.

This study focuses on Vietnam's provinces for the following reasons. First, Vietnam has emerged as one of the most attractive destinations for FDI, particularly following its accession to the World Trade Organization in 2007 (Cao, 2019). Second, considerable disparities exist in FDI attraction across Vietnam's provinces and cities. While FDI has substantially contributed to technology transfer, the diffusion of technology and skills varies across sectors and regions (Hoang et al., 2021). Third, the innovation ecosystems within Vietnam's provinces are distinct, characterized by industrial parks, research institutes, and business networks. These ecosystems play an important role in affecting foreign enterprises' investment decisions (Nguyen et al., 2023). Additionally, Resolution No. 19-NQ/TW, introduced in 2022, emphasizes the transition from an agricultural economy to an industrial and service-based economy. This policy aims to foster FDI attraction and innovation for sustainable economic development, which is essential for addressing labor dynamics and income inequality.

This study aims to explore the relationship between innovation, FDI, and income inequality by employing system generalized method of moments estimations to address concerns regarding autocorrelation, heteroskedasticity, and endogeneity. Previous studies have not considered the simultaneous impact of FDI and innovation on income inequality, particularly within a nonlinear framework. According to Lee et al. (2022), linear prediction models can be used to estimate time series, though this approach may lead to incorrect findings and policy suggestions. Consequently, a nonlinear approach is necessary to explore the relationship between innovation, FDI, and income inequality.

This study yields the following surprising results. First, our results reveal a U-shaped association between innovation and income inequality, while an inverted U-shaped relationship exists between FDI and income inequality. These findings align with Liu and Lawell (2015) and Le et al. (2021), as well as support modernization theory, skill-biased technical change theory, and Schumpeter's technological advancement theory. Furthermore, our results suggest that innovation moderates the

relationship between FDI and income inequality. Finally, robustness tests suggest that our results remain robust when an alternative proxy for income inequality is applied.

Our study contributes significantly to the literature on Sustainable Development Goal (SDG) 10 in various ways. First, it addresses a significant research gap by comprehensively investigating the role of innovation in moderating the relationship between FDI and income inequality in Vietnam's provinces within a nonlinear framework. Second, whereas most prior studies have focused on multiple countries (Biurrun, 2022; Huynh, 2021; Lee et al., 2022; Nguyen, 2021; Ongo et al., 2024; Soto et al., 2024; Wang & Lee, 2023), our study uniquely utilizes a provincial-level dataset to analyze these dynamics in a transition economy such as Vietnam. Finally, our study provides critical insights for policymakers regarding the implementation of inclusive innovation strategies to enhance competitiveness (Ciriaci et al., 2016; Suhrab et al., 2024) and the formulation of FDI attraction strategies that foster job creation, knowledge transfer, and technological advancement (Do et al., 2024; Hoang & Le et al., 2024). These measures help ensure a more equitable distribution of FDI benefits, ultimately reducing income inequality and promoting sustainable development (Antonelli & Gehringer, 2017).

The structure of the study is as follows: Section 2 is the literature review, Section 3 is the research methodology, Section 4 is the results and discussion, and Section 5 is the conclusion.

2. LITERATURE REVIEW

2.1. Core Theories

The skill-biased technical change theory posits that technological advancements or innovations do not impact all workers uniformly, but advantage high-skilled workers while disadvantaging low-skilled ones (Liu & Lawell, 2015; Permana et al., 2018). This theory suggests that innovation can result in significant gains, likely benefitting individuals with complementary abilities or those working in innovative sectors. However, new technologies often replace low-skilled workers, reducing their employment share while increasing employment opportunities and income levels for high-skilled workers. Consequently, innovation may initially increase inequality.

Endogenous growth theory underscores the dual-edged impact of innovation on income inequality. While technological progress and innovation are crucial for economic growth, they can initially exacerbate income inequality by disproportionately benefiting skilled innovators, thereby widening the wage gap between high-skilled and low-skilled workers (Schumpeter, 1942). However, as innovation progresses, its impact on inequality diminishes through economies of scale (Napolitano et al., 2022). Additionally, innovation stimulates economic growth by creating new industries and job opportunities across skill levels, potentially reducing unemployment (Liu & Lawell, 2015) and promoting a more equitable income distribution (Ongo et al., 2024).

Modernization theory, introduced by Rostow (1959), posits that the developmental stages of a host country differentially impact income inequality. In the initial phases of development, FDI tends to exacerbate income inequality due to skill-biased investments that widen the income gap between skilled and unskilled workers. Schumpeter's theory of technological advancement complements

this view, suggesting that FDI introduces new technologies and fosters innovation, though these benefits are unevenly distributed, favoring enterprises and individuals capable of leveraging them (Antonelli & Gehringer, 2017). However, as a country reaches a more optimal stage of development, the impact of FDI on income inequality diminishes. FDI creates job opportunities with higher wages and better working conditions than local firms, benefiting relatively less-skilled labor and thus reducing income inequality (Xu et al., 2021). Additionally, FDI introduces new technologies and business practices, boosting productivity across sectors, which, in turn, can raise wages and generate positive spillover effects for domestic firms (Teixeira & Loureiro, 2019). Furthermore, FDI can reduce regional income disparities by targeting investment in less developed areas. These results align with Kuznets' inverted U-curve hypothesis and the empirical results of Pan-Long (1995).

