

Trade Liberalisation for Gender Equality in Education? *The Role of the World Trade Organization in Promoting Female Education*

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Abstract: Gender mainstreaming is emerging as a prominent topic in the World Trade Organization (WTO), a major global facilitator of trade liberalisation, following concerns that ‘gender-neutral’ trade agreements and policies disproportionately benefit men and harm women. Contemporary cross-country research on the effects of trade liberalisation on female education presents mixed views on whether trade liberalisation benefits female education. In this paper, we fill a previously unexplored literature gap by studying the effect of WTO accession on female educational attainment and the gender education gap. The study first covers a three-channel conceptual framework on how human capital accumulation is affected by trade liberalisation after WTO accession. Furthermore, the study exploits the variation in time between 1970 and 2015 and across 182 countries in a Difference-in-Difference regression to assess the impact of WTO accession on female educational attainment and the gender education gap. Our results indicate that WTO accession, on average, is associated with small decreases in the gender education gap, albeit we find no consistent results for the effect on female educational attainment nor any heterogeneity between developed and developing countries. Overall, the study facilitates an understanding of the association between WTO, gender, and education.

Keywords: Difference-in-Difference, Education, Gender, Gender Education Gap, Human Capital, Trade Liberalisation, World Trade Organization

JEL: F13, F16, I24, J16, J22, J24, O19

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Abbreviations

Abbreviation	Explanation
ATT	Average Treatment Effect on the Treated
CEDAW	Convention on the Elimination of All Forms of Discrimination against Women
DID	Difference-in-Difference
FLFP	Female Labour Force Participation
GATT	General Agreement on Tariffs and Trade (WTO)
GDP	Gross Domestic Product
IHME	Institute for Health Metrics and Evaluation
IMF	International Monetary Fund
IV	Instrumental Variables Estimation
UN(CTAD)	United Nations (Conference on Trade and Development)
WTO	World Trade Organization

1. Introduction

There is no tool for development more effective than the education of girls and the empowerment of women.
- Kofi Annan, 7th Secretary-General of the United Nations (Annan, 2004)

We live in a world characterised by unprecedented levels of international trade and economic integration, much owed to trade liberalisation in the last half-century (IMF, 2001; WTO, 2022b). The liberalisation of trade policies, as intensively promoted by GATT and its successor, the WTO, holds promises of social development and economic growth (Garba, 2007; IMF, 2001). The fundamental question is, to what extent does trade liberalisation promote such developments? According to several economists, trade liberalisation has indeed delivered economic development: Frankel and Romer (1999) famously asserted that a one per cent increase in trade intensity is, on average, associated with a 0.5% increase in income per capita.

Moreover, researchers link increased trade with growth measures, such as increased labour productivity (Alcala & Ciccone, 2004). Nevertheless, from a development economist lens, any impact analysis of trade liberalisation must transcend aggregate economic indicators to also review the heterogeneous effects of trade liberalisation on different groups (Todaro & Smith, 2020), as well as health and social effects (UN, 2022a).

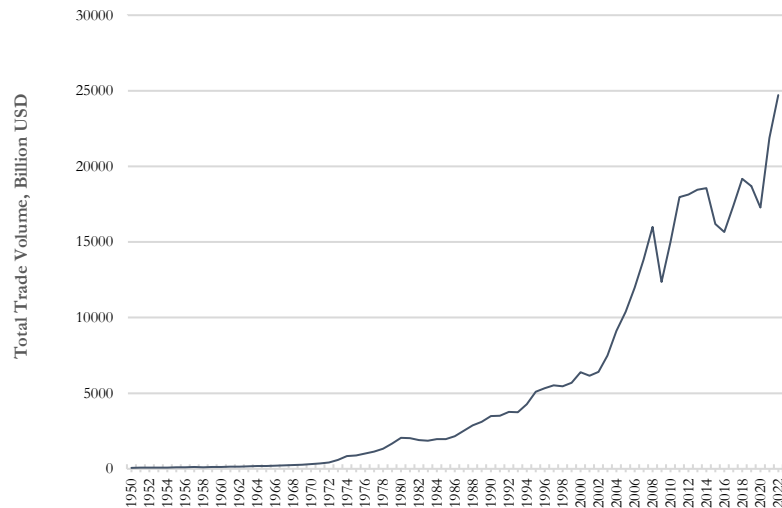


Figure 1: Annual Global Trade Volume, 1950-2022
Compiled by the authors. Source: WTO (2022b).

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In this paper, we research the heterogeneous impacts of trade liberalisation on the genders by examining the effects of accession to the WTO, a multinational organisation promoting trade liberalisation by harmonised trade rules and trade agreements, and whose members collectively represent 98% of trade (WTO, n.d.-g). More specifically, we examine how WTO accession affects female educational attainment and the gender education gap in developed and developing countries. Using a panel data study for 182 countries between 1970 and 2015, we show that WTO accession, on average, is associated with small decreases in the gender education gap. Moreover, although not statistically significant in all models, our study indicates that WTO accession, on average, is associated with increases in female educational attainment.

In 2020, the WTO and the World Bank launched a report on the interconnectedness between trade and women's socioeconomic development. A film accompanying the report has a title that demonstrates the organisations' optimism of how free trade improves women's livelihood: *When Companies Trade, Women Win* (World Bank, 2020). Albeit the report acknowledges some

challenges ahead for women's access to trade gains, trade liberalisation is interlinked with novel labour opportunities for women, also effectively stimulating societies to send more girls off to education. These effects are reported particularly in developing economies whose export-oriented sectors are known to intensively employ women (World Bank & WTO, 2020). However, not everyone shares the optimism of the WTO and the World Bank on the opportunities trade liberalisation holds for women's socioeconomic development. Opponents against trade liberalisation and the WTO argue that women's opportunities and trade-related impacts are after-thoughts in international trade and trade negotiations. The consensus among these groups is that trade agreements, with a few exceptions in the last decade, are gender-neutral and thus also inherently gender-blind. Consequently, women may not only face difficulties in reaping the same benefits from trade expansion as men, but gender-blind trade liberalisation may also bring harmful effects to women (c.f. Bahri et al., 2023; Fabian, 2023; Hannah et al., 2021; Zarrilli, 2017, 2018). Conclusively, the debate on the impact of trade liberalisation and the WTO on women is multifaceted, with diverse viewpoints.

We argue that empirical studies hold the potential to guide and complement the existing debate, hence setting the purpose for our study. Moreover, our purpose is built around the importance of reaching SDGs 4 and 5, on gender equality and equitable access to education, respectively (UN, 2015). Female education is imperative for inclusive growth, and educating women is associated with higher female productivity, female labour force participation (FLFP) and lower fertility (Todaro & Smith, 2020). Through these effects, education alleviates women from vicious poverty cycles, which is critical as UN Women (2022) projects the extreme poverty gender gap to deepen in the coming decade. Moreover, female education is among the best investments a society can make, given its close association with economic growth, female health, household health and personal freedom. From a household perspective, educating women has been associated with health promotion as mothers, in general, care more than fathers to promote household health (Björkman Nyqvist & Jayachandran, 2017; Glewwe, 1999) and intergenerational mobility, as mothers put more funds towards their children's future than fathers (Todaro & Smith, 2020). Lastly, looking at development through Amartya Sen's Capability approach, education serves both as a *capability* (education allows more freedoms to choose life paths) and a *functioning* (education develops valuable skills, agency, and critical thinking), rendering more fulfilment in the life of the individual woman (Sen, 1993).²

There has been a notable and positive trend in female education levels and for bridging the gender education gap since the 1970s, as seen in Figure 2. Nevertheless, women were still six percentage points behind in literacy in 2022. Moreover, in absolute and relative terms to men, women are still behind in education in developing economies (UN, 2022a; World Bank, n.d.). Plan International (2008) also estimated the cost of not educating women globally to be \$92 billion annually in 2008 and that women's lack of sufficient education is particularly damaging in the current era of rapid technological change. Lastly, Sen (1990) argues that neglect of women's equitable opportunities relative to men's has caused 100 million women to go 'missing' in the world. Sen mentions the systematic disadvantage in access to education as one cause. All these

² Amartya Sen's Capability Approach is an alternative to standard growth theories, which often focus on economic growth. In this theory, the enlargement of *functionings* (what a person can do or be) and *capabilities* (individual freedom to combine functionings) is in focus (Sen, 1993).

accounts once again solidify the purpose of studying factors affecting female education, which we do by examining the association between WTO accession and female educational attainment, in both absolute and relative terms to men.

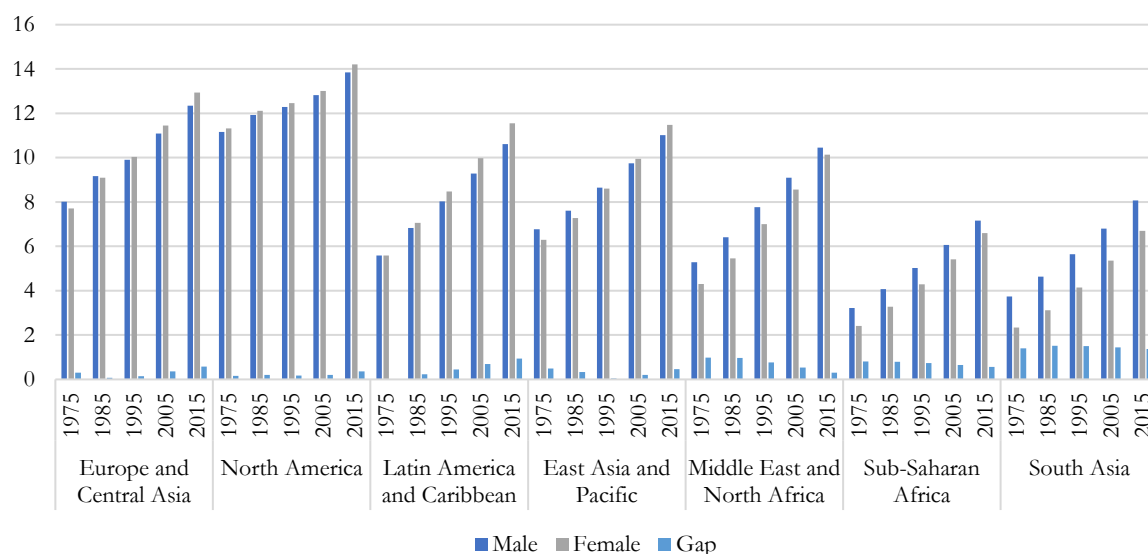


Figure 2: Average Years of Education by Gender, 1975-2015.

Compiled by the authors. Source: IHME (2015).

This paper starts with an overview of the WTO and its recent struggles with gender mainstreaming, followed by a conceptual framework which outlines how trade liberalisation and education interrelate through three labour-market channels. Subsequently, we cover previous literature on trade liberalisation and female education or the gender education gap, and develop a DID model which adds to the literature by examining the effect of WTO accession on female educational attainment and the gender education gap. After this section, we present and critically interpret the regression results, simultaneously discussing model limitations and future research areas.

2. Background and Literature Review

This section provides a framework for the proposed links between WTO accession and female education. First, 2.1 provides an overview of the WTO's purpose, history, and activities. Subsequently, 2.2 covers a three-channel conceptual framework, based on human capital theory and insights from feminist scholars, to explain how we relate trade liberalisation to education. In 2.3, we review the current literature that associates trade liberalisation and female educational attainment or the gender education gap, and subsequently establish our contribution in 2.4.

2.1. World Trade Organization

2.1.1. Background

The World Trade Organization is a multinational organisation headquartered in Geneva, Switzerland, promoting trade liberalisation through the facilitation of a harmonised trade framework. It had 164 member states by March 2024, representing 98% of world trade by volume (WTO, n.d.-g), and 25 observer nations currently negotiating accessions within the next half-decade (WTO, n.d.-c). Its main activities include hosting multilateral trade negotiations, a

centralized dispute settlement mechanism, and various trade infrastructure- and capacity-building programmes (WTO, n.d.-h, n.d.-b).

In its current organisational form, the WTO is a result of the final round of the Uruguay Round of Multilateral Trade Negotiation in 1994 (GATT, 1994). However, the idea of multilateral trade organisations traces back to early attempts to harmonise international trade policies in the 1940s. Nottage (2018) describes the Atlantic Charter from 1941 as one of the earliest attempts at global trade integration in response to retaliatory trade tariffs, like the Smooth-Hawley tariffs. Critically, neither the Atlantic Charter nor the International Trade Organization (ITO), recommended at the 1944 Bretton Woods Conference, were successfully signed, due to resistance from the US and the United Kingdom (United States, n.d.; U.S. Department of States, 1944). Instead, GATT was negotiated and signed by 23 countries in 1947. GATT has since been in effect, under different forms and with a growing number of signatories, to reduce discriminatory treatment in international trade (GATT, 1986). As the WTO replaced GATT in 1995, it featured GATT as one of several agreements, but has also expanded the scope beyond commerce to services and IP (WTO, n.d.-a).

The core objective of the WTO, defined in the Marrakesh Agreement, is to develop a durable multilateral trading system which fosters mutually beneficial trade agreements and eliminates trade barriers (GATT, 1994). Thus, states that accede to the WTO commit to liberalising their trade policies. Two fundamental working principles governing the WTO are: 1. *Most Favoured Nations (MFN)*, stipulating that a member state cannot grant more beneficial trade policies to a trading partner without extending this favour to all WTO member nations, and 2. *National Treatment*, stipulating that a member state must treat foreign and locally sourced products and services equally (WTO, n.d.-d). However, the Marrakesh Agreement also recognises how the WTO serves to create conditions for sustainable trade that benefit trade capacity, economic growth, living standards and labour-market opportunities within the member-states, specifically in developing nations (GATT, 1994).

