**Institutions, gender inequality, and economic growth**

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## Highlights

•We examine the role of gender inequality in economic outcomes (trade, GDP, and innovation).

•Workforce inequality decreases GDP, and educational inequality decreases innovations.

•Workforce inequality weakens the positive effect of FDI on trade.

•Institutional quality decreases workforce inequality, not educational inequality.

## Abstract

Our model, analyzing multi-decade data from the European Union, suggests that gender inequality acts as a mediator between institutional quality and economic outcomes. Empirical results indicate that institutional quality significantly influences these outcomes, with positive associations observed with trade and GDP, and negative associations with innovation. Institutional quality positively (negatively) impacts workforce (educational) inequality. Institutions prioritize reducing workforce inequality to boost trade and GDP, but struggle to address educational inequality, which does not similarly contribute to economic growth. While workforce inequality has a negligible impact on innovation, educational inequality significantly impedes it.

**Keywords:** European Union; Gender inequality; Gross domestic product; Innovation; Institutional quality

**JEL Classification Codes:** F18 (Trade and Environment), G15 (International Financial Markets), G18 (Government Policy and Regulation), O33 (Technological Change: Choices and Consequences • Diffusion Processes), I24 (Education and Inequality)

## 1. Introduction

We seek to answer fundamental questions regarding the impact of institutions on gender inequality, and the influence of gender inequality on trade, the gross domestic product (GDP), and innovation. Utilizing 27 European Union countries dataset from 1998 to 2022, we explore the following: *i*) Do institutions address gender inequality within the realms of workforce and/or educational inequality? *ii*) Does gender inequality enhance economic outcomes, such as trade, GDP, and/or innovation? *iii*) In this context, do institutional strategies through gender inequality influence GDP and/or innovation? Addressing these

issues is crucial not only for social justice but also for economic efficiency and sustainability. Understanding the impacts of gender inequality on economic outcomes facilitates the development of gender-focused policies in developed countries.

Gender inequality is occasionally exploited to accelerate economic growth. Busse and Spielmann (2006) and Jayachandran (2015) suggest that, in developing countries, gender inequality can contribute to rapid economic expansion by providing a pool of cost-effective labor. This approach, which uses gender disparities as a tool for economic progress, highlights a tendency to ignore or exploit such disparities to attract foreign direct investment (FDI) and enhance trade, rather than addressing the underlying problems. Prioritizing economic growth through female low-cost labor may exacerbate gender inequality in these regions. Gender inequality issue is not confined to developing nations; it remains a pressing controversy in developed countries as well. Knight and Brinton (2017) highlight the varied manifestations of gender inequality across European nations. Caliendo and Wittbrodt (2022) demonstrate that while minimum wage policies in countries like Germany can enhance women's participation in the labor market, potentially benefiting GDP, this increase in women occupying minimum wage positions might not signify a decrease in gender disparities. Instead, it could be a strategic move to boost economic growth through cost-effective labor. Following this line of thought, Bennedsen, Simintzi, Tsoutsoura, and Wolfenzon (2022), along with Goldin (2014), suggest that institutions often neglect the imperative to address gender inequality, which poses potential systemic challenges. This issue becomes apparent when increased female workforce participation, particularly in minimum wage roles, is not perceived as progress toward gender equality but rather as an economic strategy (Ryu and Nam, 2024). We question the notion that a higher rate of female workforce participation, encouraged by institutions, necessarily signifies a reduction in gender inequality, especially when it might be strategically employed to enhance GDP.

Reducing workforce inequality may not necessarily solve gender inequality. Workforce inequality is measured merely by the ratio of men to women in the workplace, particularly at the lower end of the employment distribution, which can be misleading (Maasoumi and Wang, 2019). A lower level of workforce inequality does not signify a higher level of gender equality. For example, in the agricultural sector, even though women may constitute nearly half of the workforce at the lower end of the skill distribution, this does not imply low gender inequality in this industry (Alkire, Meinzen-Dick, Peterman, Quisumbing, Seymour, and Vaz, 2013). In less developed nations, the agricultural industry remains labor-intensive and is marked by low productivity. The global economic environment now is far more competitive, with higher entry barriers for industrialization and innovation, making it more difficult for the agricultural industry to become a successfully industrialized society. Opportunities to enter into an industrialization society are constrained by limited educational opportunities and low levels of government or institutional support. Societies dependent on agriculture often face significant gender disparities and limited opportunities for innovation (Baum and Benshaul-Tolonen, 2021;

Dentzman, Pilgeram, and Wilson, 2023). Institutions strive to diminish workforce inequality as a means to reduce gender disparities, such efforts can sometimes be misinterpreted or overstated. We argue that addressing educational inequality, which closely relates to positions, wages, and status derived from skills and abilities, offers a more accurate reflection of the situation. As women achieve higher education levels, their chances of becoming skilled professionals or assuming managerial roles increase, thereby expanding the talent pool of firms at the higher end of the skill distribution, fostering diversity, and driving positive economic outcomes.

Recent studies emphasize that innovation has been a key topic in studies highlighting its importance for long-term and sustainable development (Dasaratha, 2023; Franks and Sussman, 2005; Globerman and Shapiro, 2003; Nam, Bang, and Ryu, 2023a). Innovation transcends the firm level, impacting broader economic progress and societal advancement. This requires a synergy of diverse talents and ideas, which is supported and boosted by the empowerment of the female workforce. However, understanding how gender inequality impacts the concept of innovation is limited because research is sparse.

The objective of this study is to understand the impact of institutions on gender inequality and the impact of gender inequality on economic outcomes, specifically trade (calculated as the sum of exports and imports), GDP (represented as GDP per capita), and innovation (measured by the number of patents). Additionally, this research analyzes how FDI (measured as FDI inflows) and gender inequality affect trade. Gender inequality refers to the imbalance in power, opportunities, and access to resources between men and women. We use three key variables for gender inequality: the Gender Inequality Index (*GI*), workforce inequality (*WI*), and educational inequality (*EI*). *GI* is a composite index including health, empowerment, and economic activity between males and females. *WI* refers to workforce disparities in workforce participation between males and females. *EI* refers to the disparities in educational opportunities and achievements between males and females. To measure institutional quality, we incorporate worldwide governance indicators (WGI): government effectiveness, control of corruption, regulatory quality, political stability and absence of violence or terrorism, rule of law, and voice and accountability. These six indicators assess the ability of governance.

Our findings indicate that institutions contribute to a decrease in workforce inequality but do not mitigate educational inequality. We suggest that while institutions are making efforts to reduce workforce inequality—possibly to attract FDI and enhance international trade for economic growth—they often tend to overlook educational inequality, which is a more critical indicator of gender inequality. Given the absence of a comprehensive assessment framework to evaluate government policies and regulations, there is a risk that administrators might not be held accountable for their actions (Jensen, 2010; Mayer, 2021). Institutions encounter challenges in fostering innovation by mitigating educational disparities. We document that workforce inequality reduces trade and GDP but has a negligible impact on innovation. Conversely, educational inequality reduces innovation, but does not significantly impact

trade and GDP. Educational inequality, which can be strongly related to position, wage, and status based on skills and abilities, should be used to better capture actual practices of gender inequality. As women achieve higher levels of education, their likelihood of being skilled or occupying managerial positions increases. This enhances the talent pool within firms, fosters diversity, and contributes positively to innovation. We also find that the influence of institutions is more closely associated with workforce inequality in relation to trade and GDP rather than with educational inequality in terms of innovation. This provides answers to how governments address workforce inequality to spur economic growth. Tejani and Milberg (2016) suggest that in developing countries, the female workforce can facilitate rapid economic expansion by providing a source of cost-effective labor. This is also relevant to developed countries: institutions' efforts to mitigate workforce inequality can expand the labor pool, attract FDI, enhance trade, and increase GDP by leveraging their inexpensive and substantial workforce. However, they tend to neglect the improvement of innovation for sustainable growth through reducing educational inequality in the EU and developed countries.

We contribute to studies on the role of institutions in addressing workforce and/or educational inequalities. The role of institutions in tackling gender inequality has become increasingly prominent. Rooted in institutional theory, initially proposed by North (1990) and further supported by Markussen, Sharma, Singhal, and Tarp (2021), institutions play a crucial role in mitigating gender inequality and fostering development. The strategies that institutions adopt can significantly affect the nature of gender inequality (Branisa, Klasen, Ziegler, Drechsler, and Jütting, 2014; Liao, Loureiro, and Taboada, 2022). This influence is particularly noticeable in countries that prioritize short-term economic gains over long-term investments in human capital. This approach often emphasizes reducing workforce inequality, which leads to increased female labor force participation and, consequently, economic growth in developed countries, particularly in the European Union.

We address the previously unexplored question of the relationship between gender inequality and innovation. We establish a theoretical link: a low level of gender equality may improve innovation. We distinguish between the effects of female participation and education on innovation performance. While female participation is crucial, it may not maximize a society's innovative potential. Conversely, reducing educational disparities can leverage innovation in a knowledge-based economy. Higher education levels among women increase their likelihood of being skilled or occupying managerial positions, fostering diversity, enhancing the talent pool within firms, and contributing positively to innovation, all of which are pivotal for sustainable development. Addressing gender inequality and promoting extensive female education are crucial steps towards enhanced innovation and achieving sustainable growth.

We discern how different facets of gender inequality—specifically, workforce and educational inequalities—impact GDP and/or innovation. Educational disparities align with the Stolper-Samuelson theorem, a fundamental economic concept that examines the effects of trade. This theorem posits that

trade benefits skilled individuals, while low-skilled jobs might face a relative disadvantage, potentially diminishing demand and exacerbating income inequality. Increased female labor force participation has been linked to GDP growth; we argue that increased female labor force participation does not necessarily signify a decrease in gender inequality. The decrease in educational inequality uncovers new pathways that could lead to increased innovation. We propose a strategy that focuses on prioritizing and addressing these issues.

Our study also contributes to the research on gender inequality in developed countries, focusing specifically on the 27 EU nations. Although the prevailing view suggests that gender inequality is not a critical issue in developed nations, our research spanning approximately 30 years challenges this perspective, showing that gender inequality is indeed a serious and urgent issue needing resolution in these countries. Several studies have addressed the issue of gender inequality in developed countries and discussed the seriousness of the problem. (Blau and Kahn, 2017; Brogaard, Gerasimova, and Rohrer, 2024; Knight and Brinton, 2017). We underscore that gender inequality is a pressing concern in developed countries, particularly within the European Union nations, requiring focused attention and action.