2.2. The Nexus Between Innovation and Income Inequality

Permana et al. (2018) argue that innovation does not uniformly increase overall income; low-skilled jobs are susceptible to replacement and offer low wages, whereas high-skilled positions benefit from increased productivity and wages, leading to significant salary disparities (Antonelli & Gehringer, 2017). Cetin et al. (2021) report that technological innovation in Turkey increases income inequality and creates barriers for new enterprises. Overall, the evidence indicates that innovation increases income inequality, aligning with the theory of skill-biased technical change and the results of Permana et al. (2018), Law et al. (2020), and Cetin et al. (2021).

Conversely, Biurrun (2022) explains that innovation reduces income inequality in European countries. Increased R&D promotes economic and technological growth, generating more job opportunities. Suhrab et al. (2024) demonstrate that technological innovation can reduce GINI by enhancing local workforce productivity, increasing wages, and providing access to new technologies in BRICS countries, thereby promoting a more equal income distribution (Antonelli & Gehringer, 2017).

Additionally, Liu and Lawell (2015) and Ongo et al. (2024) find a nonlinear association between innovation and income inequality. Liu and Lawell (2015) find a U-shaped association between innovation levels and the urban-to-rural income ratio in China. Ongo et al. (2024) discover an inverted U-shaped association between innovation and income inequality in 48 African nations. They explain that the initial phases of innovation exacerbate income inequality, but a turning point is reached in later stages, where innovation reduces inequality through economies of scale (Napolitano et al., 2022), ultimately improving wages and social equity. This result aligns with Adrián Risso and Sánchez (2019) and endogenous growth theory.

Based on the findings of Ongo et al. (2024), Adrián Risso and Sánchez (2019), skill-biased technological change theory, and endogenous growth theory, we propose the following hypotheses:

H1. Innovation negatively influences income inequality.

H2. Innovation and income inequality exhibit an inverted U-shaped relationship.

2.3. The Nexus Between FDI and Income Inequality

Several theoretical frameworks sparked debate over whether FDI exacerbates or mitigates income inequality. These include neoclassical theory, modernization theory, dependency theory, human capital theory, and the resource-based view theory—offering comprehensive knowledge of FDI's complex effects on income inequality.

Empirical studies on the association between FDI and income inequality yield highly complex and mixed results (Do et al, 2024; Gossel, 2024; Khan & Nawaz, 2019; Rezk et al., 2022). Prior studies divide these effects into three categories: positive, negative, and nonlinear (Huynh, 2021). First, FDI inflows tend to increase income inequality. Khan and Nawaz (2019) demonstrated that the amount of inward FDI stock in Commonwealth of Independent States countries widened income disparities. Similarly, Huynh (2021) found that FDI exacerbated income inequality in Asian countries, a similar finding supported by Nguyen (2021, 2023) in developed economies. Furthermore, FDI accelerates skill-biased technological progress, benefiting high-skilled workers while displacing low-skilled ones. It also heightens competition, making less-advanced domestic firms more at risk of failure, further widening income inequality.

Second, prior research consistently highlights a negative association between FDI inflows and income inequality. Xu et al. (2021) demonstrated that FDI reduces income inequality in African countries by promoting growth and financial inclusion. Similarly, Lee et al. (2022) underscored FDI's importance in addressing domestic capital shortages, creating jobs, and enabling technology spillovers, which collectively narrow income disparities. In developing economies, FDI-related policies often prioritize job creation for unskilled and low-income workers. Consequently, even low-quality FDI inflows can improve incomes for these groups, thereby reducing inequality (Nguyen, 2021, 2023). Ofori et al. (2023) confirmed the positive distributional effects of FDI in Africa, while Yuldashev et al. (2023) reported similar trends in Asian economies. Soto et al. (2024) added that FDI alleviates income inequality and enhances welfare, particularly in countries with lower tax burdens, reinforcing its role in promoting stable growth.

Finally, modernization theory posits that industry-localized spillovers from FDI-driven technological advancements increase demand for high-skilled labor in the early stages of economic growth, raising their wages relative to those of low-skill workers. Over time, as these spillover effects diffuse across sectors, labor demand and wage disparity narrow (Teixeira & Loureiro, 2019). This dynamic suggests an inverted U-shaped relationship between FDI and income inequality, consistent with the Kuznets inverted U-curve hypothesis, which Pan-Long (1995) empirically supports. Similarly, Le et al. (2021) identified a nonlinear relationship between FDI and income inequality in Vietnam. Despite these findings, limited research exists on the provincial-level impact of FDI on income inequality. This study addresses this gap by providing a comprehensive analysis of the relationship between FDI and income inequality across Vietnamese provinces.

Based on the results from Le et al. (2021), the Kuznets' inverted-U curve hypothesis, and modernization theory, we propose the following hypotheses:

H3. FDI negatively influences income inequality.

H4. FDI and income inequality exhibit an inverted U-shaped relationship.

2.4. The Role of Innovation in the Relationship Between FDI and Income Inequality

Innovation plays an essential role in determining the relationship between FDI and income inequality. On the one hand, innovation can weaken their positive relationship by fostering more inclusive economic structures. Specifically, innovation drives the emergence of new industries and employment opportunities beyond traditional FDI-driven sectors, advancing manufacturing through smart factories and artificial intelligence (Baffour Gyau, 2025). This transformation enhances production efficiency, reduces costs, and expands employment within global supply chains, thereby improving access to affordable goods and increasing wages for low-income groups (Baffour Gyau, 2025). Furthermore, innovation fosters demand for skilled labor and encourages increased investment in education and workforce development (Bloom et al., 2019). Aghion et al. (2015) further assert that innovation stimulates employment and enhances competition and productivity, ultimately raising wages across a broader range of workers.