Overall, the WTO and its precursor, GATT, play a significant role in facilitating trade liberalisation, as seen by the decreased average tariff rates after each of their multilateral trade rounds (see Table 1).

Table 1: Average Tariff Reductions by GATT/WTO Multilateral Trade Rounds
*Tariff reduction refers to the average MFN (member-state) tariff rates. Source: (WTO, n.d.-f, 2007)

GATT/WTO Round	Tariff reduction*
Geneva (1947)	-26%
Annecy (1949)	-3%
Torquay (1950-1951)	-4%
Geneva (1955-1956)	-3%
Dillon Round (1961-1962)	-4%
Kennedy Round (1964-1967)	-38%
Tokyo Round (1973-1979)	-33%
Uruguay Round (1986-1994)	-38%
Doha Round (2001- <i>ongoing</i>)	N/A

2.1.2. WTO and Gender

At a 2007 ministerial-level WTO event, Fabian (2015) accounts that the President of Finland, Tarja Halonen, turned to the Director General of the WTO and proclaimed, “You must find a way to bring gender into the WTO”. Fabian, who was present at the meeting, notes that any mentions of ‘gender’ or ‘women’ were excluded from the official transcript of Halonen’s speech

and concludes that ‘gender’ is a controversial topic within the WTO. Moreover, several researchers have labelled GATT or WTO gender-blind (Bahri et al., 2023; Fabian, 2023; Zarrilli, 2017). It is thus not surprising to find that neither GATT nor the WTO (before 1995) have historically considered themselves to be working with gender (Bahri et al., 2023). In summary, despite the Marrakesh Agreement specifying the objectives of the WTO as creating conditions for increasing social and economic welfare, the WTO has refrained from gender mainstreaming.

Fabian (2023) argues that the inability of the WTO, and previously GATT, to address gender successfully, is a multi-layered problem. To exemplify, Fabian addresses the consensus-based decision-making progress in the WTO, which allows non-progressive groups to stall crucial agreements that promote gender-specific causes. Moreover, Fabian mentions how civil groups and NGOs are often excluded from debates in the WTO. Furthermore, Hannah et al. (2021) argue that there is a wide discrepancy among WTO members regarding how ‘gender’ should be addressed, and stress that this divide may create, rather than reduce, gender biases.

It is critical to note that, since the 2010s, the WTO has started integrating gender into its work. Bahri et al. (2023) note that, in 2006, the WTO “Aid-for-Trade”, a trade capacity-building programme, addressed the ‘gender perspective’ of trade for the first time. However, the breakthrough for gender mainstreaming in the WTO was the 2017 Buenos Aires Ministerial Conference, which resulted in the *Joint Declaration on Trade and Women’s Economic Empowerment*. Not only does this declaration address the heterogeneous effects of trade between the genders, but it also concerns women’s empowerment in the labour force. More practically, this is facilitated by training, information exchange between member-states on best practices to empower women, and by establishing more gender-disaggregated trade data to better inform policymakers (WTO, 2017). Furthermore, in 2020, the WTO created the “Informal Working Group on Trade and Gender” to monitor the work (WTO, 2020). Lastly, a WTO report shows that 70% of the WTO member states had gender mainstreamed at least one trade-related policy by 2018 (der Boghossian, 2019). Moreover, 147 WTO-related regional trade agreements had at least one gender-specific provision; and, out of particular interest to our research, 52 concerned women’s access to education (WTO, 2022a).

2.2. Conceptual Frameworks and Theories

This section provides a conceptual background to how trade liberalisation (following WTO accession) is associated with promoting female education in our econometric model.³ 2.2.1 reviews ‘human capital’ in theory, followed by 2.2.2, which covers a three-channel approach for studying the links between trade liberalisation and education (a critical component of human capital). Lastly, 2.2.3 adds gender considerations to the proposed channels.

2.2.1. Human Capital Theory

Becker (1962) defines ‘human capital’ as the embedded resources in the labour force, both physical and mental abilities, which alters the prospect of real income in the future. Human capital accumulation can occur in many ways, and Becker lists knowledge- and capacity-building

³. Our conceptual framework serves as an intuitive background to *why* we relate WTO accession and female educational attainment. Nevertheless, the equations of the human capital theory and the channels are not included explicitly in our regressions. However, we use insights from the conceptual framework to build the model specifications and the analysis.

in education as one component. Critically, any human capital investments incur costs, both in terms of monetary costs, such as enrolment fees, and time-related costs. Mincer (1958) and Becker (1962) argue that people are rational in weighing these costs against expected benefits. An informed and rational individual seeks to compensate for the investment in human capital by looking at an equalisation of present values of lifetime earnings that it derives from the investment, and the opportunity cost.⁴ Notably, as human capital is illiquid (a person cannot sell their accumulated knowledge in the same manner as it could sell something of physical possession), and as future incomes are uncertain, there is an element of risk going into calculating expected benefits. (Mincer, 1958). Critically for our study, labour market conditions alter expectations (Becker, 1962; Weisbrod, 1966), affecting the propensity to invest in education.

2.2.2. Trade Liberalisation and Education

The conceptual framework behind studying WTO accession and education is that WTO accession, in which a country commits to trade liberalisation, affects labour market conditions. Followingly, rational actors (see 2.2.1) respond by altering their propensity to accumulate human capital, such as education. We utilise a three-channel approach by the World Bank and the WTO (2020)⁵, as seen in Figure 3, to explain how trade liberalisation alters incentives to invest in education. The proposed channels are that trade liberalisation affects education by (i.) altering the skill premium, (ii.) altering the opportunity cost of education, and (iii.) altering the income of families.

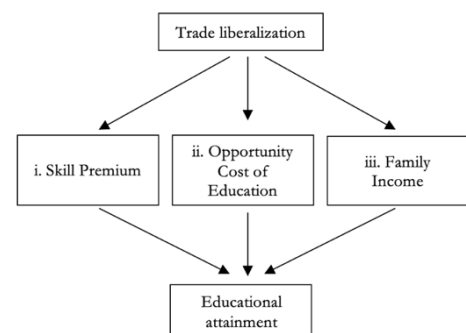


Figure 3: Visualisation of Conceptual Framework

Compiled by the authors. Source: World Bank & WTO (2020)

2.2.2.1. Skill Premium Channel

Skill premium refers to the expected returns of skill acquisition, such as by education (Acemoglu, 2003). The Findlay and Kierzkowski model, which is an alteration of the Heckscher-Ohlin theory of international trade, explains the dynamics of this channel (Findlay & Kierzkowski, 1983). By the implication of the Stolper-Samuelsson theorem in Heckscher-Ohlin, trade liberalisation positively influences the real prices and the real returns for the factor of production used intensively in a country's abundant industry. The opposite holds true for the non-intense factor of production, stimulating specialisation in the abundant industry (Stolper & Samuelson, 1941). Findlay and Kierzkowski (1983) extend the Heckscher-Ohlin model by integrating skilled and unskilled labour into the model, and theorise that trade liberalisation alters the distributional returns between skilled and unskilled labour, explaining shifting incentives to invest in education. For instance, if trade liberalisation induces specialisation in skill-intensive industries, it stimulates investment in human capital. The rationale is that societies must invest in competent labour to

⁴ The return from human capital investments is often calculated by the Mincer Earnings Function (Mincer, 1974). The most common form of the Mincer Earnings Function is $\log y = \log y_0 + rS + B_1X + B_2X^2$, where $\log y$ is the natural logarithm of real income and $\log y_0$ represents the log earnings without any human capital accumulation. To account for the relative impact of human capital, S denotes years of schooling, and X denotes 'potential labour market experience' where $X = \text{Age} - S - 6$ where Age is the age of an individual, and $(-S - 6)$ accounts for the delay in entry into the labour market as caused by schooling and as those under the age of 6 are often not in the labour market (Lemieux, 2006).

⁵ We acknowledge that WTO's co-authorship of the report could impair the relevance of using this particular framework. However, we argue that the report is representative of a wide body of research on both positive and negative effects of trade liberalisation, and note that at least one related study have used it; see Liu (2023).

manoeuvre new tools, technologies, and processes in the expanding industries. The opposite may also hold; human capital decumulation can occur if unskilled-intensive industries expand due to trade liberalisation, as the incentives to invest in education decrease.

The *skill premium* channel is tested in several studies. Heath and Mushfiq Mobarak (2015) conclude, from their case study in Bangladesh, that education is closely tied to trade expansion if the new jobs reward education. Moreover, in the US, between 1990 and 2007, for every \$1000 of Chinese unskilled-intensive imports per worker, graduation rates rose by 3.43 percentage points as the relative demand for US unskilled labour decreased drastically (Greenland & Lopresti, 2016). Furthermore, Lin and Long (2020) find that WTO accession in China in 2001 was associated with trade-induced demands for skill upgrading. Similarly, Oster and Steinberg (2013) conclude that increased foreign firm presence in India (in the form of skill-intensive IT centres) was associated with a 4.8% increase in primary school enrolment for children aged 6-14 living within a radius of a few kilometres from the newly established IT centres. Lastly, Dix-Carneiro and Kovak (2015) find that unskilled-intensive export growth decreased the skill premium in Brazil between 1991 and 2010, decreasing incentives to pursue schooling, which confirms this channel.

2.2.2.2. Opportunity Cost of Education Channel

As demonstrated in 2.2.1, ‘opportunity cost’ is a central concept in human capital theory. The opportunity cost of education is explicitly referenced in Becker’s Theory on the Allocation of Time (Becker, 1965); the idea is that the time and monetary spending in education could be invested towards another cause, such as by taking employment, should the perceived total benefits be higher. Similarly, the World Bank and the WTO (2020) propose that the opportunity cost of education may either be increased or decreased following trade liberalisation, depending on which industry expands (skilled or unskilled).

The World Bank and the WTO (2020) engage with Atkin (2016) to explain this channel. Atkin (2016) finds that the influx of new jobs to Mexico between 1986 and 2000 substantially increased the opportunity cost of education for young people, stimulating them to pursue low-skilled jobs instead. For every 25 jobs created, Atkin finds that one student dropped out in grade 9 instead of pursuing further education. Similarly, Lin and Long (2020) find that WTO accession increased the opportunity cost of education, stimulating a two-month reduction in average youth schooling. This is consistent with Lou and Li (2022), who find that, while trade expansion in China was positive for intergenerational education mobility, it caused human capital decumulation. Coxhead and Shrestha (2017) find similar results in Vietnam, especially among the rural population, which turned to unskilled labour industries following increased openness to trade. Conclusively, the *opportunity cost of education* channel is often negative for education levels. The only evidence that contradicts these studies is found in Edmonds and Pavcnik (2006). They conclude that increased trade openness, on average, reduces child labour, which is otherwise an alternative time allocation for children than education.

2.2.2.3. Income Effect Channel

Frankel and Romer (1999) show that a percentage point increase in trade intensity is, on average, associated with a 0.5% increase in income per capita. These findings further motivate the income-effect channel proposed by the World Bank and the WTO (2020), who theorise that decreased tariffs increase real income, stimulating more families to send their children to education. To exemplify, Liu (2023) finds that, as China acceded to the WTO, the positive *income effects* even outweighed the negative *opportunity cost of education*-channel.

2.2.3. Adding Gender Dynamics between Trade Liberalisation and Education

Before this section, the conceptual framework has not explicitly covered ‘gender’. Nevertheless, Elson (1993) argues that individuals are far too often wrongfully grouped and studied as if their behaviour is identical to that of the ‘economic man’. Hence, we must consider gendered effects of WTO accession (trade liberalisation) on education.

‘Gender’ is defined by UN (2022a) as a “system of norms and practices that ascribe particular roles, characteristics and behaviours to males and females based on their sex, and generally assign those born female a subordinate status in society”. Gender is thus separate from biological sex but is a social production that systematically negatively affects those born female in various settings. This subordination can be *horizontal*, in that women are being segregated from some parts of the economy, or *vertical*, in that they are not empowered to make decisions, specifically on a high level in the economy. Importantly, not all gender biases are detectable, as many are deeply rooted in society.

As accounted for by Hannah et al. (2021), feminist economist Mariama Williams argues that, while trade may not create gender inequalities, trade may well serve to reproduce or exacerbate them. A feminist analysis of globalisation (of which trade is integral) reviews gendered structures in private and public settings, and what informs these structures (Bisnath, 2001). Notably, feminist economics of trade is an entire theoretical framework; however, we have focused on vital insights that help establish the connection between trade and differences in incentives to acquire education between the genders.

2.2.3.1. Skill Premium Channel and Gender

Regarding the *skill premium* channel, Bisnath (2001) argues that, while trade-induced labour market shocks could stimulate migration and thus act as an incentive to pursue education to meet new demands or opportunities, gendered structures prohibit women's labour market sectoral mobility. For instance, in some countries, women are not allowed to move to another location for work. Conclusively, some trade shocks may stimulate positive labour signals to men only, effectively subordinating women. Thus, women's perceived returns to education may be lowered following a trade shock. Notably, this line of argument contradicts the World Bank and the WTO (2020), who argue that skill incentives for women increase with trade expansion.