The remainder of this paper is organized as follows. Section 2 examines the existing literature on gender inequality, institutions, trade, GDP, and innovation, and presents the hypotheses for our study. Section 3 presents the sample data, outlines the variables under investigation, and describes the methodological approach adopted. Section 4 presents the results of the empirical analysis. Section 5 concludes the study.

## 2. Literature review and hypotheses development

### 2.1 Gender inequality and institutions

High institutional quality can reduce barriers and inequality. Institutional quality significantly alleviates gender inequality by enhancing women's participation in the workforce and reducing workforce inequality. Institutional theory suggests that institutional quality is crucial for shaping the constraints and norms that influence society's decision-making processes (Chowdhury, Audretsch, and Belitski, 2019; Jessen, 2022; Nam, Bang, and Ryu, 2023b; North, 1990; Todea and Harin, 2024). These processes are vital for enhancing entrepreneurial thinking and improving the quality of human development (Slesman, Abubakar, and Mitra, 2021; Nam and Ryu, 2023; Nam, Frijns, and Ryu, 2024). Effective institutions are pivotal for reducing gender inequality, suggesting that robust institutional frameworks can lead to the greater inclusion of women in the labor market (Kim, 2022; Nkoa and Song, 2022). The relationship between poor institutional quality and increased inequality underscores the negative impact of inefficient institutions on workforce diversity. Moreover, the literature indicates that inequalities entail significant societal costs, manifesting as reduced human capital, compromised governance, and stifled economic growth (Acemoglu, Johnson, Robinson, and Thaicharoen, 2003; Apetrei, Sanchez-

Garcıa, and Sapena, 2019). By lowering transaction costs, incentivizing human exchange, and ensuring the protection of intellectual property rights, efficient institutions foster firms' innovation (Dobson and Ramlogan-Dobson, 2010) and create an environment conducive to reducing workforce inequality. Poor institutional quality increases the uncertainties and risks associated with economic investment, which can disproportionately affect women's employment opportunities. Based on the literature, we propose our first research hypothesis: *Institutional quality significantly alleviates gender inequality, specifically by enhancing women's participation in the workforce.*

**2.2 Role of gender inequality in the relationship between foreign direct investment and trade**

A reduction in gender inequality in the general and workforce contexts can strengthen the positive relationship between FDI and international trade. FDI, which promotes diversification, serves as a key driver of global commerce with a primary focus on boosting trade (Claessens, Djankov, Fan, and Lang, 2003; Doukas and Lang, 2003; Nam and Ryu, 2024). Thus, we conjecture that gender inequality undermines the beneficial effects of FDI on international trade.

Gender inequality in the workforce, which often results in an abundant supply of low-skilled labor, can decrease costs, increase competitiveness, and attract multinational firms looking for export-oriented FDI (Berik, Rodgers, and Zveglich, 2004; Tejani and Milberg, 2016). Productivity gains from foreign acquisitions can reduce the misallocation of talent based on gender, leading to a restructuring of the workforce. However, workforce inequality may constrain a country's economic development, potentially reducing its appeal to FDI, negatively affecting the development of new exportable goods and services, and impacting international trade (Aizenman and Noy, 2006; Anwar and Nguyen, 2011). Equal access to education, resulting from reduced gender inequality, increases women's rate of participation in the workforce, thereby expanding the labor pool. This greater diversity in the workforce, fueled by higher female participation, can boost productivity, spur the creation of novel products and services, expand export markets, and increase international trade. Gender inequality can reduce domestic demand by lowering household income (Seguino, 2010), potentially making a country less attractive for FDI and adversely affecting trade outcomes. This finding illustrates that reducing gender inequality is instrumental in enhancing international trade. Accordingly, we propose the second research hypothesis: *Gender inequality reduces the positive relationship between FDI and trade.*

**2.3 Role of gender inequality in innovation**

Egalitarian norms that increase gender parity can improve a more efficient financial decision-making process (Guiso and Zaccaria, 2023). An increase in women's educational level can significantly boost human development and trade. Inequalities faced by women can restrict their employment opportunities, impede their promotion in the workplace, and hinder economic diversification (Bertay, Dordevic, and Sever, 2020; Herd, Freese, Sicinski, Domingue, Harris, Wei, and Hauser, 2019; Thébaud, 2015). Wage

disparities, exacerbated by educational inequality, lower the benefits of investing in women. Women's educational level can lead to greater investment in research and development (R&D) by businesses, thus enhancing their innovation capabilities (Chowdhury, Doukas, and Mandal, 2023; Østergaard, Timmermans, and Kristinsson, 2011). Consequently, decreasing gender inequality in education helps cultivate a more diverse and innovative economy, fosters entrepreneurship, attracts investor-seeking countries, and lowers uncertainty, thereby indirectly enhancing trade and accelerating firms' innovation activities. Educational inequality can hinder the shift from industries that primarily rely on manual labor to those that demand higher skill levels. Concurrently, empowering women economically can funnel more resources into innovation within crucial sectors, thereby catalyzing substantial progress.

Innovation is a critical factor in economic development that extends beyond short-term advancement and fosters long-term progress. It facilitates societies' transitions from agriculture-based economies to those with improved societal structures (Cumming, Farag, and Johan, 2024; Gomulka, 2006). The significance of technological progress as a catalyst for economic expansion posits that innovation enhances productivity, reshapes the industrial landscape, and opens new avenues for economic pursuits. When public interest in gender equality increases, it leads to changes in hiring practices and increases firms' transparency in the United States (Giannetti and Wang, 2023). Freeman and Soete (1997) suggest that innovation's effects go beyond the launch of new products or methods. Such effects can significantly alter market liberalization, boost trade, and amplify industries' competitiveness, especially those benefiting from women's higher educational level; this highlights innovation's role in knowledge-driven economies (Moshirian, Tian, Zhang, and Zhang, 2021; Nam, Bang, and Ryu, 2024). A diverse employment composition can lead to the development of a wider array of strategies and solutions, culminating in enhanced decision-making quality (Dezso and Ross, 2012; Flabbi, Macis, Moro, and Schivardi, 2019; Hillman, Shropshire, and Cannella, 2007; Liu, Makridis, Ouimet, and Simintzi, 2023; Nam, Bilgin, and Ryu, 2024). Accordingly, the issues of gender inequality and innovation have emerged as key elements for sustaining growth, emphasizing the need for focused studies in these fields to promote continuous advancement. Nations with fewer gender gaps tend to have more innovative sectors, a trend supported by the observation that countries with higher levels of women's education also exhibit higher innovation rates (Noland, Moran, Kotschwar, 2016). Thus, minimizing gender inequality over time is crucial for fostering a wider spectrum of innovations that lead to sustainable economic development. Based on the literature, we propose the third research hypothesis: *Gender inequality reduces the positive effect of institutions and innovation.*

## 3. Data

We explore the effects of institutions on gender inequality, and determine the role of gender inequality in trade, GDP, and innovation. Our study considers the 27 European Union countries (Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece,

Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Poland, Portugal, Romania, Slovenia, Slovakia, Spain, and Sweden) and spans 25 years from 1998 to 2022.[1] In this study, the proxies for gender inequality include *GI*, which utilizes data from the Human Development Report provided by the United Nations Development Programme (UNDP). The variables for workforce and educational inequalities are provided by the World Bank. The other variables used in this research are also derived from the country-specific data provided annually by the World Bank.

The main research variable is gender inequality. We use three proxies for gender inequality—*GI*, *WI*, and *EI*. The *GI* incorporates three dimensions: health, reflected by adolescent birth rates and the maternal mortality ratio; empowerment, gauged through the rates of secondary education attainment among men and women and the representation of men and women in parliament; and workforce, determined by the labor force participation rates of women, ranging from 0 to 1. As this index approaches one, it signifies increasing inequality. *WI* is measured as the ratio of the labor force participation rate among the male population to that among the female population. This ratio is highlighted as a crucial metric for gender inequality by Tzannatos (1999). *EI* is measured as the ratio of gross male enrollment to female enrollment in secondary education (Busse and Spielmann, 2006).

Our conceptual model includes three dependent variables as proxies for economic outcomes: *Trade* is measured as the sum of exports and imports and expressed in hundreds of billions of dollars; *GDP* represents GDP per capita and is expressed in thousands of dollars; and *Inno* serves as a proxy for technological progress, measured as the number of patents, expressed in units of 100. Patents are widely used in empirical research as a proxy for innovation or technological change since they represent legally protected inventions and improve technologies in society (Ahmad, Farag, and Wang, 2023; Lissoni and Miguelez, 2024; Nam, Bang, and Ryu, 2023). The number of patents can be justified as an indicator of innovation. To capture the role of gender inequality, we use two explanatory variables: *FDI* and *Insti*. *FDI* represents the FDI inflow, expressed in hundreds of billions of dollars. *Insti* represents institutional quality, measured as the sum of the WGI (control of corruption, government effectiveness, regulatory quality, political stability and absence of violence or terrorism, rule of law, and voice and accountability), ranging from -15 to 15. We include a set of control variables, *Edu1*, *Edu2*, *Infla*, and *Unemploy*. One of the classical theories in international trade, the Stolper-Samuelson theorem, discusses the relationship between education (skilled and low-skilled workers) and international trade. We consider two variables related to education: *Edu1* represents the secondary education enrollment rate, while *Edu2* represents the duration of compulsory schooling. *Infla* represents inflation, measured as the growth rate of the consumer price index. *Unemploy* represents the unemployment rate, calculated as a percentage by dividing the total number of unemployed individuals, including both men and women, by the entire labor force.

[1] It is based on the EU member countries as of 2024.

Table 1 presents the descriptive statistics of the variables used to examine the role of gender inequality in trade, GDP, and innovation. All observations are annual data, provided by the World Bank and UNDP, which is suitable for the longitudinal analysis of trends over the 25 years from 1998 to 2022. Regarding the sample size, our study spans 25 years and covers 27 European Union countries, resulting in a robust dataset comprising a maximum of 675 country-year observations. The mean of *GI*, which represents overall gender inequality in the European Union, is 0.15. *WI* and *EI* indicate the ratio of male to female participation. Our data show that the means of *WI* and *EI* are 1.22 and 0.99, respectively. These values indicate a higher labor force participation rate among men than among women, and higher women's enrollment in secondary education than that of men. Specifically, the lowest *EI* value, 0.79, is observed in Sweden and the highest, 1.12, in Romania. In Sweden, female secondary education enrollment rates exceed male rates, leading the World Bank to categorize it as a high-income country. Sweden demonstrates the highest level of educational attainment among women compared with men and boasts a robust social welfare system and public services, ensuring a high level of citizen welfare in healthcare, education, and social security. Conversely, Romania exhibits higher educational enrollment rates for men than for women.