As economies transition toward knowledge-based industries, reliance on low-wage labor decreases, mitigating the income-inequality-widening effects often associated with FDI (Ongo et al., 2024). This transformation is vital, as it enables a more equitable distribution of economic benefits. Furthermore, innovation strengthens domestic firms' competitiveness, allowing them to upgrade their technological capabilities and more effectively integrate into global value chains (Hoang & Le, 2024). This shift weakens foreign enterprises' dominance, thereby promoting a fairer distribution of FDI-related advantages (Antonelli & Gehringer, 2017). Moreover, innovation stimulates skilled labor demand, increasing investment in education and workforce development. These advancements enhance upward mobility and narrow the income gap between skilled and unskilled workers (Rostow, 1959; Teixeira & Loureiro, 2019).

Conversely, innovation can also strengthen the positive relationship between FDI and income inequality. FDI inflows frequently concentrate resources within specific industries and regions, disproportionately benefiting capital owners and high-skilled workers while marginalizing low-skilled labor (Liu & Lawell, 2015; Permana et al., 2018). In this context, innovation intensifies these effects by facilitating the adoption of advanced technologies and enhancing productivity (Antonelli & Gehringer, 2017). Companies pursuing innovation may prioritize high-skilled labor, creating wage premiums for specialized expertise while neglecting low-skilled workers. This trend not only exacerbates income inequalities among labor segments but also reinforces the dominance of specific industries that attract FDI, further widening existing inequalities (Permana et al., 2018). Additionally, innovation may lead to the emergence of new market leaders, concentrating wealth within a select group of entrepreneurs and investors who capitalize on growing opportunities, thereby widening the income inequality gap.

Furthermore, the focus on R&D and advanced technologies often limits job opportunities for low-skilled workers, as demand shifts toward highly specialized roles (Cetin et al., 2021). Consequently, while FDI can stimulate economic growth, accompanying innovation may inadvertently intensify income inequality by favoring high-skilled labor, reinforcing disparities generated by FDI.

Significantly, the interplay between innovation, FDI, and income inequality has been inadequately addressed in the existing literature, particularly in Vietnam. This study aims to address this critical gap by examining how innovation influences the relationship between FDI and income inequality across various Vietnamese provinces. Drawing on the principles of endogenous growth theory and the preceding analysis, we propose the following hypothesis:

H5. Innovation weakens the positive impact of FDI on income inequality

3. METHODOLOGY

3.1. Data Collection

We collected data from 63 Vietnamese provinces for the period 2005–2020 from two primary sources: the Ministry of Planning and Investment for the FDI variable and the General Statistics Office of Vietnam for the other variables. To address outliers, we followed Duong et al. (2022) and winsorized our sample at the 1% and 99% levels, excluding observations with inadequate data necessary for calculating required variables. Our final data sample includes 63 provinces with 1,008 annual observations. We selected this study period because data availability began in 2005, coinciding with a key phase in Vietnam's institutional reform agenda. This year marked a commitment from the National Assembly and the Vietnamese government to systematically reform and enhance the institutional framework, aimed at fostering a business-friendly market economy environment (Nguyen, 2021). Several landmark legal frameworks were enacted in 2005, including the Civil Code, Commercial Law, Investment Law, and Intellectual Property Law, forming a unified legal framework for all investors—regardless of ownership structure—for the first time. Moreover, Decree No. 115/2005/ND-CP issued by the government emphasized autonomy in scientific and technical innovation, creating a favorable environment for both local and international engagement in innovation.

3.2. Model Construction

Law et al. (2020) and Cetin et al. (2021) found that innovation exacerbates income inequality, while Suhrab et al. (2024) argued that technological advancements can enhance productivity and wages, thus reducing inequality. Similarly, Khan and Nawaz (2019) and Huynh (2021) reported that FDI exacerbates income inequality, while Lee et al. (2022) and Rezk et al. (2022) indicated that increased FDI inflows are associated with reduced income inequality. This study addresses these inconsistencies by building Model (1), based on the findings of Nguyen et al. (2023) and integrating dependency theory, skill-biased technical change theory, and endogenous growth theory to examine the joint impact of innovation and FDI on income inequality:

$$GINI_{i,t} = \beta_0 + \beta_1 INN_{i,t} + \beta_2 FDI_{i,t} + \sum \beta_j control_{i,t} + \alpha_i + \alpha_t + \mu_{it} \quad (1)$$

To further evaluate the relationship between this interaction variable and income inequality, we introduce the innovation and FDI interaction variable (INN*FDI) into Model (2), following Razzaq et al. (2021) and endogenous growth theory:

$$GINI_{i,t} = \beta_0 + \beta_1 INN_{i,t} + \beta_2 FDI_{i,t} + \beta_3 INN_{i,t}*FDI_{i,t} + \sum \beta_j control_{i,t} + \alpha_i + \alpha_t + \mu_{it} \quad (2)$$

Finally, to examine the impact nonlinearity of innovation and FDI on income inequality, Models (3) and (4) are constructed, following Ongo et al. (2024) and Le et al. (2021):

$$GINI_{i,t} = \beta_0 + \beta_1 INN_{i,t} + \beta_2 FDI_{i,t} + \beta_3 INN^2_{i,t} + \sum \beta_j control_{i,t} + \alpha_i + \alpha_t + \mu_{it} \quad (3)$$

$$GINI_{i,t} = \beta_0 + \beta_1 INN_{i,t} + \beta_2 FDI_{i,t} + \beta_3 FDI^2_{i,t} + \sum \beta_j control_{i,t} + \alpha_i + \alpha_t + \mu_{it} \quad (4)$$

Where GINI represents income inequality, measured using the gross Gini coefficient. This method is consistent with Wang and Lee (2023) and Le et al. (2021), as it relies on pre-tax and pre-transfer income data from GSO, ensuring accuracy. Conversely, acquiring accurate statistics for the net Gini coefficient requires detailed tax and transfer information, presenting significant challenges (Song et al., 2021; Suhrab et al., 2024). While alternative measures such as the Palma ratio (Ofori et al., 2023) and the Human Development Index (Khan & Nawaz, 2019) offer insights, they are less effective in capturing the complexities of income distribution.