2.2.3.2. Opportunity Cost of Education Channel and Gender

Regarding the *opportunity cost of education* channel, significant gender structures negatively affect women's education. Firstly, women are more likely than men to work in unskilled sectors. The share of women in the high-skilled services sector was 40% in high-income countries and merely

3% in low-income countries (World Bank & WTO, 2020). Thus, for countries specialising in unskilled production after trade liberalisation, by the dynamics of the Findlay and Kierzkowski model (as outlined in 2.2.2.1), it is reasonable to assume that women will be more prone to leave education to pursue low-skilled employment. Similarly, Zarrilli (2018) warns about the exploitation of women as cheap sources of labour following trade expansion. Elson et al. (2007) also point out that women in developing economies are becoming sources of competitive advantage for export-oriented firms.

Secondly, one cannot talk about *the opportunity cost of education* for women without talking about gendered roles. In certain countries, a woman's role may be confined to being *homemakers*, emphasising women's "maternal qualities" (Watts, 2010). This role description is highly associated with expectations of child-rearing and early marriage (Todaro & Smith, 2020). Narrow gender role descriptions effectively disincentivise out-of-home work and formal education for women, as investment in human capital accumulation is substituted with other time allocations (Elson, 1993; Hannah et al., 2021; Jensen, 2012). Thus, the *opportunity cost of education* is also affected by the *double-burden for women*, as women must balance formal work away from home and informal work at home, effectively reducing their foothold in the formal labour market. Following the logic of Hannah et al. (2016) (see 2.2.3), trade may exacerbate the double burden if gender roles are further cemented.

2.2.3.3. Income Effect Channel and Gender

Regarding the *income effect* channel, Elson (1993) points out that, as trade liberalisation removes state income from tariffs, the government may alter public spending. Followingly, the argument is that tariff reductions increase women's care burden and expenses, such as educational expenditures. As mothers generally put more funds towards their children's future development than fathers (Todaro & Smith, 2020), it is concerning that trade liberalisation pushes down income margins, as this decreases the likelihood of sending girls into education.

2.3. Literature Review

Most previous literature relating trade liberalisation, the WTO and gender-specific development, focus on economic indicators, such as the gender wage gaps (c.f. Brussevich, 2018; Busse & Spielmann, 2006; Juhn et al., 2014; Menon & van der Meulen Rodgers, 2009; Sauré & Zoabi, 2014; van Rensburg et al., 2020) and FLFP (c.f. Brussevich, 2018; Narayan et al., 2021). Nevertheless, an expanding body of studies has shifted their attention to health and social outcomes between the genders from trade. This section covers studies related to trade liberalisation, education, and gender.⁶

National-level Panel Data Analyses

Most studies on the impact of trade liberalisation on female educational attainment focus on one country and exploit the variance over time and across regions to determine the relative impact of trade liberalisation on female educational attainment. Four examples include Nano et al. (2021), Atkin (2016), Ul-Haq et al. (2023) and Heath and Mushfiq Mobarak (2015).

⁶ Find an Annotated Literature Review for all articles included in 2.3 in Appendix B.

Nano et al. (2021) use 3SLS and IV models to show that services expansion (export-intensive) in some districts of India in the period 1987-1999 was associated with an 8.3% decline in the gender education gap, on average. Similarly, Heath and Mushfiq Mobarak (2015) find that women gained, both measured in absolute and relative terms (to men), following the trade-induced introduction of garment factories (export-oriented) in some villages in Bangladesh between 1983 and 2009. The authors find that an 8-year-old girl is 13% more likely to begin school if women in her village have started to work in the garment industry, as the garment industry rewards literacy. The gender gap in education also decreases in the study.

Although Atkin (2016) did not focus on gender specifically in his study on Mexico 1986-2000, he featured it in one of his regression outputs. With an IV approach, Atkin showed that, while less-skilled-intensive export expansion in Mexico raised the opportunity cost of education for both genders, the gender education gap decreased, as the new jobs were more attractive to men. Atkin thus aligns with Nano et al. (2021) and Heath and Mushfiq Mobarak (2015) regarding the gender education gap. On the contrary, Ul-Haq et al. (2023) employ a FGLS method to show that a percentage point increase in trade openness in Pakistan between 1990 and 2015 increased the gender education gap by 0.0268 percentage points at the 1% level.

Cross-Country Panel Data Analyses

The cross-country studies in this section are presented in consecutive order by the number of countries sampled in each study. Iqbal et al. (2020) study twelve Asian developing economies between 1990 and 2013, and used a random effect GLS regression model with fixed effects to show that trade openness (alongside other variables such as FDI and remittances) increased gender equality in education. However, the reported effects are minor, 0.001%. The results of Schultz (2006) point in a similar direction. Schulz (2006) uses an IV specification on a sample of 44-70 countries (data availability increased at every period) between 1965-1980 (quinquennial intervals) to show that trade barriers were inversely associated with female educational enrolment and gender equality in education; however, these effects are largely eroded if a country's exports are intensive in natural resources.

Blanchard and Olney (2017) also uses an IV approach on 102 countries between 1965 and 2010 (quinquennial intervals) to show that, along with the assumptions of Findlay and Kierzkowski (1983), skill-intensive exports increase skill premium and thus education levels, while the opposite holds for less skill-intensive exports as the opportunity cost of education increases. No gender education gap estimate is reported, as gender was not the focal point of their study. Similarly, Williams (2024) does not focus on gender either but includes gender-disaggregated data in one table as he studies 109 developing economies between 1965-2015 (quinquennial intervals). Williams finds that, while the *income effect* is significant and positive, the *opportunity cost of education* effect is larger and negative in the studied sample, reducing overall incentives for both genders to pursue education. The coefficient estimates for the aggregate effect are more negative for women, but the gender inequality effect is insignificant.

The two studies with the largest sample sizes are Bussmann (2009) and Gray et al. (2006), for 134 countries (annually 1970-2000) and 180 countries (quinquennial intervals 1975-2000), respectively. Bussmann (2009) uses a two-step GMM approach with IV to find that the impact

of trade liberalisation on female educational attainment (both in absolute and relative terms) is insignificant, except for the enrolment in primary schools, which increases with 5% with a one per cent increase in trade intensity. Lastly, Gray et al. (2006) show that trade openness and membership in the World Bank, UN and CEDAW are associated with increased literacy levels and a decreased gender education gap. Nevertheless, the authors also note that, when controlling for cultural differences (religion, history with women's suffrage), all trade-related coefficients become insignificant, except for CEDAW membership.

2.4. Contribution to the Literature

In our review of the existing literature, we have found a research gap in examining the impact of WTO accession on female education. As the WTO guides international trade norms and flows through its operations (see 2.1), and as we have argued that trade liberalisation alters education through several channels, it is imperative to assess the impact of WTO membership on educational outcomes. We will contribute to bridging this research gap by a panel data study for 182 countries (a larger sample than any study in 2.3) between 1970 and 2015. Only a few analyses have previously explored the association between WTO membership and educational outcomes, and these focus on one country (c.f. Lin & Long, 2020; Liu, 2023; Pan & Leight, 2021). While a national-level panel data study provides critical policy insights into the nature of the effects of WTO accession in a particular country, our use of a cross-country panel data study allows us to investigate the global effects of WTO.

Our second contribution to the literature is assessing the effect of WTO accession on gender-specific education outcomes. We note that the panel data studies outlined in 2.3 do not fully agree on the direction of the effect of trade liberalisation on female educational attainment and the gender education gap. Furthermore, no studies have examined the heterogeneous effects of WTO accession on educational outcomes between the genders. Nevertheless, as we argue in section 2.2.3, there is reason to expect heterogeneous effects of trade liberalisation between the genders in terms of education. Thus, we intend to explore the impact of WTO accession on female educational attainment, both in absolute terms and the gender education gap. We argue that this is a critical exploration, as sceptics argue that the WTO was gender-blind until the 2010s (see 2.1.2). Moreover, the relevance of our exploration cannot be stressed enough, provided that we explore the causes of female education and gender equality, which are critical for inclusive growth and for reaching SDGs 4 and 5 (see Section 1).

Lastly, our third contribution to the literature revolves around the methodology and data collection. Most cross-country studies use the same methodology (IV approach) and utilise the Barro and Lee datasets, offering only quinquennial data on gender-disaggregated educational attainment (Barro & Lee, 2013). We utilise a dataset with annual data to increase the variability across time, and a DID design as opposed to IV, which broadens the literature base.

3. Research Question and Hypothesis Development

Provided our aimed contribution to the literature, our overarching research question is:

Does accession to the WTO, which works for trade liberalisation by facilitating trade agreements and harmonised global trade rules, impact female educational attainment and the gender education gap?

Most of the previous literature has indicated that trade liberalisation positively correlates with absolute increases in female educational attainment. Moreover, Gray et al. (2006) indicate that CEDAW membership is positively associated with female education. Hence, we develop a one-sided hypothesis, H_1 , to test whether WTO accession, on average, is positively associated with female educational attainment.⁷

H_1 : *Countries' accession to the WTO between 1970 and 2015 is, on average, positively associated with female educational attainment.*

As discussed in section 2.2.3, gender roles are at risk of being altered following trade expansion. Followingly, the gender education gap may widen if women cannot access new labour opportunities. In contrast, most studies referenced in 2.3 infer that the gender education gap is inversely associated with trade liberalisation. To study this in relation to WTO accession, we test H_2 . We use a one-sided test and hypothesise that our results align with the previous studies.

H_2 : *Countries' accession to the WTO between 1970 and 2015 is, on average, associated with a reduced gap between male and female educational attainment.*

To extend our model, using the insights of previous literature (see 2.3) that find indications of heterogeneous effects of trade liberalisation between developed and developing countries (c.f. Williams, 2024), we test for heterogeneity in the effects of WTO accession depending on a country's development status. We hypothesise that developed countries gain more in absolute and relative female educational attainment, and test H_3 and H_4 .

H_3 : *The accession of developed countries to the WTO between 1970 and 2015 is, on average, associated with higher increases in female educational attainment compared to developing countries that accede to the WTO within the same timeframe.*

H_4 : *The accession of developed countries to the WTO between 1970 and 2015 is, on average, associated with a larger reduction in the gap between male and female educational attainment, compared to developing countries that accede to the WTO within the same timeframe.*

Three critical notes on all hypotheses presented, which also act as delimitations in our paper, are: (1.) Our research scope is time-bounded as we test only accession between 1970 and 2015. (2.) We use a DID with a staggered design (see 5.3). Thus, our hypotheses refer to an average treatment effect on the treated (ATT) of all countries acceding to WTO between 1970 and 2015.

⁷ Educational attainment refers to the highest level of education attained by an individual or a group. In our model specification, we express educational attainment as the total years of education attained by a person. Thus, we use educational attainment synonymously with the *average years of education* when studying a population.

Put differently, we have to assume that the ‘treatment effect’ of acceding the WTO is equivalent across all years, following the rationale in Borusyak et al. (2018). (3.) We test the *aggregate effect* of WTO accession, indicating that we do not independently assess the channels outlined in 2.2.2. Instead, we use these channels as a conceptual framework and for analysis.

4. Data

Our study makes use of several datasets to build a robust model. The datasets contain secondary data to us, meaning that we have not constructed the datasets nor created the data points ourselves (Dahmström, 2011). We join the selected datasets together using RStudio and Excel. Moreover, we use a panel data structure to observe the same set of entities (countries) over time. As opposed to studying a single country over time (time series data) or several countries at one point in time (cross-sectional data), panel data allows us to exploit the variation in the data across time and countries (Wooldridge, 2020) to isolate an ATT of WTO accession.

For data on educational attainment, we use the dataset *Global Educational Attainment 1970-2015* from the Institute for Health Metrics and Evaluation (IHME, 2015). This dataset contains the average education levels by gender and age cohorts for 188 countries. This dataset, which features annual data, allows us to exploit more variability in the data than the widely used Barro and Lee datasets with quinquennial data (Barro & Lee, 2013). Moreover, this dataset does not have any problems with missing data. We use the age cohort 15-24 years. Although WTO does have some later-in-life vocational training with Aid-for-Trade (see 2.1.1), we assume that the main impact of WTO accession affects those in schooling ages, given decreasing returns to education by age (Falvey et al., 2010). Lastly, using this dataset sets our time boundary to 1970-2015. This period is relevant to the study as it covers most of the years that countries could have acceded to WTO or its precursor, GATT.

We use the *Penn World Table* dataset (Feenstra et al., 2015; Groningen Growth and Development Centre, 2023) for GDP per capita and trade volume data. This data set contains annual data for variables such as GDP per capita, exports, and imports for 183 countries between 1950-2019. By using this dataset, we limit the sample size to 182 countries.⁸ For the remaining variables (population, fertility rate, WTO membership, years of female suffrage, communist state and development level), we use data from the United Nations, from the WTO, and from Harvard Business School (Clapp, 2013; Skaaning et al., 2015; UN, 2022b; WTO, n.d.-c), which we argue are widely recognised as credible sources. They are also frequently used in studies featured in 2.3.

⁸. We exclude one country, Venezuela, from the Penn World Table dataset as this country was not included in the *Global Educational Attainment 1970-2015* dataset. For list of countries included, see Appendix C.