**Table 1.** Descriptive statistics

| | | Obs | Mean | Std | Min | Max |
|---|---|---|---|---|---|---|
| Gender inequality | *GI* | 648 | 0.15 | 0.08 | 0.01 | 0.46 |
| | *WI* | 648 | 1.22 | 0.18 | 1.03 | 2.38 |
| | *EI* | 628 | 0.99 | 0.05 | 0.79 | 1.12 |
| *Felabor* | | 658 | 78.20 | 4.13 | 62.91 | 89.19 |
| *Trade* | | 675 | 4.09 | 6.00 | 0.06 | 40.78 |
| *GDP* | | 675 | 29.19 | 21.91 | 1.60 | 133.71 |
| *Inno* | | 604 | 35.32 | 94.37 | 0.01 | 517.36 |
| *FDI* | | 652 | 0.04 | 0.28 | -1.52 | 1.62 |
| *Insti* | | 621 | 104.57 | 16.69 | 15.40 | 158.40 |
| *Edu1* | | 629 | 107.12 | 16.06 | 79.28 | 164.08 |
| *Edu2* | | 657 | 10.34 | 1.44 | 8.00 | 13.00 |
| *Unemploy* | | 675 | 8.49 | 4.28 | 1.81 | 27.47 |
| *Infla* | | 675 | 3.07 | 4.60 | -4.48 | 59.10 |

*Notes*. This table illustrates the descriptive statistics. *Obs* denotes the number of country-year observations. *Mean*, *Std*, *Min*, and *Max* represent the average, standard deviation, minimum, and maximum values, respectively. *GI* represents the gender inequality index. *WI* represents workforce inequality, measured as the ratio of the labor force participation rate among the male population to that among the female population. *EI* represents educational inequality, measured as the ratio of gross male enrollment to female enrollment in secondary education. *FeLabor* is measured as the ratio of the labor force with advanced education to the corresponding working-age population. Advanced education includes short-cycle tertiary education, bachelor's degrees, master's degrees, and doctoral degrees or their equivalents. *Trade* is the sum of exports and imports, expressed in hundreds of billions of dollars. *GDP* represents GDP per capita, expressed in thousands of dollars. *Inno* represents innovation, measured as the number of patents, expressed in units of 100. *FDI* represents the FDI inflow, expressed in hundreds of billions of dollars. *Insti* represents institutional quality, measured as the sum of the

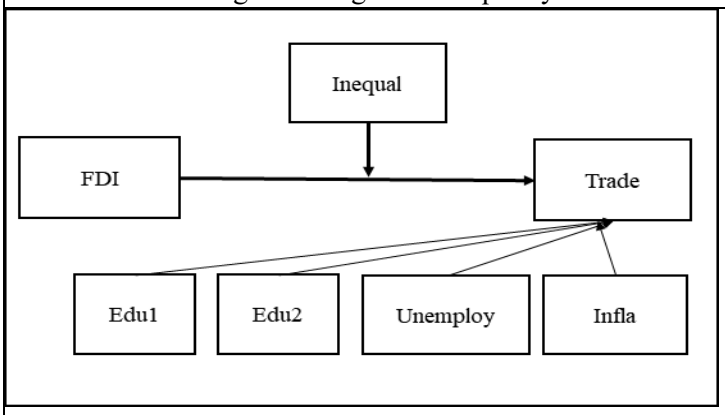
Worldwide Governance Indicators, ranging from -15 to 15. *Edu1* represents the secondary education enrolment rate. *Edu2* is the duration of compulsory schooling. *Unemploy* refers to the unemployment rate, measured by summing the unemployment figures for both men and women and then dividing this by the total labor force. *Infla* is measured as the growth rate of the consumer price index.

The mean of *Edu1*, the secondary education enrollment rate, is 107.12, with Belgium recording the highest at 164.09 and Bulgaria recording the lowest at 79.28. Between 1998 and 2022, particularly between 2014 and 2015, Belgium displayed remarkably high secondary education enrollment rates, nearing 160%. This phenomenon can be attributed to several cultural and political factors, including the prioritization of education policy in Belgium. Education is considered a key element of national development, reflecting a country's investment and interest in providing high-quality education to all citizens, driven by the younger generation of immigrants. By contrast, Bulgaria's low secondary education enrollment rate overall is driven by its low income relative to the rest of the European Union, and agriculture is its major industry.

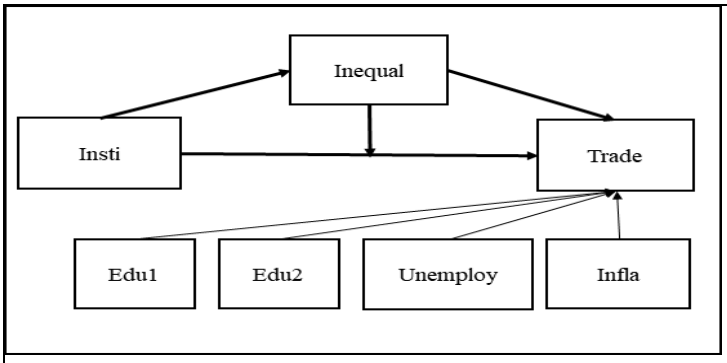
Figure 1 illustrates four models that explore the roles of gender inequality: *i*) Model 1 examines how gender inequality moderates the relationship between FDI and trade. *ii*) Model 2 explores both the mediating and moderating effects of gender inequality on the connection between institutions and trade. *iii*) Model 3 investigates the mediating influence of gender inequality on the relationship between institutions and GDP. *iv*) Model 4 assesses the mediating impact of gender inequality on the link between institutions and innovation.

**Figure 1.** Conceptual models

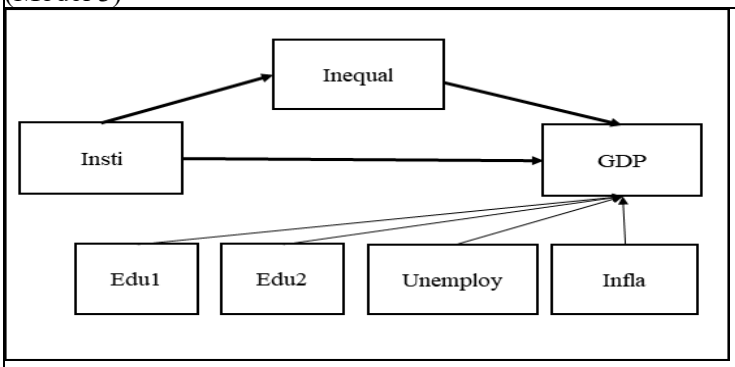
Panel A. Moderating roles of gender inequality in the relationship between FDI and trade (Model 1)



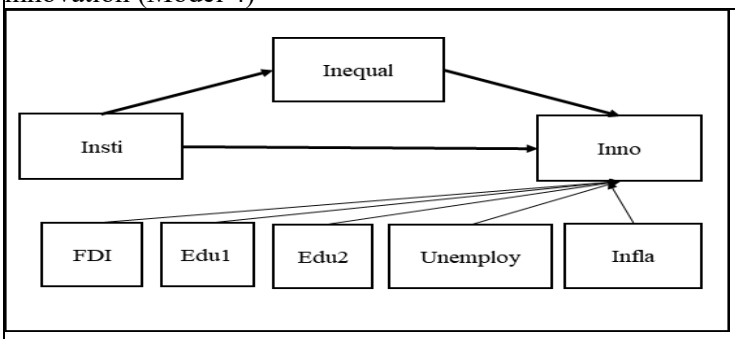

Panel B. Mediating and moderating roles of gender inequality in the relationship between institutional quality and trade (Model 2)




Panel C. Mediating roles of gender inequality in the relationship between Institutional quality and GDP (Model 3)




Panel D. Mediating roles of gender inequality in the relationship between institutional quality and innovation (Model 4)




*Notes.* This figure illustrates the effects of gender inequality on economic outcomes (trade, GDP, and innovation) in the European Union. Panel A focuses on the moderating role of gender inequality in the relationship between FDI and trade. Panel B identifies the mediating and moderating roles of gender inequality in the relationship between institutions and trade. Panel C determines the mediating role of gender inequality in the relationship between institutions and GDP. Panel D verifies the mediating role of gender inequality in the relationship between institutions and innovation. *Trade* is defined as the sum of exports and imports. *FDI* represents the foreign direct investment inflow. *Inequal* represents gender inequality including three variables: *GI* represents the gender inequality index; *WI* represents workforce inequality, measured by the ratio of the labor-force participation rates between the male and female populations; and *EI* represents educational inequality, measured as the ratio of gross male enrollment to female enrollment in secondary education. *Insti* represents institutional quality, measured as the sum of the Worldwide Governance Indicators. *GDP* represents GDP per capita. *Inno* represents innovation, measured as the number of patents. *Edu1*, *Edu2*, *Unemploy*, and *Infla* are control variables included in Panels A to C. In Panel D, *FDI* is introduced as an additional control variable alongside the existing control variables. *Edu1* represents the secondary education enrolment rate. *Edu2* is the duration of compulsory schooling. *Unemploy* represents the unemployment rate, calculated as a percentage by

dividing the total number of unemployed individuals, including both men and women, by the entire labor force. *Infla* represents the inflation rate.