Innovation (INN) is measured using the technological balance of payments for machinery and equipment at the provincial level (Lewandowska, 2021), capturing a province's capacity to absorb foreign technology and enhance innovation capacity, thereby improving productivity and generating new employment opportunities. Innovation can reduce income inequality by fostering skill development and economic diversification, but it may also widen disparities if technological advancements disproportionately benefit high-skilled workers or specific industries (Aghion et al., 2015).

FDI is measured as the ratio of FDI to GDP (Gossel, 2024; Nguyen, 2023) to allow for better cross-province comparisons. FDI influences income inequality through two opposing channels: job creation and workforce skills improvement (Razzaq et al., 2021). However, it may also exacerbate income disparities if the benefits are concentrated among high-skilled workers and capital-intensive sectors (Suhrab et al., 2024).

Control variables include GRDP, measured by the gross regional domestic product of each province divided by the average population of the province (Tran et al., 2023). GRDP influences income inequality through two opposing mechanisms. Higher GRDP per capita fosters economic growth, job creation, and income expansion, potentially reducing inequality (Tran et al., 2023). However, if growth is concentrated in capital-intensive sectors or skilled labor, income disparities may widen as wealth accumulates in specific regions (Suhrab et al., 2024).

Education (EDU) is measured as the high school graduation rate (McLaren & Yoo, 2017). Education reduces income inequality by improving job access and boosting productivity. Higher education levels increase access to well-paying jobs, narrowing wage gaps between skilled and

unskilled workers (McLaren & Yoo, 2017). Additionally, education enhances labor productivity and technological adaptability, raising overall income and reducing disparities (Minh Ho et al., 2020; Teixeira & Loureiro, 2019).

The urbanization rate (URB) is captured by the urban-to-total population ratio (Rezk et al., 2022). Urbanization can either alleviate or intensify income inequality depending on labor market dynamics (Razzaq et al., 2021).
Finally, public expenditures (PE) are represented as the ratio of government consumption to GDP (Ongo et al., 2024; Teixeira & Loureiro, 2019), reflecting the government's role in resource allocation and income inequality adjustment within the economy. Additionally, "i" indicates cross-sections, "t" refers to time, α_i is each province's fixed effect, α_t is the year's fixed effect, and μ_{it} is the residual value. All variable definitions are presented in Appendix A.

3.3. Estimation Methods

We apply conventional estimation methods, including ordinary least squares (OLS), the fixed effects model (FEM), and the random effects model (REM). We conduct the Hausman and redundant fixed effects tests to identify the optimal estimation approach, following Razzaq et al. (2021) and Nguyen et al. (2024). Since standard panel regressions may suffer from autocorrelation and heteroscedasticity issues, we perform the Wald and Wooldridge tests. Then, we test for endogeneity in our model using the Durbin–Wu–Hausman test. Following Nguyen and Su (2022) and Nguyen et al. (2024), we employ the two-step GMM estimator.

The foundational work of Anderson and Hsiao (1982) introduced the first-difference method combined with instrumental variables to handle endogeneity in panel data. Arellano and Bond (1991) advanced this approach by proposing the GMM estimator, later refined into the two-step system GMM by Blundell and Bond (1998). As Roodman (2009) highlights, the two-step system GMM performs optimally for datasets with large cross-sections and short periods. Accordingly, we utilize the two-step system GMM estimator, employing lagged endogenous variables—FDI and GINI—as instruments, following Anderson and Hsiao (1982) and Nguyen and Su (2022). Additionally, year and area effects are included in the instrument list to control for potential bias from fixed effects. To ensure the robustness of our results, we conduct robustness tests by employing an alternative proxy for income inequality.

4. RESULTS AND DISCUSSION

4.1. Descriptive Statistics

Table 1: Descriptive statistics

	Mean	Maximum	Minimum	Std. Dev.	Observations
GINI	0.4106	0.4336	0.3652	0.0140	1,008
INN	22.1666	30.2460	17.9901	2.6299	1,008
FDI	0.7426	0.9123	0.5279	0.0788	1,008
GRDP	2.2242	2.3854	2.0765	0.0643	1,008
EDU	0.9234	0.9994	0.6029	0.0870	1,008
URB	0.2647	0.8690	0.0933	0.1662	1,008
PE	0.3472	1.2872	0.0231	0.2318	1,008

Note: The presented table provides descriptive statistics for the sample data, encompassing 1008 annual observations from 63 provinces in Vietnam from 2005 to 2020. Definitions for all variables can be found in Appendix A.