Table 2: Descriptive Statistics
Compiled by the authors using *sumtable()* in RStudio

Variable	N	Mean	Std. Dev.	Min	Pctl. 25	Pctl. 75	Max
Female educational attainment	6295	7.604	3.477	0.57	4.795	10.395	15.6
Gender educational gap	6295	0.218	0.929	-2.59	-0.44	0.85	4.37
WTO member	6295	0.671	0.47	0	0	1	1
GDP per capita (ln)	6295	8.168	1.533	4.594	6.971	9.375	11.663
Population (ln)	6295	15.59	1.883	9.896	14.573	16.794	21.014
Fertility rate	6295	3.993	2.006	1.09	2.068	5.828	8.713
Female voting years (ln)	6295	3.175	1.152	0	2.833	3.912	4.771
Communist state	6295	0.07	0.256	0	0	0	1
Trade intensity (ln)	6295	-0.501	0.649	-3.896	-0.872	-0.062	1.476
Developing country	6295	0.624	0.484	0	0	1	1

Using Table 2, we analyse our data structure and find no indications of extreme outliers.

5. Empirical Model

5.1. Research Design and Scope

This study uses a quantitative research design to examine the effect of WTO accession on female educational attainment and the gender education gap for 182 countries between 1970 and 2015. Quantitative research means that we test the proposed relationship empirically with quantified observations. We argue that quantitative research is preferable to qualitative research, as our study aims to make inferences about an association and test causality between several factors (Aidley, 2018).

The research approach is ‘experimental’. According to the criteria in Yin (2003), an experimental study approach is most appropriate given our research question, given its focus on a contemporary event (rather than historical). Furthermore, our research design can be more precisely categorised as ‘quasi-experimental’. While full experimental designs, particularly randomised control trials (RCTs), are considered the “gold standard” for evaluating treatment effects (Drummond & Murphy-Reyes, 2018), such experiments require control and self-selection (Aidley, 2018). Instead, quasi-experimental studies follow a similar logic but relax the assumption of self-selection, which is needed in our case as countries can select to accede to the WTO (Dahmström, 2011; Yin, 2003). Our specific type of quasi-experimental study is a DID regression with two-way fixed effects (TWFE), see 5.3.

5.2. Variable Specification

Table 3: Variable Definitions and Categorisation

	Variable	Definition	Unit
<i>Dependent variables</i>	$FEA_{i,t+5}$	Female educational attainment. The average number of years spent in education for females aged 15-24 in year $t + 5$ in country i .	Years
	$GEG_{i,t+5}$	Gender education gap. $MEA_{i,t+5} - FEA_{i,t+5}$. ⁹ The difference between the average years of male schooling and the average years of female schooling, all aged 15-24, in year $t + 5$ in country i .	Years
<i>Independent variable</i>	WTO_{it}	WTO membership. Indicates whether country i was a member of the WTO/GATT in year t .	Binary
<i>Control variables</i>	GDP_{it}	GDP per capita. The total GDP divided by the total population in country i in year t (measured in current prices USD)	USD (ln)
	Pop_{it}	Total population. The size of the total population in country i at year t .	Number (ln)
	FR_{it}	Fertility rate. The average number of children a woman gives birth to during her lifetime in country i in year t .	Number
	YFS_{it}	Years of female suffrage. The number of years in year t that women in country i have had the right to vote in public elections.	Years (ln)
	CS_{it}	Communist country. Indicates whether country i is a communist or Marxist state in year t .	Binary
	TI_{it}	Trade intensity. The total trade (exports and imports) divided by the total GDP of country i at year t .	Ratio
	Dev_{it}	Developing country. Indicates whether country i is classified as a developing country in year t .	Binary
<i>Fixed effects</i>	μ_i	Country (entity) fixed effects. Encapsulates factors that remain constant in country i over time.	N/A
	θ_t	Time fixed effects. Encapsulates global trends (across countries) at time t .	N/A

5.2.1. The Dependent Variables

The dependent variables of this study, $FEA_{i,t+5}$ and $GEG_{i,t+5}$, are indicators for absolute and relative levels (to male) of education for females aged 15-24. The dependent variables have a five-year lead, meaning we measure the effect of WTO accession on the dependent variables five years later. The rationale for setting up the regressions in this way is that we assume the effects of WTO accession go through labour market effects (see 2.2.2), which requires time. Leading the dependent variables is also reasonable, as WTO accession is a commitment to liberalise trade rather than an immediate removal of trade barriers (see section 2.1.1). Lastly, as the dependent variables capture the average years of education, leading the variable is necessary as any effect of WTO will first impact how many individuals enrol in educational institutions, whereas raising the effect on the average years of education will be observed only as those enrolled progress onto higher degrees of education in later years. We relax the assumption of a five-year lead in 6.4.1.

⁹ $MEA_{i,t+5}$ is defined as the male equivalent to $FEA_{i,t+5}$: Male educational attainment. The average number of years spent in education for males aged 15-24 in year $t + 5$ in country i .

5.2.2. The Independent Variable

The study uses a binary variable, WTO_{it} , that takes on the value 1 when a country is a member of WTO or GATT to study WTO accession.¹⁰ As elaborated in 2.1.1, WTO was created in 1995, while its precursor, GATT, was created in 1947. We assume that the effect of acceding to the WTO is broadly equivalent to acceding to GATT. GATT and the WTO share the purpose of trade liberalisation through multilateralism but differ only in scope, motivating the use of GATT as a proxy for the years before 1995. Followingly, we consistently refer to WTO accession when we mean WTO/GATT accession in this analysis. We relax this assumption in 6.4.2.

5.2.3. The Control Variables¹¹

This section motivates the selection of our control variables. In 5.2.3.1, we motivate confounding factors, other than WTO accession, that influence the general education level. Furthermore, provided the discussion in 2.2.3 on how gender roles affect decisions on human capital accumulation, we control for factors (cultural and social) that specifically affect female educational attainment and the gender education gap in 5.2.3.2.

5.2.3.1. Factors Influencing the General Education Level

GDP per capita. We include GDP_{it} to control for different levels of economic development between countries. The intuition is that a country's economic wealth affects educational expenditure on a household and institutional level, influencing educational enrolment and thus, educational attainment. In the literature studying trade liberalisation and education, GDP per capita is commonly used (c.f. Bussmann, 2009; Gray et al., 2006; Williams, 2024).

Population size. We include Pop_{it} , to account for the fact that smaller countries have a higher propensity to trade than larger countries. For instance, in a small nation, the domestic market is insufficient to support substantial economic growth, which might be the case for a larger country. Followingly, the labour market conditions will be different, which we want to control for to isolate the effect of WTO accession. This variable is used in several studies featured in 2.3 (c.f. Bussmann, 2009; Williams, 2024).

5.2.3.2. Factors Influencing the Genders Differently

Average fertility rate. FR_{it} . Following Black et al. (2005) and the rationale outlined in 2.2.3, the average fertility rate interplays with the women's education level given the double-care burden. Following that, we want to control for differences between countries in the average fertility rate to isolate the ATT for WTO accession.

Years of female suffrage. YFS_{it} . As the cultural views on gender roles are not homogeneous across countries or over time, we also need to control for cultural shifts in the view of women's roles within societies, as shifts are likely to affect female educational attainment and the gender education gap. Female suffrage is used by Gray et al. (2006) as a proxy for cultural views, as suffrage indicates the acknowledgement of females as equal participants in society.

¹⁰ Appendix C lists WTO/GATT members by their respective accession dates.

¹¹ For elaboration on TI_{it} and Dev_{it} , refer to 5.3.2.

Communist state, CS_{it} . Gray et al. (2006) and Williams (2024) suggest that countries governed by a communist or Marxist ideology generally exhibit more support for gender equality. Consequently, a country with this ideology should exhibit a smaller gender education gap and steeper increases in female educational attainment. Followingly, we want to control for this factor.

5.2.4. Interpretation of Estimated Coefficients

Three control variables are in their logarithmic form: Pop_{it} , YFS_{it} and TI_{it} . The rationale for this transformation is that we do not expect the effect of these variables to follow a linear pattern on the dependent variables; instead, we assume that their impact will depend on the individual country's baseline level. That is, the effect of having gone from 0 to 1 year of female suffrage is likely to affect education levels more than the effect from 50 to 51 years. Furthermore, the logarithmic form also alters the interpretation of the reported estimates. For instance, by studying the coefficient for TI_{it} in the regression output, we refer to a per cent change in trade intensity on the dependent variables (Stock & Watson, 2020).

A critical note on the interpretation of the control variables is that we cannot assign a causal interpretation to the control variables' estimated coefficients. While we include control variables to remove bias and thus isolate the effect of the independent variable (WTO accession) on the dependent variables, this does not imply that the coefficients of the control variables are unbiased. It would potentially require additional controls or a different model specification to make a causal interpretation of the control variables (Stock & Watson, 2020).

5.3. Econometric Specification

Our study features eight regressions with the same underlying econometric design, Difference-in-Difference (DID) with a staggered treatment and two-way fixed effects (TWFE). In 5.3.1, we discuss the methodology. In 5.3.2, we develop the regressions in four stages (models), as summarised in Table 4.

Table 4: Summary of Regressions

	Reg 1	Reg 2	Reg 3	Reg 4	Reg 5	Reg 6	Reg 7	Reg 8
Model	1	1	2	2	3	3	4	4
Hypothesis	H_1	H_2	H_1	H_2	H_1, H_3	H_2, H_4	H_1, H_3	H_2, H_4
Includes TI_{it} ?	No	No	Yes	Yes	No	No	Yes	Yes
Includes Dev_{it} ?	No	No	No	No	Yes	Yes	Yes	Yes

5.3.1. Overview of Econometric Models

Difference-in-Difference (DID)

The DID framework is widely used with panel data to study the effect of a treatment or policy intervention (Baker et al., 2022). DID compares the means of treated and untreated groups before and after an intervention. Critically, DID relies on the assumption that the treated group would have continued exhibiting a trend parallel to that of the control group (untreated) without the intervention, see Figure 4.¹²

Consequently, if the treated groups display heterogeneous and statistically significant effects to the control group after receiving treatment, it is possible to make causal inferences on the effect of the treatment (Schwerdt & Woessmann, 2020).

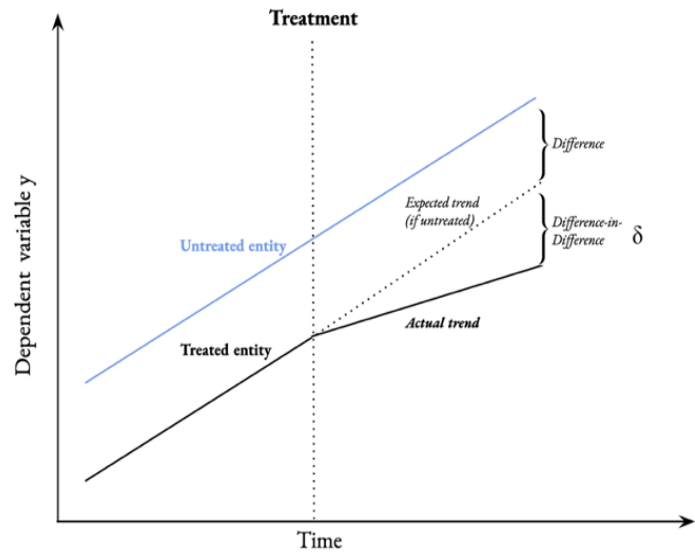


Figure 4: Graphical Example of Difference-in-Difference
Compiled by the authors. Source: Stock & Watson (2020)

Our application of the DID framework uses a staggered design, meaning that the treatment in question, WTO accession, occurs in different years depending on when a country accedes to the WTO. The implication of using a staggered DID design is that our interpretation will differ from the standard DID set-up, as we must interpret the results as if the treatment effect is consistent over time for all entities treated (ATT). We expand on the limitations of staggered DID in Section 8. Lastly, we argue for the fulfilment of relevant DID assumptions in 5.4.

Two-way fixed effects (TWFE)

In applying TWFE to our model specification, we take out effects that are constant across entities but vary over time (time-fixed effects) and factors that vary across entities but are constant over time (entity-fixed effects). Consequently, using TWFE removes global trends, like global enhancement of female education levels, and unobserved heterogeneity within entities, which would otherwise cause omitted variable bias in our regression (Wooldridge, 2020).

5.3.2. Model Specifications

Model 1: Standard DID Model

The simplest version of our DID model, Model 1, regresses $FEA_{i,t+5}$ and $GEG_{i,t+5}$ on WTO_{it} , and uses control variables (excluding TI_{it} and Dev_{it}) and TWFE. Reg 1 studies the effect of WTO accession on female educational attainment, while Reg 2 studies the effect on the gender

¹² In its simplest form (two periods, with one treated entity and one untreated), DID: $\delta = [E(y | entity = treated, time = after treatment) - E(y | entity = treated, time = before treatment)] - [E(y | entity = untreated, time = after treatment) - E(y | entity = untreated, time = before treatment)]$ (Schwerdt & Woessmann, 2020).

education gap. We note, once again, that all regressions pertain to the aggregate effect of WTO accession instead of independently studying the channels outlined in 2.2.2.

$$FEA_{i,t+5} = \beta_1 WTO_{it} + \beta_2 X_{it} + \mu_i + \theta_t + \varepsilon_{it} \quad (\text{Reg 1})$$

$$GEG_{i,t+5} = \beta_1 WTO_{it} + \beta_2 X_{it} + \mu_i + \theta_t + \varepsilon_{it} \quad (\text{Reg 2})$$

Regs 1 and 2 allow us to examine H_1 and H_2 , respectively, by studying the β_1 parameter.¹³ More specifically, $H_1: \beta_1 > 0$; $H_1^1: \beta_1 \leq 0$ for Reg 1, and $H_2: \beta_1 < 0$; $H_2^2: \beta_1 \geq 0$ for Reg 2. β_1 is interpreted as the average treatment effect of the treated (ATT) on the dependent variables for countries that acceded to the WTO between 1970 and 2015, ceteris paribus. Moreover, β_2 captures the relative effect of the control variables, included in vector X_{it} , while μ_i represent country fixed-effects, θ_t time-fixed effects and ε_{it} the idiosyncratic error term.