We use Equation (1) to assess the moderating role of gender inequality on the effect of FDI on trade, Equations (2) and (4) to analyze the mediating and moderating roles of gender inequality on the effect of institutions on trade, Equations (5) to verify the mediating and moderating roles of gender inequality on the effect of institutions on trade, Equations (6) to (8) to assess the moderating role of gender inequality on the effect of institutions on GDP, and Equations (9) to (11) to analyze the moderating role of gender inequality on the effect of institutions on innovation, for FE regressions. To assess these effects, we use the following equations:

The moderating role of gender inequality on the effect of FDI on trade:

$$Trade_{i,t} = \alpha_0 + \alpha_1 FDI_{i,t} + \alpha_2 Inequal_{i,t} + \alpha_3 Ineqal \cdot FDI_{i,t} + \alpha_c Control_{i,t} + \mu_i + \varepsilon_{i,t}, \quad (1)$$

The mediating role of gender inequality on the effect of institutions on trade:

$$Trade_{i,t} = \alpha_0 + \alpha_1 Insti_{i,t} + \alpha_c Control_{i,t} + \mu_i + \varepsilon_{i,t}, \quad (2)$$

$$Inequal_{i,t} = \alpha_0 + \alpha_1 Insti_{i,t} + \alpha_c Control_{i,t} + \mu_i + \varepsilon_{i,t}, \quad (3)$$

$$Trade_{i,t} = \alpha_0 + \alpha_1 Insti_{i,t} + \alpha_2 Inequal_{i,t} + \alpha_c Control_{i,t} + \mu_i + \varepsilon_{i,t}, \quad (4)$$

The moderating role of gender inequality on the effect of institutions on trade:

$$Trade_{i,t} = \alpha_0 + \alpha_1 Insti_{i,t} + \alpha_2 Inequal_{i,t} + \alpha_3 Inequality \cdot Insti_{i,t} + \alpha_c Control_{i,t} + \mu_i + \varepsilon_{i,t}, \quad (5)$$

The mediating role of gender inequality on the effect of institutions on GDP:

$$GDP_{i,t} = \alpha_0 + \alpha_1 Insti_{i,t} + \alpha_c Control_{i,t} + \mu_i + \varepsilon_{i,t}, \quad (6)$$

$$Inequal_{i,t} = \alpha_0 + \alpha_1 Insti_{i,t} + \alpha_c Control_{i,t} + \mu_i + \varepsilon_{i,t}, \quad (7)$$

$$GDP_{i,t} = \alpha_0 + \alpha_1 Insti_{i,t} + \alpha_2 Inequal_{i,t} + \alpha_c Control_{i,t} + \mu_i + \varepsilon_{i,t}, \quad (8)$$

The mediating role of gender inequality on the effect of institutions on innovation:

$$Inno_{i,t} = \alpha_0 + \alpha_1 Insti_{i,t} + \alpha_c Control_{i,t} + \mu_i + \varepsilon_{i,t}, \quad (9)$$

$$Inequal_{i,t} = \alpha_0 + \alpha_1 Insti_{i,t} + \alpha_c Control_{i,t} + \mu_i + \varepsilon_{i,t}, \quad (10)$$

$$Inno_{i,t} = \alpha_0 + \alpha_1 Insti_{i,t} + \alpha_2 Inequal_{i,t} + \alpha_c Control_{i,t} + \mu_i + \varepsilon_{i,t}, \quad (11)$$

where *i* denotes the country and *t* is the year. *Trade* is defined as the sum of exports and imports. *FDI* represents the foreign direct investment inflow. $Inequal \in \{GI, WI, EI\}$. *GI* represents the gender inequality index. *WI* represents workforce inequality, measured by the ratio of the labor-force participation rates between the male and female populations. *EI* represents educational inequality,

measured as the ratio of gross male enrollment to enrollment in secondary education. *Insti* represents institutional quality, measured as the sum of the Worldwide Governance Indicators. *GDP* represents GDP per capita. *Inno* is measured as the number of patents. *Inequal·FDI* and *Inequal·Insti* are interaction terms. $Control_{i,t}$=$\{Edu1_{i,t},\ Edu2_{i,t},\ Unemploy_{i,t},\ Infla_{i,t}\}$. $\alpha_c$ is the coefficient of *Edu1*, *Edu2*, *Unemploy*, and *Infla*, respectively. These control variables are included in Equations (1) to (8). *FDI* is introduced as an additional control variable alongside the existing control variables in Equations (9) to (11). $\mu$ denotes the individual effect and $\varepsilon$ denotes the idiosyncratic errors.

## 4. Empirical Results

Table 2 presents the results of examining the moderating role of gender inequality in the relationship between FDI and trade. The interaction terms *GI·FDI* and *WI·FDI* negatively affect trade, implying that *GI* and *WI* moderate the relationship between *FDI* and *Trade*. The negative magnitudes of *GI·FDI* and *WI·FDI*, combined with the positive effect of *FDI*, suggest that a decrease in *GI* and *WI* enhances the positive impact of *FDI* on *Trade*. However, *EI* positively moderates the relationship between *FDI* and *Trade*, indicating that increased educational inequality encourages trade. In the context of the European Union as a developed market, our findings reveal that FDI complements international trade and that reducing workforce inequality provides a sufficient labor force, strengthening the positive effect of FDI on trade. Notably, an increase in educational inequality boosts trade. We interpret this to mean that skilled women benefiting from high-quality education earn higher wages. This improvement does not align with the objectives of FDI and trade (losing price competitiveness), even in developed countries.

**Table 2.** Moderating roles of gender inequality in the relationship between FDI and trade

| | M1[*Trade*] | M2[*Trade*] | M3[*Trade*] | M4[*Trade*] | M5[*Trade*] | M6[*Trade*] | M7[*Trade*] |
|---|---|---|---|---|---|---|---|
| *FDI* | 1.884*** | 1.806*** | 3.682*** | 1.836*** | 24.213*** | 1.819*** | -45.994*** |
| | (5.10) | (5.28) | (5.09) | (5.18) | (5.27) | (4.98) | (-5.75) |
| *GI* | | -27.306*** | -25.788*** | | | | |
| | | (-9.79) | (-9.15) | | | | |
| *GI·FDI* | | | -22.406*** | | | | |
| | | | (-2.94) | | | | |
| *WI* | | | | -6.485*** | -6.094*** | | |
| | | | | (-7.13) | (-6.80) | | |
| *WI·FDI* | | | | | -19.110*** | | |
| | | | | | (-4.88) | | |
| *EI* | | | | | | 14.774*** | 13.638*** |
| | | | | | | (3.90) | (3.70) |
| *EI·FDI* | | | | | | | 48.423*** |
| | | | | | | | (5.98) |
| *Edu1* | 0.012 | -0.028** | -0.025** | -0.006 | -0.006 | 0.026** | 0.021 |
| | (0.92) | (-2.27) | (-2.05) | (-0.46) | (-0.49) | (2.02) | (1.64) |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| *Edu2* | 0.582*** | 0.137 | 0.144 | 0.418*** | 0.458*** | 0.484*** | 0.500*** |
| | (4.19) | (1.00) | (1.06) | (3.10) | (3.46) | (3.48) | (3.70) |
| *Unemploy* | -0.113*** | -0.091*** | -0.095*** | -0.131*** | -0.142*** | -0.130*** | -0.130*** |
| | (-3.95) | (-3.43) | (-3.58) | (-4.74) | (-5.22) | (-4.53) | (-4.69) |
| *Infla* | -0.023 | 0.057** | 0.055** | -0.028 | -0.023 | -0.008 | -0.008 |
| | (-0.81) | (2.09) | (2.03) | (-1.03) | (-0.85) | (-0.27) | (-0.30) |
| Intercept | -2.200 | 10.255*** | 9.675*** | 9.336*** | 8.525*** | -17.259*** | -15.742*** |
| | (-1.20) | (4.85) | (4.59) | (3.92) | (3.64) | (-4.05) | (-3.80) |
| *F*-test | 13.35*** | 28.98*** | 26.41*** | 20.58*** | 21.75*** | 13.94*** | 17.80*** |
| $R^2$ | 0.311 | 0.251 | 0.240 | 0.186 | 0.205 | 0.316 | 0.384 |
| Obs | 595 | 595 | 595 | 595 | 595 | 595 | 595 |

*Notes*. This table presents the moderating role of gender inequality in the relationship between FDI and trade using fixed-effect regressions. Dependent variables are shown in squared brackets. *Trade* is measured as the sum of exports and imports. *FDI* represents the FDI inflow. *GI*, *WI*, and *EI* are proxies for gender inequality. *GI* represents the gender inequality index. *WI* represents workforce inequality, measured as the ratio of the labor force participation rate among the male population to that among the female population. *EI* represents educational inequality, measured as the ratio of gross male enrollment to female enrollment in secondary education. *GI·FDI*, *WI·FDI*, and *EI·FDI* are interaction terms, measured as the product of the gender inequality proxies (*GI, WI,* and *EI*) and *FDI*. The control variables are *Edu1*, *Edu2*, *Unemploy*, and *Infla*. *F*-test represents the *F*-test statistic, indicating a test against the null hypothesis that all the coefficients are zero. $R^2$ is the overall R-squared value. *Obs* is the country-year observations. The number of countries is 27 in all the models. Figures in parentheses are *t*-statistics. *** and ** denote statistical significance at the 1% and 5% levels, respectively.

Panel A of Table 3 presents the results for the mediating and moderating roles of gender inequality in the relationship between institutional quality and trade. In Panel A, both *GI* and *WI* negatively mediate the relationship between institutional quality and trade, while *EI* does not mediate this relationship. Overall, the results of Panel A are similar to those in Table 3: decreases in *GI* and *WI* stimulate more trade, yet an increase in *EI* also drives more trade. This suggests that even in developed countries, an abundant workforce, bolstered by greater participation by women, promotes economic development. However, reducing inequality through women's education remains a challenge to be addressed in the European Union. Panel B presents the results for the moderating effects of *GI*, *WI*, and *EI* on the relationship between institutional quality and trade. The results reveal that both *GI·Trade* and *WI·Trade* significantly affect trade, while *EI·Trade* does not. This indicates that *GI* and *WI* play moderating roles that impede trade growth. Therefore, the involvement of women in the workforce should be encouraged to enhance trade in the European Union, although *EI* does not serve as a moderator in this relationship.