Table 1 presents the GINI index, which reveals income inequality in Vietnam, with an average value of 0.41. Bac Ninh exhibited the highest GINI index with a value of 0.43, whereas Lai Chau showed the lowest with a value of 0.31. The average value of INN is 22.16. Ho Chi Minh City notably reports the highest level of innovation nationwide, with a value of 30.24. Conversely, Gia Lai demonstrates the lowest level of innovation, with a value of only 17.99. The average FDI inflow is 0.74, indicating a significant impact of FDI on income inequality. Specifically, Ho Chi Minh attracts the highest FDI inflow in Vietnam, with a value of 0.91, while Ninh Thuan, with a value of 0.52, receives the least FDI. Additionally, Table 1 includes the mean values and standard deviations for other control variables, such as gross regional domestic product, education levels, urbanization rate, and public expenditures.

4.2. Pearson Correlation Matrix

Table 2: Pearson correlation matrix

	INN	**FDI**	**DRDP**	**EDU**	**URB**	**PE**	**VIF**
INN	1.0000						1.7686

FDI	0.3914***	1.0000					1.3740
	(0.0000)	-----					
GRDP	0.0156	-0.2637***	1.0000				1.3359
	(0.6214)	(0.0000)	-----				
EDU	0.1425***	0.1708***	0.2999***	1.0000			1.1891
	(0.0000)	(0.0000)	(0.0000)	-----			
URB	0.5166***	0.1080***	0.1921***	0.1222***	1.0000		1.4478
	(0.0000)	(0.0006)	(0.0000)	(0.0001)	-----		
PE	-0.4122***	-0.2330***	0.1600***	-0.0413	-0.2499***	1.0000	1.2597
	(0.0000)	(0.0000)	(0.0000)	(0.1898)	(0.0000)	-----	

Note: Significance levels at 1%, 5%, and 10% are indicated by ***, **, and *, respectively.

Table 2 illustrates the correlation matrix for our dataset. All coefficient correlations, with no perfect correlations, are acceptable, as they are all less than 0.6. The strongest correlation value between INN and URB is approximately 0.5166. Additionally, the VIFs of all variables are less than 2. As a result, our study does not contain multicollinearity issues (Duong et al., 2022).

4.3. Regression Results from the System GMM Method

The results of the GMM estimations for Models (1) through (4) are displayed in Table 3. The AR(1) test's P-value is less than 1%. Furthermore, the AR(2) and Hansen tests exhibit P-values greater than 10%. Therefore, these models generate validity for the instrumental variables (Duong et al., 2022; Nguyen et al., 2024).

Table 3: Regression Results from the GMM Method

Variables	Model (1)	Model (2)	Model (3)	Model (4)
GINI(-1)	0.0352***	0.2343***	0.0397***	0.0464**
	(2.2785)	(84.23355)	(2.6838)	(2.3875)
INN	-0.0051***	-0.0023***	-0.0855***	-0.0062***
	(-5.0964)	(-23.6149)	(-4.7998)	(-2.8377)
FDI	0.0138***	0.1571***	0.0213***	0.2492**
	(2.6851)	(60.5399)	(3.4966)	(2.0847)
INN*FDI		-0.0053***		
		(-46.1792)		
INN*INN			0.0015***	
			(4.6027)	
FDI*FDI				-0.1639**
				(-2.0723)
GRDP	0.3218***	0.2550***	0.3734***	0.3326***
	(32.1804)	(123.370)	(24.0313)	(18.9196)
EDU	-0.0281***	-0.0324***	-0.0297***	-0.0309***
	(-6.4563)	(-180.453)	(-6.5737)	(-6.0704)
URB	-0.1689***	-0.0539***	-0.1682***	-0.1691***
	(-8.1376)	(-39.7854)	(-7.1437)	(-5.5582)
PE	-0.0139***	-0.0323***	-0.0164***	-0.0114**
	(-3.1803)	(-122.107)	(-4.2580)	(-2.1692)
No. of obs.	882	882	882	882
Province fixed effect	Yes	Yes	Yes	Yes
Year fixed effect	Yes	Yes	Yes	Yes
Instruments rank	63	65	63	63
Turning point			27.63	0.76
J-statistic	60.5392	59.9186	60.6815	60.6815
Prob (Hansen test)	0.3154	0.3703	0.2785	0.2785
Prob AR (1)	0.0000	0.0000	0.0000	0.0000
Prob AR (2)	0.7779	0.1823	0.9987	0.9987

Note: This table illustrates the outcomes of the GMM estimation. Significance levels are indicated by symbols ***, **, and * at 1%, 5%, and 10%, respectively. The T-values are in parentheses.

4.4. Discussion

Table 3 reveals a negative relationship between innovation and income inequality in all models. Investment in modern machinery and equipment to stimulate innovation in Vietnamese provinces has enhanced productivity growth and driven economic development (Antonelli & Gehringer, 2017). This process leads to economies of scale (Napolitano et al., 2022), directly improving local businesses' competitiveness, increasing job opportunities, raising wages, and reducing income inequality (Hoang & Le, 2024; Suhrab et al., 2024). Moreover, innovation facilitates the transition from an agricultural economy to one centered on industry and services, creating diverse job opportunities across various skill levels and potentially lowering unemployment rates and promoting more equitable income distribution (Ongo et al., 2024). Consequently, our findings support Hypothesis 1 and align with Biurrun (2022), Suhrab et al. (2024), and endogenous growth theory.