Model 2: Adding Trade Intensity as a Control Variable

In Model 2, we add TI_{it} (trade intensity, a proxy for trade openness) to Regs 1-2 to problematise our discussions about H_1 and H_2 . Controlling for TI_{it} allows us to take out the overall effect of trade liberalisation on the dependent variables and instead look at the additional value explicitly brought by acceding to the WTO. In Model 2, β_1 in Regs 3-4 has a different meaning than in Model 1: it unveils whether WTO accession has any effect *beyond* general trade liberalisation, ceteris paribus. Thus, we can more closely examine support for H_1 and H_2 . Lastly, H_1 and H_2 , and the respective null hypotheses, are equivalent to those in Model 1.

$$FEA_{i,t+5} = \beta_1 WTO_{it} + \beta_2 TI_{it} + \beta_3 X_{it} + \mu_i + \theta_t + \varepsilon_{it} \quad (\text{Reg 3})$$

$$GEG_{i,t+5} = \beta_1 WTO_{it} + \beta_2 TI_{it} + \beta_3 X_{it} + \mu_i + \theta_t + \varepsilon_{it} \quad (\text{Reg 4})$$

Models 3 and 4: Investigating the Heterogenous Effects for Developing and Developed Countries

To test H_3 and H_4 , we extend our model specification further by including an interaction term: $Dev_{it} \times WTO_{it}$. By default, we also add an additional control variable, Dev_{it} . Regs 5-6 (Model 3) mirror the regressions in Model 1 and adds $Dev_{it} \times WTO_{it}$, while Regs 7-8 (Model 4) mirror the regressions in Model 2 (which includes TI_{it}) and also add $Dev_{it} \times WTO_{it}$.

$$FEA_{i,t+5} = \beta_1 WTO_{it} + \beta_2 (Dev_{it} \times WTO_{it}) + \beta_3 Dev_{it} + \beta_4 X_{it} + \mu_i + \theta_t + \varepsilon_{it} \quad (\text{Reg 5})$$

$$GEG_{i,t+5} = \beta_1 WTO_{it} + \beta_2 (Dev_{it} \times WTO_{it}) + \beta_3 Dev_{it} + \beta_4 X_{it} + \mu_i + \theta_t + \varepsilon_{it} \quad (\text{Reg 6})$$

$$FEA_{i,t+5} = \beta_1 WTO_{it} + \beta_2 (Dev_{it} \times WTO_{it}) + \beta_3 Dev_{it} + \beta_4 X_{it} + \beta_5 TI_{it} + \mu_i + \theta_t + \varepsilon_{it} \quad (\text{Reg 7})$$

$$GEG_{i,t+5} = \beta_1 WTO_{it} + \beta_2 (Dev_{it} \times WTO_{it}) + \beta_3 Dev_{it} + \beta_4 X_{it} + \beta_5 TI_{it} + \mu_i + \theta_t + \varepsilon_{it} \quad (\text{Reg 8})$$

In Regs 5-8, β_1 represents the average treatment effect (ATT) of WTO accession for countries that acceded to the WTO between 1970 and 2015, ceteris paribus (including development level). Moreover, β_2 captures whether WTO accession, on average, has a different effect on the

¹³ While some DID equations include separate parameters in the following manner:

$DV = \alpha_1 \text{time} + \alpha_2 \text{treated} + \alpha_3 (\text{time} \times \text{treated}) + \varepsilon$ to differentiate the pre- and post-effects of a treatment, the use of a binary treatment variable in our study, WTO_{it} , and TWFE, imply that our DID estimator (δ) is captured by $\beta_1 = \alpha_3$.

dependent variables if a country is classified as a developing economy, *ceteris paribus*. Thus, β_2 is critical to H_3 and H_4 . Furthermore, β_3 represents the average effect on the dependent variables of being a developing country, *ceteris paribus*, while β_4 pertains to the control variables (except TI_{it}) and β_5 controls for TI_{it} . To make causal inference, $H_3: \beta_2 < 0; H_0^3: \beta_2 \geq 0$ and $H_4: \beta_2 > 0; H_0^4: \beta_2 \leq 0$.

5.4. Internal Validity

This section argues for the internal validity of our specified models by examining the degree of fulfilment of the four assumptions of a model with panel data, as set out by Stock and Watson (2020). Moreover, we add Assumption V for the DID model.

Assumption I: Conditional mean independence. The conditional mean independence assumption conditions the error term to be uncorrelated with the independent variable in any period. This assumption is arguably strong in any study without complete randomisation, and as our study features self-selection into the WTO, omitted variable bias causes concern for the fulfilment of this assumption. To help this problem, we include TWFE and selected control variables to decrease the risk of violating this assumption.

Assumption II: Identically and independently distributed variables. This assumption conditions the data not to have heteroskedasticity (non-identical distribution) nor autocorrelation (non-independent distribution) (Croux et al., 2004). Heteroskedasticity implies that the residuals in the estimated regression do not exhibit a constant or uniform distribution. Moreover, autocorrelation means that a variable is correlated over time (serially correlated) for a given entity (Stock & Watson, 2020). In determining whether these issues are present in our data, we perform two tests for the two phenomena, respectively: the Breusch-Pagan test for heteroskedasticity (Breusch & Pagan, 1979; Koenker, 1981) and the Durbin-Watson test, modified for use with panel data (Bhargava et al., 1982). Both tests show statistically significant results, indicating that heteroskedasticity and autocorrelation might exist in our models (see Appendices D and E). Consequently, we choose to perform the regression with heteroskedasticity-and-autocorrelation-robust (HAR) standard errors (Kiefer & Vogelsang, 2002; Stock & Watson, 2020), which we cluster at the country level, as this is standard practice when estimating treatment effects (Miller, 2023).

Assumption III: Finite kurtosis. The third assumption conditions that the variables included in our model specification have non-zero and finite fourth moments, which would otherwise bias the estimates. This assumption usually holds without extreme outliers or data entry errors (Stock & Watson, 2020). From reviewing the descriptive statistics for our variables (see Section 4), we argue that extreme outliers are not a problem in our dataset. Moreover, some variables included are practically bounded by upper limits; for instance, TI_{it} is bounded by GDP and the trade intensity of other nations. Consequently, the risk for extreme outliers decreases.

Assumption IV: No perfect multicollinearity. The fourth assumption conditions that there should be no perfect linear relationship among the independent or control variables, which would make it more difficult to discern the effect of a specific variable on the dependent variables. We compute the variance inflation factors test (VIF) in Appendix F to assess whether multicollinearity is an

issue with our variable specification. In this test, multicollinearity is problematic if the VIF factor exceeds 5 (Marquardt, 1970; Naimi et al., 2014). The maximum VIF factor for any variable in our data is GDP_{it} in Model 4 (3.5425), well below the threshold. For our primary independent variable of interest, WTO_{it} , the VIF factor is 1.24-1.27 across all models. Conclusively, we argue for the satisfaction of this assumption. Nevertheless, we are cautious about multicollinearity between WTO_{it} and TI_{it} in Regs 3-4 and 7-8 as WTO_{it} and TI_{it} are both proxies for trade liberalisation.

Assumption V: Parallel trends assumption. Using a DID regression specification requires an additional assumption for causal inference, the parallel trends assumption. This assumption posits that the treatment and control groups exhibit a similar trend in the dependent variable pre-intervention (Lechner, 2011). In our study, this implies that there can be no pre-trends in the dependent variables exclusive to countries that eventually accede to the WTO relative to those that do not. There are no formal ways to guarantee that the parallel trend assumption holds. Nevertheless, this study adopts the *event-study DID* methodology, as set out in Li (2022), on the baseline regression (Model 1) in Appendix G to examine any indicated violations of the parallel trends assumptions. Using this model, we argue that there are no indicated violations of the parallel trends assumption.

6. Results and Analysis

This section interprets the results of the DID models, as outlined in Section 5.3. Moreover, we contextualise the results with the paper's hypotheses and determine whether these are supported. 6.1 and 6.2 present the results from Models 1-2 and 3-4, respectively. Each sub-sub section separately analyses the effects on female educational attainment and the gender education gap, and ends with a discussion on hypothesis support. Moreover, in 6.3, we summarise all supported and unsupported hypotheses. Lastly, 6.4 discusses the R^2 coefficients, while 6.5 tests the robustness of the model using two sensitivity analyses.

6.1. Interpreting the Results from Models 1 and 2

Table 5: Regression Outputs, Models 1 and 2
Compiled by the authors using the *plm()* function with HAR standards errors in RStudio

	<i>Dependent variable:</i>			
	FEA _{i,t+5} (Reg 1)	GEG _{i,t+5} (Reg 2)	FEA _{i,t+5} (Reg 3)	GEG _{i,t+5} (Reg 4)
WTO member	0.040** (0.019)	-0.043*** (0.010)	0.020 (0.019)	-0.032*** (0.010)
Trade intensity (ln)			0.121*** (0.010)	-0.064*** (0.005)
GDP per capita (ln)	0.209*** (0.012)	-0.101*** (0.006)	0.273*** (0.013)	-0.135*** (0.007)
Population (ln)	-0.529*** (0.038)	0.348*** (0.020)	-0.458*** (0.038)	0.310*** (0.020)
Fertility rate	-0.353*** (0.009)	0.115*** (0.005)	-0.348*** (0.009)	0.112*** (0.005)
Female suffrage years (ln)	0.040*** (0.014)	-0.048*** (0.007)	0.044*** (0.013)	-0.050*** (0.007)
Communist state	0.168*** (0.031)	-0.025 (0.016)	0.167*** (0.031)	-0.024 (0.016)
Fixed effects	Entity, Time	Entity, Time	Entity, Time	Entity, Time
Observations	6,295	6,295	6,295	6,295
R2	0.248	0.163	0.265	0.183
Adjusted R2	0.220	0.132	0.237	0.152
F Statistic	333.694*** (df = 6; 6067)	197.480*** (df = 6; 6067)	311.814*** (df = 7; 6066)	193.468*** (df = 7; 6066)

Note:

*p<0.1; **p<0.05; ***p<0.01

6.1.1. Female Educational Attainment in Models 1 and 2

Output Interpretation

Table 5, columns 1 and 3, correspond to Regs 1 and 3, which examine the ATT of WTO accession between 1970 and 2015 on female educational attainment using Models 1 and 2, respectively.

In Reg 1, the DID estimator for WTO accession is positive and significant at the 5% level. Followingly, the interpretation is that WTO accession, on average, is associated with an increase of the average years of female education by 0.040 years (~15 days)¹⁴, *ceteris paribus*.

In Reg 3, which extends Model 1 by controlling for trade intensity, TI_{it} , the reported magnitude of the DID estimator reduces by half to 0.020 years (~7 days), but the estimator is insignificant. Critically, the insignificance of the DID estimator does not rule out the existence of any effect of WTO accession on the average years of female education. Instead, it means that the study cannot

¹⁴ We transform years to days by multiplying the coefficient with 365.25 (0.25 accounts for leap years).

infer that the effect of WTO accession is distinguishable from overall changes in trade intensity. Moreover, caution is particularly warranted as multicollinearity is likely high between WTO_{it} and TI_{it} , potentially making assigning variability between WTO_{it} and TI_{it} difficult in the regression.

Another critical point of caution is for interpreting the estimate on trade intensity in Reg 3, which is significant at the 1% level. The interpretation of the estimated coefficient is that a per cent increase in trade intensity is, on average, associated with increasing the average years of female education by 0.121 years (~44 days), *ceteris paribus*. However, provided the argument in 5.2.4, we argue that we cannot make a causal interpretation of the trade intensity coefficient.

Hypothesis 1

Following the results presented in this section, using Model 1, we reject H_0^1 at the 95% confidence level and infer that, on average, there is a positive and significant ATT of WTO accession on the average years of female education for countries acceding to the WTO between 1970 and 2015. In other words, we find support for H_1 . Nevertheless, using Model 2, H_0^1 cannot be rejected. Following this discrepancy, we argue that the overall interpretation should be that we cannot reject H_0^1 . While H_1 strictly talks about the effect of WTO accession, it would be incorrect to assign causality to WTO accession, given that this effect is not discernible from overall trade liberalisation. Nevertheless, Models 1 and 2 indicate a positive correlation between overall trade liberalisation and the average number of years of female education. This relationship may be driven by WTO accession, but we cannot make any such causal inference in our study.

6.1.2. Gender Education Gap in Models 1 and 2

Output Interpretation

Table 5, columns 2 and 4, correspond to Regs 2 and 4, which examine the ATT of WTO accession between 1970 and 2015 on the gender education gap using Models 1 and 2, respectively.

In Reg 2, the DID estimator for WTO accession is negative and significant at the 1% level. Followingly, the interpretation is that, WTO accession, on average, is associated with a decrease in the gap between the average years of female education to male education by 0.043 years (~16 days), *ceteris paribus*. In Reg 4, the DID estimator is reduced to 0.032 years (~12 days) and is still significant at the 1 % level. Thus, unlike in 6.1.1, the significant result for the DID estimator in Model 2 means that we can discern an effect of WTO accession, on average, on the gender education gap *beyond* that arising from a change in trade intensity.