**Table 3.** Roles of gender inequality in the relationship between institutions and trade
Panel A. Mediating role of gender inequality

| | M1[*Trade*] | M2[*GI*] | M3[*Trade*] | M4[*WI*] | M5[*Trade*] | M6[*EI*] | M7[*Trade*] |
|---|---|---|---|---|---|---|---|
| *Insti* | 0.075*** | -0.002*** | 0.050*** | -0.004*** | 0.064*** | 0.001*** | 0.073*** |
| | (10.34) | (-24.84) | (4.73) | (-11.60) | (7.94) | (6.40) | (9.61) |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| *GI* | | | -13.060*** | | | | |
| | | | (-3.25) | | | | |
| *WI* | | | | | -2.945*** | | |
| | | | | | (-3.07) | | |
| *EI* | | | | | | | 5.017 |
| | | | | | | | (1.37) |
| *Edu1* | -0.018 | -0.000*** | -0.023* | -0.001 | -0.019 | -0.001*** | -0.012 |
| | (-1.46) | (-3.20) | (-1.90) | (-1.09) | (-1.61) | (-8.33) | (-0.91) |
| *Edu2* | 0.100 | -0.005*** | 0.032 | -0.005 | 0.085 | 0.003* | 0.087 |
| | (0.76) | (-3.75) | (0.24) | (-0.91) | (0.65) | (1.65) | (0.66) |
| *Unemploy* | -0.040 | -0.001*** | -0.055** | -0.006*** | -0.059** | 0.002*** | -0.048* |
| | (-1.47) | (-4.22) | (-2.05) | (-5.32) | (-2.13) | (5.48) | (-1.75) |
| *Infla* | 0.133*** | -0.000 | 0.127*** | -0.007*** | 0.112*** | -0.000 | 0.134*** |
| | (4.01) | (-1.30) | (3.86) | (-4.81) | (3.33) | (-0.48) | (4.04) |
| Intercept | -2.765* | 0.453*** | 3.152 | 1.787*** | 2.497 | 1.018*** | -7.871* |
| | (-1.69) | (25.97) | (1.29) | (24.43) | (1.06) | (52.76) | (-1.93) |
| *F*-test | 30.91*** | 250.78*** | 27.98*** | 41.29*** | 27.74*** | 25.00*** | 26.12*** |
| $R^2$ | 0.060 | 0.338 | 0.142 | 0.103 | 0.055 | 0.442 | 0.071 |
| Obs | 576 | 576 | 576 | 576 | 576 | 576 | 576 |

Panel B. Moderating role of gender inequality

| | M1[*Trade*] | M8[*Trade*] | M9[*Trade*] | M5[*Trade*] | M10[*Trade*] | M7[*Trade*] | M11[*Trade*] |
|---|---|---|---|---|---|---|---|
| *Insti* | 0.075*** | 0.050*** | 0.148*** | 0.064*** | 0.166*** | 0.073*** | -0.123 |
| | (10.34) | (4.73) | (8.90) | (7.94) | (2.97) | (9.61) | (-0.79) |
| *GI* | | -13.060*** | 41.740*** | | | | |
| | | (-3.25) | (5.01) | | | | |
| *GI·Insti* | | | -0.473*** | | | | |
| | | | (-7.41) | | | | |
| *WI* | | | | -2.945*** | 4.647 | | |
| | | | | (-3.07) | (1.10) | | |
| *WI· Insti* | | | | | -0.088* | | |
| | | | | | (-1.84) | | |
| *EI* | | | | | | 5.017 | -15.139 |
| | | | | | | (1.37) | (-0.92) |
| *EI· Insti* | | | | | | | 0.198 |
| | | | | | | | (1.26) |
| *Edu1* | -0.018 | -0.023* | -0.025** | -0.019 | -0.021* | -0.012 | -0.008 |
| | (-1.46) | (-1.90) | (-2.22) | (-1.61) | (-1.74) | (-0.91) | (-0.63) |
| *Edu2* | 0.100 | 0.032 | -0.111 | 0.085 | 0.070 | 0.087 | 0.063 |
| | (0.76) | (0.24) | (-0.87) | (0.65) | (0.54) | (0.66) | (0.47) |
| *Unemploy* | -0.040 | -0.055** | -0.076*** | -0.059** | -0.058** | -0.048* | -0.043 |
| | (-1.47) | (-2.05) | (-2.93) | (-2.13) | (-2.13) | (-1.75) | (-1.55) |
| *Infla* | 0.133*** | 0.127*** | -0.017 | 0.112*** | 0.103*** | 0.134*** | 0.138*** |
| | (4.01) | (3.86) | (-0.47) | (3.33) | (3.03) | (4.04) | (4.15) |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Intercept | -2.765* | 3.152 | -5.800** | 2.497 | -5.924 | -7.871* | 11.899 |
| | (-1.69) | (1.29) | (-2.21) | (1.06) | (-1.15) | (-1.93) | (0.73) |
| *F*-test | 30.91*** | 27.98*** | 34.25*** | 27.74*** | 24.36*** | 26.12*** | 22.64*** |
| $R^2$ | 0.060 | 0.142 | 0.077 | 0.055 | 0.050 | 0.071 | 0.072 |
| Obs | 576 | 576 | 576 | 576 | 576 | 576 | 576 |

*Notes*. Panels A and B, respectively, present the mediating and moderating roles of gender inequality in the relationship between institutions and trade using fixed-effect regressions. Dependent variables are shown in squared brackets. *Trade* is the sum of exports and imports. *Insti* represents institutional quality, measured as the sum of the Worldwide Governance Indicators. *GI* represents the gender inequality index. *WI* represents workforce inequality, measured as the ratio of the labor force participation rate among the male population to that among the female population. *EI* represents educational inequality, measured as the ratio of gross male enrollment to female enrollment in secondary education. *GI·Trade*, *WI·Trade*, and *EI·Trade* are interaction terms, measured as the product of the gender inequality proxies (*GI*, *WI*, and *EI*) and *Trade*. The control variables are *Edu1*, *Edu2*, *Unemploy*, and *Infla*. *F*-test represents the *F*-test statistic, indicating a test against the null hypothesis that all the coefficients are zero. $R^2$ is the overall R-squared value. *Obs* is the country-year observations. The number of countries is 27 on both panels. Figures in parentheses are *t*-statistics. ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.

Table 4 presents the results for the mediating role of gender inequality in the relationship between institutional quality and GDP. It highlights significant findings regarding the relationships between institutions and GDP, institutions and gender inequality, and gender inequality and GDP. First, our findings show that *Insti* significantly affects GDP in all the models, indicating a robust engagement in fostering GDP growth. Second, *Insti* significantly and negatively affects both *GI* and *WI*, but positively affects *EI*, suggesting that, while institutions encourage higher workforce participation among women, they do not reduce educational inequality. Results indicate that institutions do not actively increase women's education rates. In the short term, focusing on decreasing educational inequality may seem inefficient since increasing women's education requires significant investment in terms of time and resources. Societal preferences that favor men are already well-established in the systems of developed countries (Thébaud, 2015). However, we underscore the importance of governmental efforts to decrease gender gaps in education. Supporting the empowerment of female education enables women to fully realize their potential in the long term and yields diverse economic outcomes. Third, *GI* and *WI* negatively affect *GDP*, while *EI* positively impacts *GDP*. It may seem counterintuitive that higher educational inequality among women can positively influence GDP. Under certain conditions, this inequality can foster economic growth. Increasing women's education leads to higher wages; thus, it does not directly drive GDP growth. The findings in Table 4, aligned with those in Table 3, show that decreases in gender inequality (*GI*) and workforce inequality (*WI*) positively influence trade and GDP, whereas a decrease in educational inequality (*EI*) does not boost either trade or GDP.

**Table 4.** Mediating roles of gender inequality in the relationship between institutions and GDP

| | M1[*GDP*] | M2[*GI*] | M3[*GDP*] | M4[*WI*] | M5[*GDP*] | M6[*EI*] | M7[*GDP*] |
|---|---|---|---|---|---|---|---|
| *Insti* | 0.442*** | -0.002*** | 0.315*** | -0.004*** | 0.361*** | 0.001*** | 0.424*** |
| | (17.29) | (-24.84) | (8.55) | (-11.60) | (13.09) | (6.40) | (16.07) |
| *GI* | | | -65.956*** | | | | |
| | | | (-4.73) | | | | |
| *WI* | | | | | -21.555*** | | |
| | | | | | (-6.60) | | |
| *EI* | | | | | | | 32.093** |
| | | | | | | | (2.51) |
| *Edu1* | -0.010 | -0.000*** | -0.037 | -0.001 | -0.022 | -0.001*** | 0.028 |
| | (-0.23) | (-3.20) | (-0.88) | (-1.09) | (-0.55) | (-8.33) | (0.63) |
| *Edu2* | 0.751 | -0.005*** | 0.404 | -0.005 | 0.636 | 0.003* | 0.669 |
| | (1.63) | (-3.75) | (0.88) | (-0.91) | (1.43) | (1.65) | (1.46) |
| *Unemploy* | 0.073 | -0.001*** | -0.007 | -0.006*** | -0.065 | 0.002*** | 0.017 |
| | (0.77) | (-4.22) | (-0.07) | (-5.32) | (-0.70) | (5.48) | (0.18) |
| *Infla* | 0.796*** | -0.000 | 0.766*** | -0.007*** | 0.643*** | -0.000 | 0.802*** |
| | (6.85) | (-1.30) | (6.71) | (-4.81) | (5.63) | (-0.48) | (6.93) |
| Intercept | -25.542*** | 0.453*** | 4.339 | 1.787*** | 12.973 | 1.018*** | -58.204*** |
| | (-4.45) | (25.97) | (0.51) | (24.43) | (1.61) | (52.76) | (-4.09) |
| *F*-test | 86.41*** | 250.78*** | 78.61*** | 41.29*** | 85.00*** | 25.00*** | 73.77*** |
| $R^2$ | 0.149 | 0.338 | 0.385 | 0.103 | 0.142 | 0.442 | 0.119 |
| Obs | 576 | 576 | 576 | 576 | 576 | 576 | 576 |

*Notes*. This table presents the mediating role of gender inequality in the relationship between institutions and trade using fixed-effect regressions. Dependent variables are shown in squared brackets. *GDP* refers to GDP per capita. *Insti* represents institutional quality, measured as the sum of the Worldwide Governance Indicators. *GI*, *WI*, and *EI* are proxies for gender inequality. *GI* represents the gender inequality index. *WI* represents workforce inequality, measured as the ratio of the labor force participation rate among the male population to that among the female population. *EI* represents educational inequality, measured as the ratio of gross male enrollment to female enrollment in secondary education. The control variables are *Edu1*, *Edu2*, *Unemploy*, and *Infla*. *F*-test represents the *F*-test statistic, indicating a test against the null hypothesis that all the coefficients are zero. $R^2$ is the overall R-squared value. *Obs* is the country-year observations. The number of countries is 27 in all the models. Figures in parentheses are *t*-statistics. ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.

Table 5 presents the moderating role of gender inequality in the relationship between institutions and innovation to discern which inequality factor drives innovation. It highlights significant findings on the relationships between institutions and innovation, institutions and gender inequality, and gender inequality and innovation. First, *Insti* has a significantly negative effect on *Inno* in M1. Second, in M2 and M4, *Insti* negatively affects *GI* and *WI*, and only has a significantly positive impact on *EI* in M6. Third, *GI* and *WI* have no effect on *Inno* in M3 and M5, whereas *EI* alone negatively affects *Inno* in M7. This indicates that *EI* plays a negative moderating role in the relationship between institutions and innovation, while *GI* and *WI* do not play moderating roles in innovation.