Additionally, Table 3 reveals a significant positive relationship between FDI and income inequality, indicating that rising FDI inflows exacerbate income inequality in Vietnamese provinces. This finding aligns with skill-biased technological change theory, which argues that FDI benefits high-skilled workers while displacing low-skilled ones, thereby widening wage inequality (Huynh, 2021; Khan & Nawaz, 2019). Moreover, increased competition from foreign firms can displace less competitive domestic enterprises, leading to job losses and declining incomes for local low-skilled workers, further widening regional income inequality (Do et al., 2024; Nguyen, 2023). Finally, the attraction of FDI inflows across Vietnamese provinces exhibits substantial variation (Cao, 2019). Major economic hubs, such as Ho Chi Minh City, Hanoi, and Bac Ninh, attract high-tech investments, yielding higher average wages than less-industrialized provinces (Le et al., 2021), thus increasing income inequality between provinces. Our result aligns with Do et al. (2024) and does not support Hypothesis 3.

In Model (3), the findings indicate a U-shaped relationship between innovation and income inequality. Initially, as innovation increases, income inequality decreases. However, once innovation surpasses a threshold of approximately 27.63, income inequality rises again. Innovation can reduce income inequality by enhancing competitiveness and fostering equitable societal development. However, as innovation progresses, its benefits often concentrate among a few individuals and businesses who can access and leverage advanced technologies, resulting in increased income inequality when innovation replaces low-skilled jobs or when its economic benefits are unevenly distributed (Permana et al., 2018). Our results align with Liu and Lawell (2015) and endogenous growth theory but are inconsistent with Adrián Risso and Sánchez (2019) and Ongo et al. (2024), thus not supporting Hypothesis 2. This result highlights that fostering inclusive innovation through enhanced competitiveness and job creation, expanding access to education, vocational training (consistent with SDG 4), and technology transfer can help governments mitigate income disparities and promote more equitable economic growth (Ciriaci et al., 2016; Suhrab et al., 2024). Strengthening this link allows policymakers to design innovation policies that mitigate adverse distributional effects, thereby aligning with United Nations Sustainable Development Goal 10 on reducing inequality.

Model (4) reveals an inverted U-shaped relationship between FDI and income inequality, highlighting its implications for sustainable development. Initially, as FDI inflows increase,

income disparities may widen, particularly when investments are concentrated in high-value-added industries and more developed provinces, which benefit specific sectors and leave others behind (Nguyen, 2021, 2023). However, beyond a critical threshold of approximately 0.76, the spillover effects of FDI—such as technology transfer, skill enhancement, and job creation—gradually reduce income inequality by fostering inclusive economic growth and improving labor market conditions (Teixeira & Loureiro, 2019). Vietnam's economic context reflects this inverted U-shaped relationship, aligning with the Kuznets inverted U-curve hypothesis. Thus, our findings support Hypothesis 4. This pattern aligns with the United Nations Sustainable Development Goal (SDG) 10 on reducing inequality and SDG 8 on promoting inclusive and sustainable economic growth. These insights enable policymakers to identify provincial competitive advantages and design targeted mechanisms to attract FDI into priority sectors that promote equitable development (Do et al., 2024). Additionally, FDI inflows can expand employment opportunities for both skilled and unskilled workers while facilitating knowledge transfer and technological adoption, fostering sustainable economic growth (Hoang & Le et al., 2024).

Table 3 reveals that innovation weakens the impact of FDI on income inequality. Our findings indicate that provinces with higher levels of innovation attract more multinational corporations, as these firms seek to capitalize on local innovation for improved production, technological collaboration, risk mitigation, and project viability (Stoian & Filippaios, 2008). This shift fosters a more sustainable and diversified investment environment, reducing reliance on low-skill, labor-intensive FDI that typically exacerbates income inequality (Permana et al., 2018).

The mechanism through which FDI affects income inequality operates in two main ways. First, FDI inflows, particularly in capital-intensive and technology-driven sectors, tend to favor high-skilled workers, leading to wage disparity and widening income gaps (Do et al., 2024; Huynh, 2021; Khan & Nawaz, 2019). Additionally, heightened competition from foreign firms can displace less competitive domestic enterprises, further intensifying regional inequality (Nguyen, 2023). However, innovation plays a crucial role in mitigating this inequality-amplifying effect of FDI. Innovation facilitates the development of new industries and jobs beyond traditional FDI-driven sectors, such as in the manufacturing sector through smart factories and artificial intelligence. Consequently, these developments provide low-income groups with access to commodities at relatively lower costs and wages due to increased production efficiency, cost reduction, and increasing job opportunities within global supply chains (Baffour Gyau, 2025). This process fosters competition, enhances productivity, and leads to higher wages across a more diverse labor market (Aghion et al., 2015). Additionally, innovation strengthens the competitiveness of domestic firms by enabling technological upgrades and deeper integration into global value chains. This shift reduces foreign enterprises' dominance and ensures a more equitable distribution of FDI-related benefits (Antonelli & Gehringer, 2017).

Furthermore, innovation intensifies the demand for skilled labor, incentivizing greater investments in education and workforce development (Bloom et al., 2019). Over time, this structural transformation enhances social mobility, narrows the wage gap between skilled and unskilled workers, and fosters more inclusive economic growth (Rostow, 1959; Teixeira & Loureiro, 2019). Our findings are consistent with Razzaq et al. (2021), Law et al. (2020), and endogenous growth theory, as well as support Hypothesis 5. They suggest that policymakers should integrate both

innovation and FDI into strategies aimed at reducing income disparities in Vietnamese provinces, aligning with the United Nations' goal of reducing inequality (SDG 10).

Finally, Table 3 indicates that GRDP is positively associated with income inequality, suggesting that economic growth exacerbates inequality. In contrast, education exhibits a significant negative effect, reducing inequality by supplying skilled labor that complements technological advancements (Permana et al., 2018). Similarly, urbanization exhibits a negative association with inequality, while higher public expenditures significantly reduce inequality, highlighting the redistributive role of government spending.