We hold the same caution as in 6.1.1 when interpreting TI_{it} , which is significant at the 1% level. The interpretation of the estimated coefficient is that a per cent increase in trade intensity is, on average, associated with increasing the gap between the average years of female education and male education by 0.064 years (~23 days), *ceteris paribus*. Nevertheless, we do not assign causality.

Hypothesis 2

Following the results presented in this section, H_0^2 is rejected both in Models 1 and 2 at the 99% confidence level. Consequently, we find support for H_2 and infer that, on average, there is a

negative and significant ATT of WTO accession on the gap between the average years of male and female education for countries acceding between 1970 and 2015. In other words, gender equality in education, on average, benefits from WTO accession in our study.

6.2. Interpreting the Results from Models 3 and 4

Table 6: Regression Outputs, Models 3 and 4

Compiled by the authors using the *p/m()* function with HAR standard errors in RStudio

	<i>Dependent variable:</i>			
	FEA _{i,t+5} (Reg 5)	GEG _{i,t+5} (Reg 6)	FEA _{i,t+5} (Reg 7)	GEG _{i,t+5} (Reg 8)
WTO member	0.051** (0.022)	-0.044*** (0.011)	0.033 (0.022)	-0.034*** (0.011)
Trade intensity (ln)			0.121*** (0.010)	-0.065*** (0.005)
GDP per capita (ln)	0.209*** (0.012)	-0.101*** (0.006)	0.273*** (0.013)	-0.135*** (0.007)
Population (ln)	-0.529*** (0.038)	0.348*** (0.020)	-0.458*** (0.038)	0.310*** (0.020)
Fertility rate	-0.353*** (0.009)	0.115*** (0.005)	-0.348*** (0.009)	0.112*** (0.005)
Female suffrage years (ln)	0.040*** (0.014)	-0.048*** (0.007)	0.044*** (0.013)	-0.050*** (0.007)
Communist state	0.168*** (0.031)	-0.025 (0.016)	0.167*** (0.031)	-0.024 (0.016)
Developing country	0.013 (0.015)	-0.003 (0.008)	0.015 (0.015)	-0.004 (0.008)
WTO member × Developing	-0.018 (0.019)	0.002 (0.010)	-0.021 (0.018)	0.003 (0.010)
Fixed effects	Entity, Time	Entity, Time	Entity, Time	Entity, Time
Observations	6,295	6,295	6,295	6,295
R2	0.248	0.163	0.265	0.183
Adjusted R2	0.220	0.132	0.237	0.152
F Statistic	250.344*** (df = 8; 6065)	148.085*** (df = 8; 6065)	242.640*** (df = 9; 6064)	150.462*** (df = 9; 6064)

Note:

*p<0.1; **p<0.05; ***p<0.01

6.2.1. Female Educational Attainment in Models 3 and 4

Output Interpretation

Table 6, columns 1 and 3, correspond to Regs 5 and 7, which examine the ATT of WTO accession between 1970 and 2015 on the average years of female education using Models 3 and 4, respectively. Critically, we also test for heterogeneity between developed and developing countries.

In Reg 5, the DID estimator for WTO accession is positive and significant at the 5% level. Followingly, the interpretation is that WTO accession, on average, is associated with an increase in the average years of female education by 0.051 years (~19 days), *ceteris paribus*. This estimate is higher than in Reg 1, meaning that controlling for development status does alter the correlation between WTO accession and female educational attainment. This dynamic also holds for Reg 7 relative to Reg 3 (including TI_{it}).

In both Regs 5 and 7, the interaction terms for $Dev_{it} \times WTO_{it}$ are negative, implying that developing countries that ascend to the WTO experience an increased reduction in the average years of female education by 0.018 years (~7 days) and 0.021 years (~8 days) as compared to developed countries, respectively. Nevertheless, these estimates are insignificant. Thus, we cannot causally infer that there is heterogeneity between developed and developing countries in our model for female educational attainment.

Hypotheses 1 and 3

Given that all results in this subsection correspond in direction and significance to the results presented in 6.1.1, and only alter the magnitudes, the non-rejection of H_1 is still valid.

Furthermore, H_0^3 cannot be rejected. Despite that the increased magnitudes, compared to Models 1 and 2, indicate that development status alters the relationship, we cannot establish causality and thus cannot find support for H_3 .

6.2.2. Gender Education Gap in Models 3 and 4

Output Interpretation

Table 6, columns 2 and 4, correspond to Regs 6 and 8, which examine the ATT of WTO accession between 1970 and 2015 on the gender education gap using Models 3 and 4, respectively. Critically, we also test for heterogeneity between developed and developing countries.

For the gender education gap, the DID estimators and the trade intensity control variables in Tables 3 and 4 differ with a maximum of 0.002 years (~1 day) and the significance levels and directions are unaffected. Thus, we argue that the only difference in interpretation is in '*ceteris paribus*', given that we also control for the development level.

Regs 6 and 8 both return positive results for the interaction term, $Dev_{it} \times WTO_{it}$, implying that developing countries that accede to WTO experience an additional increase in the gender education gap, as compared to developed countries, *ceteris paribus*. Nevertheless, these estimates are not significant. Consequently, we cannot causally infer that there is heterogeneity between developed and developing countries in our model for the gender gap in education.

Hypotheses 2 and 4

Following the results presented in this section, the rejection of H_0^2 from 6.1.2 is still valid.

Moreover, H_0^4 cannot be rejected. Thus, we do not find support for H_4 .

6.3. Summary of Hypotheses Support

Table 7: Summary of Hypotheses Support

Hypothesis	Status
H ₁	Not supported
H ₂	Supported
H ₃	Not supported
H ₄	Not supported

6.4. Goodness-of-Fit, R^2

We obtain low R^2 and adjusted R^2 coefficients for all regressions, implying that the model specification only partially captures the variability in the dependent variables (Taylor, 2020). Nevertheless, we argue that this does not mean our model specification lacks. In Appendix H, we use the Hausman test to infer that our model specifications, which use *fixed effects*, yield more consistent estimators than the equivalent model specifications with *random effects* (Baltagi, 2021; Hausman, 1978). However, as we use the equivalent models with random effects in Appendix I, the reported R^2 are significantly higher. Conclusively, a low R^2 statistic does not necessarily imply a poor choice of model specifications in terms of consistency.

6.5. Sensitivity Analyses

We have performed two sensitivity tests to test our results' robustness. The first sensitivity analysis relaxes the assumption of a five-year lead for our dependent variables. The second sensitivity analysis relaxes the assumption that GATT membership is an appropriate proxy for WTO membership. With both sensitivity tests, we aim to examine whether relaxing these assumptions alters the results significantly, thus making our model vulnerable to assumptions.

6.5.1. Sensitivity Test I: Number of Lead Years in the Dependent Variable

In Appendix J, we relax the assumption that WTO accession will affect educational attainment in five years. We change our baseline regression (Model 1) to include no leads, as well as two, four, six, eight and ten lead years. The results (see Appendix J) indicate that a five-year lead is a well-suited choice, and that changing the leads does not alter the model's result significantly. Consequently, the model is robust to this assumption.

6.5.2. Sensitivity Test II: Using GATT as a Proxy for WTO

In Appendix K, we test the assumption that GATT accession is a suitable proxy for WTO accession for the years before 1995. By distinguishing between WTO and GATT in our baseline regression (Model 1), we see that the direction and significance levels indicate equivalent results to our baseline model. Nevertheless, we identify indications of time-dynamic effects of WTO accession. Nevertheless, standard DID cannot capture any anticipation effects or otherwise time-dynamic effects, as we expand on in 8.1. Conclusively, we argue that using GATT as a proxy does not impair the study results if we consistently refer to the ATT.

7. Discussion

This section contextualises the analysis presented in Section 6 with concepts and literature from Section 2. Moreover, we establish the implications of the study's result and our contribution.

Section 6 finds that WTO accession, on average, is inversely associated with the gender education gap, thus supporting H₂. These results align with other panel data studies on trade liberalisation and female education, like Iqbal et al. (2020), Schultz (2006) and Gray et al. (2006), and national-level studies like Nano et al. (2021), Atkin (2016) and Heath and Mushfiq Mobarak (2015). Our results contrast with those found in Williams (2024) and Ul-Haq et al. (2023).¹⁵ Relative to the literature base we have found, our study is novel in finding any gender effects in education after WTO accession, similar to how Gray et al. (2006) found that CEDAW membership was positive for female educational attainment and inversely associated with the gender education gap. From our results, several vital implications arise.

A critical implication of this study's support for H₂ is that the effect of WTO accession on education is heterogeneous between the genders as the gap education gap decreases.¹⁶ The heterogeneity that we find confirms the argument in Elson (1993) that it is unwise to treat all groups as 'economic men'. Moreover, by interpreting this heterogeneity in the language of the WTO's sceptics (see 2.1.2), treating trade liberalisation as a gender-neutral phenomenon in the WTO would be equivalent to being gender-blind. Following this, the intent of the WTO to gender mainstream in the early 2000s seems appropriate, given our results. Even as our study does not find any harmful effects of WTO accession, we conclude that it is critical to employ a gender lens on the WTO's work to foster more inclusive growth and unveil potential side effects that may risk leaving women behind from specific trade interventions.

A second implication of our results is that, in the context of the WTO's objective to facilitate increasing living standards and labour-market opportunities by trade liberalisation, the WTO should work more intensively with gender. All DID coefficients for WTO accession are small, ranging up to only a few weeks' impact, which implies that the effect of becoming a WTO member, on average, is small. Provided the discussion in 2.2.3 on how some women are at risk of being harmed by trade and the discussion in Section 1 on the importance of educating women to achieve inclusive growth, the reported effects are arguably insufficiently minor. Nevertheless, caution should be considered when interpreting the low magnitudes for WTO accession. Critically, in the three-channelled conceptual framework on how trade liberalisation affects human capital accumulation (see 2.2.2), the *income effect*, *skill premium*, and *opportunity cost of education* channels may cancel out each other in the *aggregate effect* (as measured in our study).

Section 6 did not find support for H₁, H₃ or H₄. Critically, this does not imply that there is no effect. Regarding H₁, Schultz (2006), Bussman (2009), and Gray et al. (2006) found improvements in female educational outcomes following trade liberalisation in their cross-country studies, and we have also included studies that show an opposite effect in 2.3. Regarding

¹⁵ We note that these studies use different proxies for trade liberalisation uses and female education, and have different significance levels of their results, across different models in their studies. Consequently, comparability is only moderately high. See Appendix B for an Annotated Literature Review.

¹⁶ This study does not infer *why* there is heterogeneity, albeit 2.2.3 outlines potential explanations.

H₃ and H₄, we hypothesised that developed countries would have benefited more from WTO accession than developing economies in increasing female educational attainment and reducing the gender education gap. Nevertheless, we found no such significant effects in our study. Notably, although Williams (2024) found indications of such heterogeneity, the author's estimates were also insignificant. However, we note that Heath and Mushfiq Mobarak (2015) and Nano et al. (2021) report decreasing levels of the gender education gap for India and Bangladesh, respectively, while Ul-Haq et al. (2023) report an increased gender education gap following trade expansion. Considering that all of these studies focus on developing economies and exhibit different trends for gender-specific education outcomes, and as we found no significant result in our study, a likely implication is that the nature of the trade expansion, rather than the development status, is essential to study. Indeed, Blanchard and Olney (2017) reported that trade expansion's effect on education differed depending on countries' composition of skill in imports and exports. In our study, spanning 45 years and 182 countries, the lack of data hindered us from such a model extension.

8. Limitations

8.1. Staggered Effects

This paper applies a standard DID setup (see 5.3) to a staggered treatment, WTO accession. The standard DID model is common when studies deal with treatments or interventions that have roll-out designs or staggered treatments (Baker et al., 2022). Nevertheless, Borusyak et al. (2018) were the first to note that this application introduces threats to internal validity and also alters interpretability. While the standard DID set-up compares the means of entities belonging to the control and treatment groups before and after treatment, a study with staggered treatments does not feature a uniform *before* and *after* period. Thus, the reported DID estimators must be treated as an average treatment effect on the treated (ATT) for all periods. To illustrate why this is a problem, we can consider our example with WTO accession. A country that acceded to the WTO (GATT) in 1971, like Romania (see Appendix C), is unlikely to experience equivalent effects of WTO accession on female educational attainment as Vietnam, which acceded in 2007, given the anticipation effects of WTO membership. Indeed, Appendix K indicates larger effects in all models when excluding the GATT years, meaning the effects are higher after 1995. Even without anticipation effects, which would introduce bias, the effect of WTO membership is unlikely linear, given that the scope and network effects within WTO change over time. The second problem is that, given that countries belonging to the control group may switch to the treatment group, the control group may not provide a suitable counterfactual to the treatment group, which decreases the ability to make causal inferences (Baker et al., 2022).