**Table 5.** Mediating roles of gender inequality in the relationship between institutions and innovation

| | M1[*Inno*] | M2[*GI*] | M3[*Inno*] | M4[*WI*] | M5[*Inno*] | M6[*EI*] | M7[*Inno*] |
|---|---|---|---|---|---|---|---|
| *Insti* | -0.050** | -0.002*** | -0.063* | -0.004*** | -0.046* | 0.001*** | -0.037 |
| | (-2.13) | (-24.05) | (-1.81) | (-10.82) | (-1.76) | (6.40) | (-1.52) |
| *GI* | | | -7.041 | | | | |
| | | | (-0.51) | | | | |
| *WI* | | | | | 1.177 | | |
| | | | | | (0.32) | | |
| *EI* | | | | | | | -22.245* |
| | | | | | | | (-1.87) |
| *FDI* | -2.656*** | 0.002 | -2.646*** | 0.001 | -2.653*** | 0.002 | -2.603** |
| | (-2.61) | (0.63) | (-2.60) | (0.08) | (-2.61) | (0.49) | (-2.57) |
| *Edu1* | 0.075* | -0.000*** | 0.073* | -0.000 | 0.076* | -0.001*** | 0.047 |
| | (1.94) | (-3.03) | (1.88) | (-0.86) | (1.96) | (-8.40) | (1.15) |
| *Edu2* | 0.053 | -0.005*** | 0.013 | -0.005 | 0.055 | 0.003** | 0.146 |
| | (0.12) | (-3.76) | (0.03) | (-0.77) | (0.12) | (2.14) | (0.32) |
| *Unemploy* | -0.013 | -0.001*** | -0.020 | -0.006*** | -0.006 | 0.002*** | 0.024 |
| | (-0.15) | (-3.86) | (-0.23) | (-4.82) | (-0.06) | (5.28) | (0.27) |
| *Infla* | -0.102 | -0.000 | -0.105 | -0.007*** | -0.094 | -0.000 | -0.104 |
| | (-0.96) | (-1.30) | (-0.99) | (-4.45) | (-0.87) | (-0.23) | (-0.98) |
| Intercept | 33.729*** | 0.451*** | 36.785*** | 1.738*** | 31.736*** | 1.010*** | 56.089*** |
| | (6.14) | (24.94) | (4.52) | (23.11) | (3.85) | (50.85) | (4.27) |
| *F*-test | 2.39** | 191.62*** | 2.08*** | 28.36*** | 2.06** | 21.07** | 2.56** |
| $R^2$ | 0.038 | 0.332 | 0.016 | 0.086 | 0.041 | 0.464 | 0.062 |
| Obs | 526 | 553 | 526 | 553 | 526 | 553 | 526 |

*Notes*. This table presents the mediating role of gender inequality in the relationship between institutions and innovation using fixed-effect regressions. Dependent variables are shown in squared brackets. *Inno* represents innovation measured as the number of patents. *Insti* represents institutional quality, measured as the sum of the Worldwide Governance Indicators. *GI* represents the gender inequality index. *WI* represents workforce inequality, measured as the ratio of the labor force participation rate among the male population to that among the female population. *EI* represents educational inequality, measured as the ratio of gross male enrollment to female enrollment in secondary education. The control variables are *FDI*, *Edu1*, *Edu2*, *Unemploy*, and *Infla*. *F*-test represents the *F*-test statistic, indicating a test against the null hypothesis that all the coefficients are zero. $R^2$ is the overall R-squared value. *Obs* is the country-year observations. The number of countries is 27 in all the models. Figures in parentheses are *t*-statistics. ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.

The results in Table 5 suggest that reducing gender inequality in education can help create a more diverse and innovative economy. The wage gap caused by educational inequality can impede human capital development by decreasing the return on investment in female employees. Women's education can lead firms to increase their investment in R&D, thereby enhancing their innovation capacity. Innovation is crucial for economic development because it promotes long-term growth over short-term development. Hence, gender inequality and innovation have emerged as critical elements for sustained growth, and research in these areas is essential for sustainable development in advanced

countries. Hence, we confirm that educational inequality among women can reduce innovation in the European Union. In Table 5, we add *FDI* as a control variable for innovation, considering that technology transfer occurs during the process where foreign enterprises make foreign direct investments in domestic companies. Aidt (2022) notes that technology transfer contributes to innovations. By including the FDI variable as a control in the analysis of innovation, we account for the potential impact that foreign investments have on the transfer of technology, thereby facilitating innovation within domestic firms.

These results have significant implications for future studies. Previous studies have treated workforce inequality as a measure of gender inequality. However, workforce inequality should not be based solely on the status of women in the workplace. For instance, while women often constitute nearly half of the workforce in the agricultural sector (Adegbite and Machethe, 2020), it does not imply that gender inequality in this industry is low. Societies focused on agriculture often demonstrate significant gender inequalities and encounter restricted opportunities for innovation (Dentzman, Pilgeram, and Wilson, 2023). Thus, we recommend that educational inequality, which can be strongly related to wage and status based on skills and abilities, be used to better capture actual practices.

Overall, we obtain several important findings on the impact of gender inequality on society through trade, GDP, and innovation. Among the components of gender equality, workforce inequality has the power to drive GDP and trade, whereas educational inequality fosters innovation. Moreover, although institutions do drive workforce inequality, they do not promote educational inequality or drive innovation. Wage gaps that limit employment options for women may impede human capital development and economic diversification. Consequently, pronounced educational inequalities may restrict a nation's economic progress in labor-intensive sectors, hindering a shift over time toward industries more reliant on technology. Women's economic empowerment injects more financial resources into innovation in key sectors, leading to significant progress. We contend that the influence of innovation extends beyond simply unveiling new products and processes. This emphasizes the crucial nature of innovation within a knowledge-driven economy while suggesting that institutions must strive to address gender inequality.

European Union is often categorized into north-south and east-west divisions based on economic, historical, and social disparities. The north-south divide primarily reflects economic differences. Northern European countries generally boast lower unemployment rates and higher GDP per capita compared to their southern counterparts. Historically, the countries in Eastern Europe have a legacy of communism, a trait not shared with Western Europe. This historical background continues to influence their current economic and social structures. These disparities might differently impact social structures and gender equality potentially affects economic outcomes such as trade, GDP, and innovation. For our analysis, we have classified 27 European countries into three groups: *i*) Northern and Western Europe (10 countries): Austria, Belgium, Denmark, Finland, France, Germany, Ireland,

Luxembourg, the Netherlands, and Sweden; *ii*) Eastern Europe (12 countries): Bulgaria, Croatia, Cyprus, the Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, Slovenia, and Slovakia; *iii*) Southern Europe (5 countries): Greece, Italy, Malta, Portugal, and Spain. This classification aims to explore how historical and economic disparities influence gender inequality and innovation across these regions.

Table 6 presents the impacts of gender inequality on trade, GDP, and innovation across different European regions: Northern and Western European Union (Panel A), Eastern European Union (Panel B), and Southern European Union (Panel C). Results show that *GI* shows a significantly negative effect on both *Trade* and *GDP* across all panels; *WI* has a significantly negative impact on *Trade* and *GDP* in Panel A, on *GDP* in Panel B, and on both trade and *GDP* in Panel C; and *EI* has a significantly positive effect on *Trade* and *GDP* in Panels A and B, and a significantly negative impact on *Trade a*nd *GDP* in Panel C. Meanwhile, *EI* has a significantly negative effect on *Inno* in Panel A and shows insignificant effects in Panels B and C. Workforce inequality consistently diminishes trade and GDP, which could potentially deliver labor cost-effectiveness and an affluent labor pool essential for economic development, regardless of regional, political, or economic differences. Interestingly, education inequality in the most developed regions, such as the Northern and Western European Union, increases trade and GDP but can decrease innovation, which is consistent with our main finding using 27 European Union. This suggests a greater need for investment in education for women, which forms the foundation for innovation. In Panels B and C — regions that are either economically underdeveloped or have distinct political backgrounds — investment in education, particularly in educating women, appears to have a minimal impact on innovation. In short, Northern and Western European Union countries drive the results for the 27 European Union countries, indicating that workforce inequality decreases trade and GDP, while educational inequality reduces innovation.

**Table 6.** Roles of gender inequality in economic outcomes
Panel A. Northern and Western European Union

| | M1[*Trade*] | M2[*Trade*] | M3[*Trade*] | M4[*GDP*] | M5[*GDP*] | M6[*GDP*] | M7[*Inno*] | M8[*Inno*] | M9[*Inno*] |
|---|---|---|---|---|---|---|---|---|---|
| *GI* | -95.903*** | | | -381.082*** | | | 29.055 | | |
| | (-13.93) | | | (-16.95) | | | (1.07) | | |
| *WI* | | -40.914*** | | | -171.382*** | | | 11.291 | |
| | | (-12.55) | | | (-16.80) | | | (0.93) | |
| *EI* | | | 25.093** | | | 205.428*** | | | -128.033*** |
| | | | (2.50) | | | (6.04) | | | (-5.01) |
| *FDI* | 0.587*** | 0.454** | 0.509* | 1.754*** | 1.192* | 0.980 | -1.245* | -1.222 | -0.695 |
| | (2.86) | (2.10) | (1.78) | (2.62) | (1.76) | (1.01) | (-1.66) | (-1.63) | (-0.97) |
| *Edu1* | -0.033* | -0.027 | 0.050 | -0.084 | -0.065 | 0.480*** | 0.075 | 0.075 | -0.222*** |
| | (-1.97) | (-1.54) | (1.56) | (-1.53) | (-1.18) | (4.42) | (1.21) | (1.20) | (-2.67) |
| *Edu2* | -1.171*** | -0.438 | 0.691** | -1.720* | 0.926 | 5.194*** | -1.213 | -1.516 | -1.170 |
| | (-4.23) | (-1.63) | (2.10) | (-1.90) | (1.10) | (4.64) | (-1.13) | (-1.58) | (-1.36) |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| *Unemploy* | -0.746*** | -0.847*** | -0.977*** | 0.530 | 0.167 | -0.166 | 1.763*** | 1.793*** | 1.542*** |
| | (-6.26) | (-6.83) | (-6.01) | (1.36) | (0.43) | (-0.30) | (3.93) | (4.02) | (3.66) |
| *Infla* | 0.058 | -0.110 | -0.523** | 1.446*** | 0.886 | -0.444 | 0.577 | 0.659 | 0.331 |
| | (0.34) | (-0.63) | (-2.30) | (2.61) | (1.61) | (-0.58) | (0.81) | (0.94) | (0.50) |
| Intercept | 36.982*** | 68.050*** | -23.018* | 103.539*** | 240.100*** | -261.906*** | 72.613*** | 65.138*** | 235.955*** |
| | (9.77) | (11.62) | (-1.80) | (8.37) | (13.10) | (-6.04) | (5.10) | (3.11) | (7.18) |
| *F*-test | 47.99*** | 40.45*** | 9.34*** | 61.48*** | 60.47*** | 12.77*** | 4.05*** | 3.99*** | 8.51*** |
| $R^2$ | 0.025 | 0.004 | 0.166 | 0.086 | 0.016 | 0.000 | 0.027 | 0.063 | 0.080 |
| Obs | 222 | 222 | 222 | 222 | 222 | 222 | 210 | 210 | 210 |