4.5. Robustness Test by Employing an Alternative Income Inequality Proxy

We test the robustness of our findings by employing an alternative proxy for income inequality. Following Soto et al. (2024) and Khan and Nawaz (2019), we measure income inequality using the Human Development Index (HDI), a composite indicator that assesses the average state of welfare across three dimensions: standard of living, health, and education. Provinces with higher HDI scores typically exhibit lower levels of income inequality.

Table 4 presents findings indicating a positive and significant coefficient for the interaction variable INN*FDI. Additionally, a U-shaped relationship between innovation and income inequality is observed, while the relationship between FDI and income inequality is insignificant. These results confirm that innovation mitigates the positive impact of FDI on income inequality. Furthermore, the findings remain robust even when utilizing an alternative proxy for income inequality. In summary, our results illustrate a U-shaped relationship between innovation and income inequality, emphasizing the critical role of innovation in the relationship between FDI and income inequality in Vietnamese provinces.

Table 4: Robustness Test Results by Using an Alternative Proxy of Income Inequality

Variables	Model (3)	Model (4)	Model (5)	Model (6)
HDI(-1)	0.6606***	0.7043***	0.6607***	0.7733***
	(38.7482)	(13.2124)	(55.3896)	(14.9165)
INN	0.0017***	-0.0028	0.0253***	0.0090***
	(2.8586)	(-1.5661)	(3.6027)	(1.9799)
FDI	-0.0058**	-0.0911*	-0.0041***	-0.0179
	(-2.4221)	(-1.7750)	(-3.7711)	(-0.8444)
INN*FDI		0.0045*		
		(1.8359)		
INN*INN			-0.0005***	
			(-3.6458)	
FDI*FDI				0.0181
				(0.7127)
GRDP	0.2745***	0.3411***	0.3055***	0.2865***
	(9.8066)	(6.8858)	(14.8411)	(5.0409)***
EDU	-0.0425***	-0.0326**	-0.0382***	-0.0458***
	(-6.8606)	(-2.5045)	(-10.0204)	(-3.0718)
URB	-0.0174**	-0.0162	-0.0282***	-0.0774**
	(-2.0821)	(-0.9362)	(-7.8540)	(-3.2741)
PE	0.0007	0.0011	0.0017	0.0167*
	(0.1397)	(0.1231)	(0.3058)	(1.7559)
No. obs.	189	189	189	189
Province fixed effect	Yes	Yes	Yes	Yes
Year fixed effect	Yes	Yes	Yes	Yes
Instruments rank	51	33	60	30
Turning point			26.07	0.49
J-statistic	48.1263	32.1618	52.4450	27.9414
Prob (J-statistic)	0.3094	0.1533	0.4566	0.1776
Prob AR (1)	0.0004	0.0001	0.0002	0.0406
Prob AR (2)	0.2546	0.6823	0.2908	0.2784

Note: Significance levels are indicated by symbols ***, **, and * at 1%, 5%, and 10%, respectively. The T-values are in parentheses.

4.6. Robustness Results in Low- and High-Innovation Provinces

We conducted two scenarios on our sample to examine the impact of innovation and FDI on income inequality. Table 5 presents the decomposition of the full sample into two subsamples based on the provinces' innovation investment intensity. Variations in production technology lead some provinces to invest more in modern machinery and equipment than others. Following Duong

(2022), we divided our sample into two subsamples using the median value of INN. Table 5 reveals that the interaction coefficients between innovation and FDI remain negative and significant across both subsamples. However, the nonlinear relationship persists only in the low-innovation group, insignificant in the high-innovation group. These results indicate that our primary findings are robust for provinces with low levels of innovation, whereas provinces with high levels of innovation prioritize innovation efficiency to attract higher FDI inflows, which, in turn, generates a spillover effect that helps reduce income inequality. Table 5 is presented in Appendix B.

5. CONCLUSION

This paper investigates the effects of innovation and FDI on income inequality across 63 Vietnamese provinces and cities from 2005 to 2020. We employ GMM estimations to address potential endogeneity issues. Our findings reveal a U-shaped relationship between innovation and income inequality and an inverted relationship between FDI and income inequality. Additionally, they indicate that innovation moderates the relationship between FDI and income inequality in Vietnamese provinces. To further validate our findings, we test the robustness of our results using an alternative proxy for income inequality. Our conclusions are consistent with Liu and Lawell (2015), the Kuznets' inverted-U curve hypothesis, and endogenous growth and modernization theories.

Our study offers several policy implications for decreasing income inequality in the Vietnamese provinces, aligning with SDG 10 (reducing inequality). First, policymakers should incentivize investment in modern machinery and equipment to boost labor productivity and income. However, ensuring the benefits of innovation are widely distributed in society is vital, especially in low-innovation provinces. Specifically, we recommend implementing policies that prioritize education and skill development to help workers adapt to new technologies. Second, policymakers should support enterprises with financial, technical, and training in rural and remote areas, as well as promote cooperation and knowledge transfer between domestic and foreign enterprises through partnerships and technology-sharing initiatives—setting targeted mechanisms to attract FDI toward priority sectors that foster equitable development. Finally, both domestic and foreign investment in innovation should be encouraged through tax support and funding policies. Developing innovation centers can help spread the economic benefits of innovation, while supporting domestic businesses' global value chain participation can create numerous job opportunities and stable incomes.