For our study, we apply the standard DID set-up but adjust our interpretations and inferences with the insights highlighted in this section. The main argument for not using any alternative methods, like event study DID (c.f. Borusyak et al., 2018; Callaway & Sant'Anna, 2021; Li, 2022) is that these methods are new and require robust assumptions that are difficult to satisfy given our study scope. Moreover, the interpretability of the regression may suffer from alternative modelling designs. For instance, for the effect of WTO accession on female education, event-study DID would require us to interpret the results in terms of leads and lags to account for the

time-dynamic nature of acceding to the WTO in different periods. Consequently, this makes it difficult to ascribe any straightforward interpretations of the impact of WTO accession. Conclusively, we refrain from using event study DID in our main study. However, we employ the event study DID, as outlined in Li (2022), to help test for violations of the parallel trends assumption (see 5.4 and Appendix G).

8.2. Endogeneity Concerns

Some control variables in our study risk introducing bias in our model. For FR_{it} , there are indications of reverse causality with female educational attainment (c.f. Götmark & Andersson, 2020; Impicciatore & Tomatis, 2020). Nevertheless, as we believe that it is critical to include FR_{it} , given the *opportunity cost of education*-channel outlined in 2.2.3, and as it is included in previous literature investigating similar relationships (c.f. Yin & Choi, 2023), we argue that the bias from omitting this variable is larger than the bias that arises from including it. Moreover, reverse causality is also a problem for TI_{it} , as education may affect trade intensity. Previous literature (c.f. Frankel & Romer, 1999; Williams, 2024) uses an instrumental variable approach to solve this problem. For our study, TI_{it} is only control variable, and we will only examine its effects in conjunction with WTO_{it} .

8.3. Missing Data and Unbalanced Panels

Using panel data from 45 years and 182 countries presents the problem with some non-random missing data (MNAR).¹⁷ For instance, we encounter missing data as we include newly-independent states. While we acknowledge that MNAR is a limitation of our model, we argue that our model specification is not disproportionately affected as all panel data studies face this issue when studying a period where countries cease to exist. Conclusively, we argue that the non-randomness is not due to anything that will significantly influence the associations in our model.

To address MNAR, studies may extrapolate data, such as by some weighing technique that assigns parts of a data point of the former state to the new state for the years before the new state's creation. Nevertheless, extrapolation techniques require robust assumptions and thus risk introducing significant bias (Cole, 2008). Thus, we have instead decided to include data on the new countries for the years since they gained independence. In Appendix C, we show that all countries have at least two non-WTO years prior to accession. Following this, including these states still allows the DID estimate to capture variability in the data before and after accession.

9. Future Study Areas

This section outlines future study areas and possible methodological extensions to our study. Inspired by Sections 7 and 8, further studies may adjust our model specification to address methodological challenges or expand on areas where this study did not go into detail. First, while this study uses a DID estimator to capture the *aggregate effect* of all three channels proposed in 2.2.2, future studies may incorporate these channels in one dynamic model, or study them

¹⁷ van Buuren (2021) outlines three types of missing data: MNAR (Missing Not at Random), MAR (Missing at Random) and MCAR (Missing Completely at Random). MNAR causes concern for the internal validity, and must therefore be treated or otherwise argued for.

independently, provided sufficient data is available. Integrating the channels explicitly in a model would require more data points, but may achieve higher specificity in describing the association between WTO accession and female schooling. We note that doing so should be possible, as Blanchard and Olney (2017) and Williams (2024) have distinguished between different labour market effects between trade liberalisation and education in their studies. Moreover, Liu (2023) specifically uses the framework of the World Bank and the WTO (2020), which we outline in 2.3.

To study the time-dynamic nature of WTO accession and simultaneously reduce the threats of staggered effects, a second extension of our model could be an event study DID design, using the model outlined in Li (2022). Thirdly, as significant advancement in terms of gender mainstreaming in the WTO occurred after our study period, like the *Joint Declaration on Trade and Women's Economic Empowerment* and gender provisions in free trade agreements (see 2.1.2), future studies may expand or focus the study period beyond 2015 to assess the relative impact of these interventions. Lastly, instrumentation could be an option to address endogeneity concerns with variables such as trade intensity and fertility, provided suitable instrumental variables are identified.

10. Concluding Remarks

This study has examined the effect of WTO accession on female educational attainment and the gender education gap. We have first outlined a conceptual framework on the association between trade liberalisation and human capital accumulation in education through three labour market channels: the *skill premium*-channel, the *opportunity cost of education*-channel and the *income effect*-channel. Moreover, we add gender-related considerations to each channel using wisdom from several feminist scholars. Furthermore, we collect data on gender-disaggregated levels of educational attainment for 182 countries between 1970 and 2015, as well as data on various confounding societal and macroeconomic factors that female's propensity to invest in education. Subsequently, we develop eight DID regressions that assess the ATT of all countries joining the WTO between 1970 and 2015 to answer the following research questions:

Does accession to the WTO, which works for trade liberalisation by facilitating trade agreements and harmonised global trade rules, impact female educational attainment and the gender education gap?

Our initial DID regression results (Model 1) suggest a small, positive effect of WTO accession, on average, on female educational attainment in terms of average years of female education, and an inverse relationship to the gender education gap. Nevertheless, as we control for the trade intensity (Model 2), the proposed relationship is only significant for the association between WTO accession and the gender education gap. Our interpretation is that the effect of WTO accession on the gender education gap goes *beyond* countries' changes in trade openness, meaning a separate impact of WTO as an organisation. However, we cannot discern such an effect on female educational attainment. Furthermore, as we control for the development status of the countries included in our sample (Models 3 and 4), we find no heterogeneous effects of WTO accession between developed and developing countries. Using insights from the three-channel conceptual framework, we argue that the relationship may depend on the nature of trade expansion (skilled or unskilled) after WTO accession, rather than the development status.

Our results are novel in explaining the heterogeneous impact of WTO accession on education between the genders. Although the reported estimates are small, the study adds value to the debate on the relative impact of the WTO as the leading organisation facilitating trade liberalisation, in the light of concerns that it does not see gendered effects of trade liberalisation. Thus far, our results indicate that WTO's efforts are not harmful but insufficient, provided WTO's objective is to benefit not only trade capacity and economic growth, but also living standards and labour-market opportunities (see 2.1.1).

Based on our findings and the limitations of our model (including staggered effects), we recommend four extensions of our model. First, we propose studying the *skill premium*, *opportunity cost of education* and *income effect*-channels separately, to unveil the multi-layered dynamics of trade liberalisation after WTO accession. Secondly, we suggest using an event study DID design to explore the time-dynamic nature of WTO accession. Third, we recommend extending or focusing the study period beyond 2015 to analyse the effect of WTO's new gender mainstreaming initiatives. Lastly, we propose instrumentation for some of the control variables.

11. Declaration of Interests

The authors of this paper declare that they are not affiliated with any individual or party with an agenda to promote or discourage trade liberalisation or the WTO. Moreover, the authors declare that they have no financial or other conflicts of interest.

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13. Appendices

Appendix A: Declaration on Generative AI

This paper does not include text, illustrations, code, or other material produced by generative AI. All tools used in producing this paper were given pre-approval by the paper's supervisor, Anders Olofsgård, via email.

We used Grammarly (as an add-in program in Word) and Word's word-processing tools for text processing. The use of these text processing programmes focused on increasing correctness, consistency, and clarity by removing grammatical errors and other text errors, such as fragmented sentences, slang, or inconsistent use of British and American English.

ChatGPT 3.5 and 4.0 were used only to enhance the authors' understanding of concepts and to generate Boolean commands, which was given as a recommendation by SSE Library on Jan 16th 2024. ChatGPT was not used to produce content, collect data, or find articles. All text is written by us, the authors, and the article and data collection were conducted manually through databases or other manual search methods. Thus, we argue that the interaction with generative AI and its impact and risks are extremely limited. Lastly, we argue that using generative AI, as stated in this section, has enhanced our understanding and increased efficiency. For instance, letting ChatGPT generate Boolean commands enabled us to research databases with a higher degree of precision, which helped us find the first couple of articles. Nevertheless, we find that using AI as an information source is unsustainable and potentially unethical.

Appendix B: Annotated Literature Review

Table 8: Annotated Literature Review¹⁹

Report type	Report	Country, Years studied; (Intervals)	Method and Main Results
Cross-regional panel data (National level)	Nano et al. (2021)	India; 1987-1999 (annual)	IV (reported as main findings): Partially trade-induced growth in the services sector (in treated districts) between 1987 and 1999 is associated with an increase in the average years of education (both genders) of 4.4%, or 42 days ($p < 0.05$). Moreover, the decline in the gender education gap was 8.3% ($p < 0.01$). 3SLS: Effects are significant and have the same direction as the IV results but have a lower magnitude.
	Atkin (2016)	Mexico; 1986-2000 (annual) Note: Uses net new export per worker at age 16 as their independent variable	IV: The average years of cohort gender-specific schooling decreased for men and women by 4.4 and 2.5 years, respectively. (P: not reported). Following that, the gender gap decreased by 1.9 (4.4-2.5) years. Nevertheless, the gender education gap is not tested as a separate regression.
	Ul-Haq et al. (2023)	Pakistan; 1990-2015 Note: Uses the age cohort 25 years and above, whereas our study uses the age cohort 15-24. Moreover, this study defines trade openness as the average tariff on all industries, weighted by the fraction of labour in a particular industry relative to the labour force.	FGLS: An increase in trade liberalisation by removing 1% of import tariffs is associated with a 0.0268 percentage point increase in the gender education gap ($p < 0.01$). Absolute levels of education were not reported. PCSE: 0.024 increase in gender educational gap ($p < 0.01$)
	Heath & Mushfiq Mobarak (2015)	Bangladesh; 1983-2009 (annual)	OLS: Each year of exposure to garment factories (export-oriented) is associated with 0.26 years ($p < 0.01$) of increased

¹⁹ Table 8 refers only to the literature reviewed in section 2.3, as these studies are closest in scope to our study.

			average education across the genders and an additional 0.22 ($p<0.01$) years more for females. For example, the authors' findings indicate that an 8-year-old girl is 13% more likely to attend school after the women of her village have begun working in the garment industry. The average year of exposure to the garment industry is reported to be 6.8 years. Consequently, the authors calculate an average 1.5-year decline in the gender education gap.
Report type	Report	Number. of countries studied; years studied (intervals)	Main result
Cross-country panel data	Iqbal et al. (2020)	12; 1990-2013 (annual)	GLS: A percentage point increase in trade ratio increased the female-to-male ratio in schooling years by 0.001 % ($p<0.01$). No absolute measures were reported.
	Schultz (2006)	44-70; 1965-1980 (quinquennial)	IV: An increase in the rates of tariffs or quotas in a country is associated with a decline in the years of expected enrolment for both females and males. However, trade-related policies affect women more than men. Put reversely, trade liberalisation is beneficial for the expected years of education for both genders, but it is more beneficial for women than for men. Given the results, no conclusion can be drawn regarding the gender education gap.
	Blanchard and Olney (2017)	102; 1965-2010 (quinquennial)	IV: The authors report mixed results as the study separates imports and exports (the aggregate effect of trade depends on labour composition and import-export balance). For the average years of schooling, males are more

			responsive to changes in exports. On average, a percentage change in skilled-intensive exports increases schooling for men (women) by 0.301 (0.289) years. Unskilled exports, particularly agricultural exports, decrease the average years of schooling for men more than for women. On average, a percentage change in agricultural exports (unskilled-intensive exports) decreases schooling with 0.709 (0.413) years for men and 0.597 (0.165) years for women. All p-values are below 5%, except for female unskilled-intensive exports, which is insignificant.
	Williams (2024)	109; 1965-2015 (quinquennial)	IV: A percentage increase in trade openness decreases the average years of female schooling by 0.507 years ($p < 0.05$) and by 0.208 years for males ($p < 0.05$). The gender inequality estimate is not significant. Moreover, the author reports strong indications that developing countries decrease their female schooling and increase the gender education gap more than developed countries. Nevertheless, this effect is not significant.
	Bussmann (2009)	134; 1970-2000 (quinquennial) Note: The enrolment ratio is used as a measure of education.	GMM, IV: On average, a one per cent change in trade intensity is associated with a 5.177 percentage points increase in the female primary school enrolment ratio ($p < 0.1$). There is no significant effect for female secondary school or tertiary school enrolment, and there is no significant effect of trade liberalisation for the gender gap in education.
	Gray et al. (2006)	180; 1975-2000 (quinquennial)	IV: A percentage increase in trade intensity is, on average, associated with a 2.19 percentage points

		Note: uses female illiteracy as a measure of education.	decrease in illiteracy levels ($p < 0.1$). The gender equality in literacy is increased by 1.29 percentage points ($p < 0.05$), meaning that women decrease their illiteracy rates more than male. Moreover, CEDAW membership positively correlates with increased female literacy levels and a decreased gender gap. By controlling for cultural differences (religion, history with women's suffrage) between countries, the illiteracy coefficients become insignificant for trade intensity, but CEDAW membership is still significant.
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Appendix C: Index of Countries in the Data Sample

Table 9: Index of Countries in Sample, by GATT/WTO Accession and Development Status²⁰
Compiled by the authors. Sources: (UN, 2023; WTO, n.d.-c, n.d.-e)

Developing countries			Developed countries		
Country	GATT	WTO	Country	GATT	WTO
Afghanistan	-	2016	Albania	-	2000
Algeria	-	-	Andorra	-	-
Angola	1994	1996	Antigua and Barbuda	1987	1995
Bangladesh	1972	1995	Argentina	1967	1995
Benin	1963	1996	Armenia	-	2003
Bhutan	-	-	Australia	1948	1995
Bolivia	1990	1995	Austria	1951	1995
Burkina Faso	1963	1995	Azerbaijan	-	-
Burundi	1965	1995	Bahrain	1993	1995
Cambodia	-	2004	Barbados	1967	1995
Cameroon	1963	1995	Belarus	-	-
Cape Verde	-	2008	Belgium	1948	1995
Central African Republic	1963	1995	Belize	1983	1995
Chad	1963	1996	Bosnia and Herzegovina	-	-
Comoros	-	-	Botswana	1987	1995
Congo	1963	1997	Brazil	1948	1995
Côte d'Ivoire	1963	1995	Brunei	1993	1995
Djibouti	1994	1995	Bulgaria	-	1996
DR Congo	1971	1997	Canada	1948	1995
Egypt	1970	1995	Chile	1949	1995
Eritrea	-	-	China	-	2001
Ethiopia	-	-	Colombia	1981	1995
Ghana	1957	1995	Costa Rica	1990	1995
Guinea	1994	1995	Croatia	-	2000
Guinea-Bissau	1994	1995	Cuba	1948	1995
Haiti	1950	1996	Cyprus	1963	1995
Honduras	1994	1995	Czech Republic	1993	1995
India	1948	1995	Denmark	1950	1995
Iran	-	-	Dominica	1993	1995
Jordan	-	2000	Dominican Republic	1950	1995
Kenya	1964	1995	Ecuador	-	1996
Kiribati	-	-	El Salvador	1991	1995
Kyrgyzstan	-	1998	Equatorial Guinea	-	-
Laos	-	2013	Estonia	-	1999
Lebanon	-	-	Fiji	1993	1996
Lesotho	1988	1995	Finland	1950	1995

²⁰ Note that Table 9 reports development status by July 1st 2022. Nevertheless, Dev_{it} indicates the developing status country i at time t . Consequently, development status is not static in our regressions.