Panel B. Eastern European Union

| | M1[*Trade*] | M2[*Trade*] | M3[*Trade*] | M4[*GDP*] | M5[*GDP*] | M6[*GDP*] | M7[*Inno*] | M8[*Inno*] | M9[*Inno*] |
|---|---|---|---|---|---|---|---|---|---|
| *GI* | -2.495** | | | -84.107*** | | 13.397** | | | |
| | (-2.18) | | | (-13.36) | | | (2.15) | | |
| *WI* | | -1.255 | | | -46.090*** | | | 12.899** | |
| | | (-1.40) | | | (-8.13) | | | (2.59) | |
| *EI* | | | 3.775* | | | 35.873** | | | 12.899 |
| | | | (1.89) | | | (2.55) | | | (1.22) |
| *FDI* | 0.394** | 0.398** | 0.437** | 2.588** | 2.609** | 3.904*** | -0.274 | -0.217 | -0.409 |
| | (2.02) | (2.02) | (2.24) | (2.41) | (2.09) | (2.84) | (-0.27) | (-0.21) | (-0.40) |
| *Edu1* | 0.008 | 0.013* | 0.015** | 0.065 | 0.201*** | 0.356*** | 0.103** | 0.104*** | 0.042 |
| | (1.10) | (1.78) | (2.30) | (1.58) | (4.42) | (7.89) | (2.58) | (2.73) | (1.22) |
| *Edu2* | -0.061 | -0.065 | -0.058 | 0.741* | 0.549 | 1.091** | -0.086 | -0.018 | -0.155 |
| | (-0.84) | (-0.89) | (-0.80) | (1.87) | (1.18) | (2.14) | (-0.23) | (-0.05) | (-0.40) |
| *Unemploy* | -0.091*** | -0.097*** | -0.098*** | -0.357*** | -0.576*** | -0.512*** | -0.206*** | -0.162*** | -0.194*** |
| | (-9.52) | (-10.06) | (-10.19) | (-6.81) | (-9.38) | (-7.52) | (-4.00) | (-3.21) | (-3.76) |
| *Infla* | -0.034*** | -0.042*** | -0.037*** | 0.051 | -0.246*** | -0.102* | -0.011 | 0.049 | 0.024 |
| | (-4.19) | (-5.21) | (-4.72) | (1.16) | (-4.79) | (-1.86) | (-0.27) | (1.17) | (0.58) |
| Intercept | 2.326* | 3.005 | -2.521 | 19.476*** | 48.944*** | -63.114*** | -4.291 | -18.194* | -8.071 |
| | (1.93) | (1.63) | (-1.25) | (2.95) | (4.18) | (-4.43) | (-0.68) | (-1.86) | (-0.76) |
| *F*-test | 31.72*** | 30.93*** | 31.39*** | 99.32*** | 62.54*** | 43.09*** | 4.40*** | 4.77*** | 3.83*** |
| $R^2$ | 0.123 | 0.080 | 0.157 | 0.633 | 0.246 | 0.218 | 0.019 | 0.191 | 0.053 |
| Obs | 274 | 274 | 274 | 274 | 274 | 274 | 262 | 262 | 262 |

Panel C. Southern European Union

| | M1[*Trade*] | M2[*Trade*] | M3[*Trade*] | M4[*GDP*] | M5[*GDP*] | M6[*GDP*] | M7[*Inno*] | M8[*Inno*] | M9[*Inno*] |
|---|---|---|---|---|---|---|---|---|---|
| *GI* | -19.713*** | | | -102.231*** | | 12.177 | | | |
| | (-5.23) | | | (-7.93) | | | (0.72) | | |
| *WI* | | -2.803*** | | | -21.656*** | | | 0.718 | |
| | | (-4.27) | | | (-12.37) | | | (0.25) | |
| *EI* | | | -11.173** | | | -83.296*** | | | -28.518 |
| | | | (-2.03) | | | (-4.16) | | | (-1.41) |
| *FDI* | 2.780*** | 2.634*** | 2.504*** | 6.757*** | 6.566*** | 5.539** | 5.430** | 5.649** | 5.893** |
| | (4.64) | (4.25) | *(3.81)* | (3.30) | (3.98) | (2.32) | (2.20) | (2.31) | (2.43) |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| *Edu1* | 0.001 | 0.014 | 0.088*** | 0.174** | 0.134* | 0.696*** | 0.142 | 0.119 | 0.175* |
| | (0.03) | (0.56) | (3.06) | (2.04) | (1.98) | (6.64) | (1.36) | (1.12) | (1.70) |
| *Edu2* | 0.314** | 0.586*** | 0.569*** | -0.033 | 1.445*** | 1.308*** | 2.558*** | 2.374*** | 2.505*** |
| | (2.40) | (4.62) | (4.22) | (-0.07) | (4.28) | (2.67) | (4.09) | (4.03) | (4.30) |
| *Unemploy* | 0.039 | 0.050 | 0.050 | -0.148 | -0.009 | -0.015 | 0.085 | 0.090 | 0.168 |
| | (1.20) | (1.46) | (1.30) | (-1.33) | (-0.10) | (-0.11) | (0.65) | (0.69) | (1.22) |
| *Infla* | 0.262** | 0.151 | -0.005 | 0.922** | 0.812*** | -0.402 | 0.304 | 0.422 | 0.511 |
| | (2.37) | (1.40) | (-0.05) | (2.43) | (2.83) | (-1.05) | (0.69) | (1.01) | (1.33) |
| Intercept | 2.325 | -0.872 | -1.056 | 19.865* | 22.402*** | 18.994 | -24.599* | -19.704 | 1.004 |
| | (0.77) | (-0.30) | (-0.24) | (1.92) | (2.90) | (1.20) | (-1.86) | (-1.60) | (0.06) |
| *F*-test | 18.90*** | 16.40*** | 12.54*** | 28.13*** | 52.60*** | 15.77*** | 7.01*** | 6.90*** | 7.36*** |
| $R^2$ | 0.572 | 0.396 | 0.289 | 0.349 | 0.280 | 0.094 | 0.173 | 0.233 | 0.152 |
| Obs | 117 | 117 | 117 | 117 | 117 | 117 | 105 | 105 | 105 |

*Notes*. This table presents the mediating role of gender inequality in the relationship between institutions and innovation using fixed-effect regressions. Dependent variables are shown in squared brackets. The results utilize data from the Northern and Western European Union (10 countries) in Panel A, the Eastern European Union (12 countries) in Panel B, and the Southern European Union (5 countries) in Panel C. *Trade* is measured as the sum of exports and imports. *GDP* refers to GDP per capita. *Inno* represents innovation measured as the number of patents. *Insti* represents institutional quality, measured as the sum of the Worldwide Governance Indicators. *GI* represents the gender inequality index. *WI* represents workforce inequality, measured as the ratio of the labor force participation rate among the male population to that among the female population. *EI* represents educational inequality, measured as the ratio of gross male enrollment to female enrollment in secondary education. The control variables are *FDI, Edu1*, *Edu2, Unemploy*, and *Infla*. *F*-test represents the *F*-test statistic, indicating a test against the null hypothesis that all the coefficients are zero. $R^2$ is the overall R-squared value. *Obs* is the country-year observations. The number of countries is 10 in Panel A, 12 in Panel B, and 5 in Panel C. Figures in parentheses are *t*-statistics. ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.

To ensure the role of education for females in the European Union, we examine the impact of female education and the female workforce with advanced education on economic outcomes. Table 7 presents the impacts of female education on trade, GDP, and innovation in Panel A (European Union: 27 countries), Panel B (Northern and Western European Union: 10 countries), Panel C (Eastern European Union: 12 countries), and Panel D (Southern European Union: 5 countries). To clearly understand the role of female education, we use two variables: *EduFe* (the ratio of female student enrollment in secondary education) and *LaborEdu* (the ratio of the labor force with advanced education to the corresponding working-age population). The Results from Panel A show that *EduFe* and *LaborEdu* have a significantly negative effect on both trade (M1 and M2) and GDP (M3 and M4) while showing a significantly positive effect on innovation. The results from Panel B are similar to those for Panel A, indicating that Northern and Western European Union countries drive the overall results with all European Union countries. Northern and Western Europe generally exhibit high education levels and well-developed gender equality policies, which means that women are less likely to provide low-cost labor and are more likely to receive fair compensation. Women with advanced education contribute to

diversifying and improving the quality of the workforce, particularly in areas such as technology, new production methods, and processes, contributing to innovation for sustainability. We find somewhat different results in Panel C (Eastern European transition economies) and Panel D (Southern European Union). Labor markets in transition economies can also differ from systems compared to Northern and Western societies, and the economic structure of Southern European countries differs significantly compared to Northern and Western societies. These areas often face economic instability and need to enforce policies addressing gender inequalities. Overall, the results in Panel A, including all 27 European Union countries, support our concerns that females with advanced education in the workplace foster innovation, with these results being driven by the Northern and Western economies, where economically developed countries are influencing the overall outcomes.