Our research has several limitations. First, the findings are confined to Vietnamese provinces and cities between 2005 and 2020 and do not account for the effects of the COVID-19 pandemic. Examining how the relationship between FDI, innovation, and income inequality is influenced by unprecedented shocks—such as COVID-19—would significantly enhance the study's value. Such crises can unveil new dynamics, providing insights into whether innovation acts as a weakening or strengthening factor during economic instability. Second, while our results align with prior studies, we did not explore how innovation moderates the relationship between FDI inflows and income inequality in both the short and long term. Future research could address these gaps by employing various regression methods or expanding the dataset to investigate these relationships across economic periods, thereby capturing both short-term and long-term effects.

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CONFLICT OF INTEREST

The author(s) declare(s) that there are no conflicts of interest regarding the publication of this paper.

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Appendix A: Variable definitions

Variable meaning	Variable symbol	Definitions	Sources
Dependent variable			
Income inequality	GINI	The Gini coefficient measures income inequality based on household income before taxes. It quantifies the income inequality in provinces, ranging from 0 (perfect income equality) to 1 (perfect income inequality).	Wang and Lee (2023); Le et al (2021)
Independent variables			
Innovation	INN	Innovation is measured by the technology balance of payments for modern machinery and equipment at the provincial level.	Lewandowska (2021)
Foreign Direct Investment	FDI	Net FDI inflow (% of GDP).	Nguyen (2023); Gossel (2024)
Controls Variables			
Gross Regional Domestic Product	GRDP	The gross regional domestic product of each province is divided by the average population of the province.	Tran et al. (2023)
Education	EDU	High-school graduates (%).	McLaren and Yoo (2017)
Urbanization rate	URB	The urbanization rate is the urban population divided by the total population (%).	Rezk et al. (2022), Soto et al. (2024)
Public expenditures	PE	Province consumption/ province GDP (%).	Yuldashev et al. (2023), Ongo et al. (2024)

Appendix B

Table 5: Robustness test results in low- and high-innovation provinces

Variable	Full Sample			Low innovation			High innovation		
	Model (2)	**Model (3)**	**Model (4)**	**Model (2)**	**Model (3)**	**Model (4)**	**Model (2)**	**Model (3)**	**Model (4)**
GINI(-1)	0.2343***	0.0397***	0.0464**	-0.0426***	0.0477	-0.1641***	0.1974***	0.3942***	-0.1995***
	(84.23355)	(2.6838)	(2.3875)	(-2.6777)	(1.5477)	(-11.5564)	(8.1179)	(5.8752)	(-2.7102)
INN	-0.0023***	-0.0855***	-0.0062***	0.0641	-0.0715***	<0.0001	-0.0011	0.0317	0.0108***
	(-23.6149)	(-4.7998)	(-2.8377)	(1.6159)	(-3.4941)	(0.0014)	(-0.0826)	(0.6215)	(3.6268)
FDI	0.1571***	0.0213***	0.2492**	1.8396*	0.0159	0.1755	0.2388*	-0.0433***	0.1524
	(60.5399)	(3.4966)	(2.0847)	(1.7977)	(0.8227)	(1.6697)	(1.8390)	(-3.3183)	(0.9829)
INN*FDI	-0.0053***			-0.0894*			-0.0093*		
	(-46.1792)			(-1.8064)			(-1.8124)		
INN*INN		0.0015***			0.0013***			-0.0007	
		(4.6027)			(3.3020)			(-0.6727)	
FDI*FDI			-0.1639**			-0.1434*			-0.1068
			(-2.0723)			(-1.9386)			(-1.0576)
GRDP	0.2550***	0.3734***	0.3326***	0.2396***	0.2013***	0.2218***	0.2030***	0.0866	0.0090
	(123.370)	(24.0313)	(18.9196)	(5.2998)	(8.5394)	(4.1503)	(4.0758)	(1.4873)	(0.1900)
EDU	-0.0324***	-0.0297***	-0.0309***	0.0031	0.0305***	-0.0097*	-0.0646***	0.0094	0.0423**
	(-180.453)	(-6.5737)	(-6.0704)	(0.6929)	(3.5757)	(-1.7069)	(-6.1001)	(0.5822)	(2.5687)
URB	-0.0539***	-0.1682***	-0.1691***	0.0526	0.0698	0.0484	0.0097	-0.0837**	-0.0807
	(-39.7854)	(-7.1437)	(-5.5582)	(0.4467)	(0.5888)	(0.6171)	(1.3871)	(-2.2488)	(-1.0678)
PE	-0.0323***	-0.0164***	-0.0114**	-0.0279***	-0.0436***	0.0025	0.0239	-0.0259**	-0.0978***
	(-122.107)	(-4.2580)	(-2.1692)	(-2.6506)	(-5.2731)	(0.4727)	(0.1963)	(-2.4738)	(-5.9907)
Province fixed effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Number of obs	882	882	882	476	476	476	406	406	406
Instruments rank	65	63	63	34	34	34	30	29	29
Turning point		27.63	0.76		27.57	0.61			
J-statistic	59.9186	60.6815	60.6815	25.5358	27.8678	33.2165	24.4795	21.0731	23.0136
Prob (J-statistic)	0.3703	0.2785	0.2785	0.4888	0.3649	0.1559	0.3226	0.4545	0.3432
Prob AR (1)	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001	0.0001	0.0348
Prob AR (2)	0.1823	0.9987	0.9987	0.7094	0.9783	0.1357	0.5749	0.2197	0.4939

Note: This table illustrates the outcomes of the GMM method. Significance levels are indicated by symbols ***, **, and * at 1%, 5%, and 10%, respectively.