**Table 7.** Roles of female education in economic outcomes

Panel A. European Union (27 countries)

| | M1[*Trade*] | M2[*Trade*] | M3[*GDP*] | M4[*GDP*] | M5[*Inno*] | M6[*Inno*] |
|---|---|---|---|---|---|---|
| *FeErnr* | -0.209*** | | -1.586*** | | 0.612*** | |
| | (-3.63) | | (-8.40) | | (3.73) | |
| *FeLabor* | | -0.175*** | | -0.544*** | | 0.243** |
| | | (-4.72) | | (-4.11) | | (2.02) |
| *FDI* | 1.823*** | 1.962*** | 2.955** | 3.377*** | -2.703*** | -2.749*** |
| | (4.98) | (5.56) | (2.47) | (2.68) | (-2.61) | (-2.60) |
| *Edu1* | 0.243*** | 0.003 | 1.888*** | 0.102** | -0.614*** | 0.077** |
| | (3.74) | (0.22) | (8.88) | (2.31) | (-3.31) | (2.07) |
| *Edu2* | 0.483*** | 0.456*** | 2.124*** | 2.500*** | 0.594 | 0.428 |
| | (3.45) | (3.37) | (4.64) | (5.18) | (1.39) | (0.98) |
| *Unemploy* | -0.125*** | -0.113*** | -0.515*** | -0.432*** | 0.076 | 0.051 |
| | (-4.38) | (-4.11) | (-5.50) | (-4.39) | (0.94) | (0.62) |
| *Infla* | -0.009 | -0.017 | -0.066 | -0.141 | -0.001 | 0.030 |
| | (-0.33) | (-0.63) | (-0.72) | (-1.44) | (-0.02) | (0.36) |
| Intercept | -3.298* | 13.793*** | -19.974*** | 38.387*** | 29.951*** | 4.866 |
| | (-1.80) | (3.62) | (-3.33) | (2.83) | (5.57) | (0.40) |
| *F*-test | 13.56*** | 16.27*** | 29.89*** | 18.70*** | 4.47*** | 2.71** |
| $R^2$ | 0.315 | 0.313 | 0.138 | 0.200 | 0.020 | 0.027 |
| Obs | 595 | 582 | 595 | 582 | 566 | 553 |

Panel B. Northern and Western European Union (10 countries)

| | M1[*Trade*] | M2[*Trade*] | M3[*GDP*] | M4[*GDP*] | M5[*Inno*] | M6[*Inno*] |
|---|---|---|---|---|---|---|
| *FeErnr* | -0.283** | | -2.623*** | | 1.694*** | |
| | (-2.09) | | (-5.70) | | (4.94) | |
| *FeLabor* | | -0.482*** | | -2.500*** | | 0.550* |
| | | (-4.48) | | (-6.56) | | (1.83) |
| *FDI* | 0.544* | 0.535** | 1.191 | 1.496 | -0.810 | -1.215 |
| | (1.91) | (2.00) | (1.22) | (1.58) | (-1.13) | (-1.63) |

| | | | | | | |
|---|---|---|---|---|---|---|
| *Edu1* | 0.334** | -0.036 | 3.172*** | -0.130 | -1.970*** | 0.103 |
| | (2.04) | (-1.59) | (5.68) | (-1.62) | (-4.72) | (1.61) |
| *Edu2* | 0.686** | 0.523 | 5.025*** | 4.334*** | -1.050 | -1.508* |
| | (2.06) | (1.63) | (4.43) | (3.82) | (-1.22) | (-1.66) |
| *Unemploy* | -1.006*** | -0.749*** | -0.375 | 0.617 | 1.680*** | 1.729*** |
| | (-6.19) | (-4.64) | (-0.68) | (1.08) | (4.01) | (3.76) |
| *Infla* | -0.553** | -0.426** | -0.623 | -0.301 | 0.415 | 0.574 |
| | (-2.44) | (-1.98) | (-0.81) | (-0.40) | (0.63) | (0.83) |
| Intercept | 2.188 | 49.221*** | -60.900*** | 208.344*** | 111.579*** | 30.400 |
| | (0.45) | (4.75) | (-3.64) | (5.68) | (8.75) | (1.05) |
| *F*-test | 8.95*** | 11.22*** | 11.98*** | 13.29*** | 8.39*** | 4.82*** |
| $R^2$ | 0.134 | 0.300 | 0.001 | 0.027 | 0.034 | 0.130 |
| Obs | 222 | 220 | 222 | 220 | 210 | 209 |

Panel C. Eastern European Union (12 countries)

| | M1[*Trade*] | M2[*Trade*] | M3[*GDP*] | M4[*GDP*] | M5[*Inno*] | M6[*Inno*] |
|---|---|---|---|---|---|---|
| *FeErnr* | -0.083** | | -0.678** | | -0.360* | |
| | (-2.02) | | (-2.34) | | (-1.66) | |
| *FeLabor* | | -0.054*** | | -0.306*** | | -0.045 |
| | | (-4.09) | | (-3.22) | | (-0.61) |
| *FDI* | 0.438** | 0.357* | 3.907*** | 3.413** | -0.400 | -0.470 |
| | (2.25) | (1.83) | (2.84) | (2.46) | (-0.39) | (-0.45) |
| *Edu1* | 0.097** | 0.019*** | 1.035*** | 0.389*** | 0.397* | 0.065* |
| | (2.44) | (2.90) | (3.69) | (8.45) | (1.90) | (1.82) |
| *Edu2* | -0.063 | -0.030 | 1.063** | 1.372*** | -0.185 | -0.085 |
| | (-0.87) | (-0.41) | (2.08) | (2.65) | (-0.48) | (-0.21) |
| *Unemploy* | -0.099*** | -0.090*** | -0.513*** | -0.442*** | -0.201*** | -0.178*** |
| | (-10.22) | (-9.44) | (-7.48) | (-6.48) | (-3.88) | (-3.36) |
| *Infla* | -0.037*** | -0.034*** | -0.108* | -0.081 | 0.024 | 0.024 |
| | (-4.79) | (-4.27) | (-1.96) | (-1.42) | (0.60) | (0.55) |
| Intercept | 1.359 | 4.737*** | -26.945*** | -10.174 | 5.768 | 5.320 |
| | (1.33) | (3.37) | (-3.73) | (-1.01) | (1.05) | (0.70) |
| *F*-test | 31.52*** | 33.83*** | 42.76*** | 40.71*** | 4.06*** | 3.74** |
| $R^2$ | 0.161 | 0.233 | 0.224 | 0.181 | 0.067 | 0.024 |
| Obs | 274 | 264 | 274 | 264 | 262 | 252 |

Panel D. Southern European Union (5 countries)

| | M1[*Trade*] | M2[*Trade*] | M3[*GDP*] | M4[*GDP*] | M5[*Inno*] | M6[*Inno*] |
|---|---|---|---|---|---|---|
| *FeErnr* | 0.194* | | 1.486*** | | 0.596 | |
| | (1.80) | | (3.75) | | (1.51) | |
| *FeLabor* | | 0.068 | | 0.772*** | | 0.417** |
| | | (1.38) | | (4.45) | | (2.05) |
| *FDI* | 2.477*** | 2.594*** | 5.352** | 6.863*** | 5.850** | 6.230** |
| | (3.76) | (3.81) | (2.21) | (2.88) | (2.42) | (2.56) |

| | | | | | | |
|---|---|---|---|---|---|---|
| *Edu1* | -0.108 | 0.056** | -0.800** | 0.362*** | -0.412 | 0.069 |
| | (-1.13) | (2.13) | (-2.28) | (3.91) | (-1.16) | (0.72) |
| *Edu2* | 0.570*** | 0.646*** | 1.325*** | 2.441*** | 2.524*** | 3.098*** |
| | (4.22) | (4.18) | (2.67) | (4.51) | (4.33) | (4.55) |
| *Unemploy* | 0.049 | 0.030 | -0.020 | -0.083 | 0.180 | 0.144 |
| | (1.24) | (0.81) | (-0.14) | (-0.63) | (1.29) | (1.10) |
| *Infla* | -0.009 | -0.025 | -0.423 | -0.468 | 0.513 | 0.486 |
| | (-0.08) | (-0.23) | (-1.09) | (-1.25) | (1.34) | (1.27) |
| Intercept | -12.004*** | -14.746*** | -63.368*** | -100.766*** | -28.829** | -54.739*** |
| | (-3.79) | (-2.89) | (-5.45) | (-5.63) | (-2.48) | (-2.70) |
| *F*-test | 12.29*** | 11.77*** | 14.89*** | 15.23*** | 7.43*** | 7.76*** |
| $R^2$ | 0.293 | 0.267 | 0.093 | 0.092 | 0.141 | 0.066 |
| Obs | 117 | 115 | 117 | 115 | 105 | 103 |

*Notes*. This table presents the role of female education in trade, GDP, and innovation using fixed-effect regressions. Dependent variables are shown in squared brackets. The results utilize data from all EU countries (27 countries) in Panel A, the Northern and Western European Union (10 countries) in Panel B, the Eastern European Union (12 countries) in Panel C, and the Southern European Union (5 countries) in Panel D. *Trade* is measured as the sum of exports and imports. *GDP* refers to GDP per capita. *Inno* represents innovation, measured as the number of patents. *FeErnr* is measured as the ratio of female enrollment in secondary education. *FeLabor* is measured as the ratio of the labor force with advanced education to the corresponding working-age population. Advanced education includes short-cycle tertiary education, bachelor's degrees, master's degrees, and doctoral degrees or their equivalents. The control variables are *FDI*, *Edu1*, *Edu2*, *Unemploy*, and *Infla*. *F*-test represents the *F*-test statistic, indicating a test against the null hypothesis that all the coefficients are zero. $R^2$ is the overall R-squared value. *Obs* is the country-year observations. The number of countries is 27 in Panel A, 10 in Panel B, 12 in Panel C, and 5 in Panel D. Figures in parentheses are *t*-statistics. ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.

In summary, the results concerning the relationship between women's education and economic outcomes across the European Union are similar to those observed in Northern and Western Europe, where more economically developed countries are driving overall outcomes. As women's education increases, it leads to higher-paying jobs. A higher level of education can also decrease the proportion of low-wage labor in traditional manufacturing or export-driven industries, potentially having a negative impact on trade and GDP. While women's education also increases diversity, bringing together more ideas for new production methods and processes, it promotes innovation in developed societies.

## 5. Conclusion

This study explores the role of gender inequality in trade, GDP, and innovation across all 27 European Union member states from 1998 to 2022. We use diverse proxies for gender inequality, including the *GI*, *WI*, and *EI*, to understand its impact on society through trade, GDP, and innovation, and obtain significant results. We find that a decrease in workforce inequality drives trade and GDP, whereas a decrease in educational inequality promotes innovation. Furthermore, while institutions decrease workforce inequality, they do not reduce educational inequality or drive innovation. Wage gaps that

limit employment options for women may impede human capital development and economic diversification. Consequently, high workforce inequality can confine a country's economic development to labor-intensive trade, whereas educational inequality limits its transition to a more technologically advanced society. Thus, we argue that gender inequality, whether in the form of workforce or educational inequality, plays a critical role in economic outcomes (trade, GDP, and innovation).

This study has some theoretical and practical implications. First, government institutions currently focus on GDP and trade for economic growth, which suggests opportunities for progressing innovation to drive sustainable growth. Our results indicate that women's education promotes innovation. Currently, policymakers focus solely on one avenue for GDP and trade growth, namely, reducing workforce inequality, while failing to recognize that addressing educational inequality can significantly aid societal progress. Therefore, we urge policymakers to address gender equality comprehensively, thereby "killing two birds with one stone" by fostering economic *and* social development.

## Data availability

The datasets generated and analyzed in this study are available by the World Bank and Human Development Reports in the United Nations Development Programme:
[https://databank.worldbank.org; https://hdr.undp.org/data-center]

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