Liberia	-	2016
Madagascar	1963	1995
Malawi	1964	1995
Mali	1993	1995
Mauritania	1963	1995
Mongolia	-	1997
Mozambique	1992	1995
Myanmar	1948	1995
Nepal	-	2004
Nicaragua	1950	1995
Niger	1963	1996
Nigeria	1960	1995
North Korea	-	-
Pakistan	1948	1995
Papua New Guinea	1994	1996
Philippines	1979	1995
Rwanda	1966	1996
Samoa	-	2012
São Tomé and Príncipe	-	-
Senegal	1963	1995
Sierra Leone	1961	1995
Solomon Islands	1994	1996
Somalia	-	-
South Sudan	-	-
Sri Lanka	1948	1995
Sudan	-	-
Swaziland	1993	1995
Syria	-	-
Tajikistan	-	2013
Tanzania	1961	1995
The Gambia	1965	1996
Timor-Leste	-	-
Togo	1964	1995
Tunisia	1990	1995
Uganda	1962	1995
Ukraine	-	2008
Uzbekistan	-	-
Vanuatu	-	2012
Vietnam	-	2007
Yemen	-	2014
Zambia	1982	1995
Zimbabwe	1948	1995

France	1948	1995
Gabon	1963	1995
Georgia	-	2000
Germany	1951	1995
Greece	1950	1995
Grenada	1994	1996
Guatemala	1991	1995
Guyana	1966	1995
Hungary	1973	1995
Iceland	1968	1995
Indonesia	1950	1995
Iraq	-	-
Ireland	1967	1995
Israel	1962	1995
Italy	1950	1995
Jamaica	1963	1995
Japan	1955	1995
Kazakhstan	-	2015
Kuwait	1963	1995
Latvia	-	1999
Libya	-	-
Lithuania	-	2001
Luxembourg	1948	1995
Macedonia	1966	2003
Malaysia	1957	1995
Maldives	1983	1995
Malta	1964	1995
Mauritius	1970	1995
Mexico	1986	1995
Moldova	-	2001
Montenegro	1966	2012
Namibia	1992	1995
Netherlands	1948	1995
New Zealand	1948	1995
Norway	1948	1995
Oman	-	2000
Panama	-	1997
Paraguay	1994	1995
Peru	1951	1995
Poland	1967	1995
Portugal	1962	1995
Qatar	1994	1996
Romania	1971	1995
Russia	-	2012
Saudi Arabia	-	2005
Serbia	-	-

		Seychelles	-	2015
		Singapore	1973	1995
		Slovakia	1993	1995
		Slovenia	1994	1995
		South Africa	1948	1995
		South Korea	1967	1995
		Spain	1963	1995
		St. Lucia	1993	1995
		St. Vincent and the Grenadines	1993	1995
		Suriname	1978	1995
		Sweden	1950	1995
		Switzerland	1966	1995
		Thailand	1982	1995
		The Bahamas	-	-
		Tonga	-	2007
		Trinidad and Tobago	1962	1995
		Turkey	1951	1995
		Turkmenistan	-	-
		United Arab Emirates	1994	1996
		United Kingdom	1948	1995
		United States	1948	1995
		Uruguay	1953	1995
Total (developing)	78 countries	Total (developed)	104 countries	

Appendix D: Breusch-Pagan Test (Heteroskedasticity)

Table 10: Breusch-Pagan Output
Compiled by the authors using the *bptest()* function in RStudio

	Reg 1	Reg 2	Reg 3	Reg 4	Reg 5	Reg 6	Reg 7	Reg 8
BP	3.2543	16.897	4.1873	18.0810	4.0392	22.3480	4.9786	23.5080
df	6	6	7	7	8	8	9	9
p-value	0.7763	0.0097	0.7580	0.0116	0.8536	0.0043	0.8362	0.0052

H_0 : Heteroskedasticity is not present.

H_1 : Heteroskedasticity is present.

Analysis: We use the Breusch-Pagan test to test for indications of heteroskedasticity. We reject the null hypothesis for Regs 2, 6 and 8 at the 1% level and Reg 4 at the 5% level, meaning that heteroskedasticity is present (Breusch & Pagan, 1979; Koenker, 1981). To help the problem with heteroskedasticity, we perform all regression with HAR standard errors (Kiefer & Vogelsang, 2002; Stock & Watson, 2020); see 5.4.

Appendix E: Panel Data Durbin-Watson Test (Autocorrelation)

Table 11: Panel Data Durbin-Watson Output
Compiled by the authors using the *pdwtest()* function in RStudio

	Reg 1	Reg 2	Reg 3	Reg 4	Reg 5	Reg 6	Reg 7	Reg 8
DW	0.1620	0.1652	0.1633	0.1672	0.1625	0.1654	0.1640	0.1675
p-value	<2.2e-16	<2.2e-16	<2.2e-16	<2.2e-16	<2.2e-16	<2.2e-16	<2.2e-16	<2.2e-16

H_0 : No autocorrelation in the model's residuals.

H_1 : Autocorrelation in the model's residuals.

Analysis: We use the Panel Data Durbin-Watson test to test for autocorrelation in the model's residuals. H_0 is rejected for all eight regressions at the 1% level. These results indicate the presence of autocorrelation in our data (Bhargava et al., 1982). To help the problem with heteroskedasticity, we perform all regression with HAR standard errors (Kiefer & Vogelsang, 2002; Stock & Watson, 2020), see 5.4.

Appendix F: Variance Inflation Factors Test (Multicollinearity)

Table 12: VIF Output
Compiled by the authors using the *vif()* function in RStudio

Variable	Regs 1 and 2	Regs 3 and 4	Regs 5 and 6	Regs 7 and 8
WTO membership	1.2395	1.2476	1.2634	1.2683
GDP per capita (ln)	2.2593	2.2622	3.5337	3.5425
Population (ln)	1.2233	1.3231	1.2233	1.3253
Fertility rate	2.5962	2.6616	2.6017	2.6632
Female voting years (ln)	1.4320	1.4445	1.4452	1.4615
Communist state	1.1160	1.1287	1.1160	1.1288
Trade intensity (ln)		1.2242		1.2455
Developing country			2.4742	2.5172

Analysis: We use the Variance Inflation Factors (VIF) to test for multicollinearity between the variables. A VIF factor exceeding 5 indicates multicollinearity issues (Marquardt, 1970; Naimi et al., 2014). The highest VIF factor indicated by the test regards the variable *GDP per capita (ln)* in Reg 7 (3.5337) and Reg 8 (3.5425). Since all estimates are well below the threshold of 5, a VIF analysis concludes that perfect multicollinearity is not an issue for our model

Appendix G: Event Study DID (Parallel Trends Assumption)

Table 13: Event Study DID Output (Model 1)

Compiled by the authors using the *plm()* function with HAR standard errors in R

	<i>Dependent variable:</i>			
	FEA _{i,t+5}		GEG _{i,t+5}	
GDP per capita (ln)	0.209***	(0.012)	-0.108***	(0.007)
Population (ln)	-0.530***	(0.038)	0.387***	(0.021)
Fertility rate	-0.351***	(0.009)	0.121***	(0.005)
Years of female suffrage (ln)	0.029**	(0.014)	-0.032***	(0.007)
Communist state	0.212***	(0.030)	-0.117***	(0.016)
Lag 15+	0.012	(0.019)	-0.006	(0.010)
Lag 14	0.022	(0.029)	-0.012	(0.016)
Lag 13	0.014	(0.030)	-0.006	(0.017)
Lag 12	0.015	(0.033)	-0.009	(0.018)
Lag 11	0.024	(0.029)	-0.012	(0.016)
Lag 10	0.023	(0.030)	-0.009	(0.016)
Lag 9	0.017	(0.029)	-0.009	(0.016)
Lag 8	0.024	(0.028)	-0.010	(0.015)
Lag 7	0.022	(0.028)	-0.008	(0.016)
Lag 6	0.031	(0.028)	-0.014	(0.015)
Lag 5	0.047	(0.029)	-0.023	(0.016)
Lag 4	0.055*	(0.031)	-0.027	(0.017)
Lag 3	0.046	(0.031)	-0.018	(0.017)
Lag 2	0.045	(0.033)	-0.018	(0.018)
Lag 1	0.037	(0.034)	-0.015	(0.018)
Lead 1	0.040	(0.032)	-0.023	(0.017)
Lead 2	0.052	(0.033)	-0.028	(0.018)
Lead 3	0.067**	(0.032)	-0.039**	(0.018)
Lead 4	0.026	(0.032)	-0.031*	(0.017)
Lead 5	0.009	(0.032)	-0.022	(0.017)
Lead 6	-0.009	(0.033)	-0.019	(0.018)
Lead 7	-0.056**	(0.027)	0.007	(0.015)
Lead 8	-0.045*	(0.027)	0.001	(0.015)
Lead 9	-0.060**	(0.028)	0.008	(0.016)
Lead 10	-0.040	(0.029)	0.003	(0.016)
Lead 11	-0.059*	(0.031)	0.013	(0.017)
Lead 12	-0.063**	(0.032)	0.012	(0.017)
Lead 13	-0.055*	(0.032)	0.012	(0.018)
Lead 14	-0.041	(0.033)	0.005	(0.018)
Lead 15+	0.011	(0.013)	-0.001	(0.007)
Fixed Effects	Entity, Time		Entity, Time	
Observations	6,328		6,328	
R ²	0.256		0.169	
Adjusted R ²	0.225		0.134	
F Statistic (df = 35; 6069)	59.726***		35.241***	
Note:	*p<0.1; **p<0.05; ***p<0.01			

Analysis: In Table 13, we employ the event study DID methodology outlined in Li (2022) to test for violations of the parallel trends assumption on our baseline model, Model 1. In short, the event study DID replaces the dummy variable specification in this paper with WTO_{it} , with time lags and leads representing the number of years prior to/since accession to the WTO. In order to out-rule potential pre-trend between the treated countries (WTO members) and non-treated countries (non-WTO members), the coefficients of the lagged variables must be statistically insignificant (Li, 2022). In Table 13, none of the lag variables are significant at the 5% significance level, while a few of the leads are significant. Following this, we have not found support that parallel trends erode the internal validity of our regressions.

Appendix H: Hausman Test (Specification Consistency)

Table 14: Hausman Test Output

Compiled by the authors using the *phptest()* function in RStudio

	Chi-square	df	p-value	Reject H_0
Reg 1	288.23	6	< 2.2e-16	Yes
Reg 2	53.015	6	1.165e-09	Yes
Reg 3	606.16	7	< 2.2e-16	Yes
Reg 4	46.136	7	8.226e-08	Yes
Reg 5	290.19	8	< 2.2e-16	Yes
Reg 6	51.844	8	1.804e-08	Yes
Reg 7	654.75	9	< 2.2e-16	Yes
Reg 8	46.501	9	4.86e-07	Yes

H_0 : A random effects model is preferable over a fixed effects model.

H_1 : A fixed effects model is preferable over a random effects model.

Analysis: Under the null hypothesis, both the fixed effects (FE) estimator and the random effects (RE) estimator are consistent, but the RE estimator is more efficient, indicating that an RE specification is preferable. However, under the alternative hypothesis, the RE estimator is inconsistent (or at least less consistent than the FE estimator), and thus, an FE specification is preferable (Baltagi, 2021; Hausman, 1978). In Table 14, H_0 is rejected for all eight regressions. These results indicate that using a regression model with fixed effects (as we have done, see 5.3), yields more consistency compared to using the same model with random effects.

Appendix I: Random Effects Specification

Table 15: Random Effects Output

Compiled by the authors using the *plm()* function with HAR standard errors in RStudio

	<i>Dependent variable:</i>							
	FEA _{i,t+5} (Reg 1)	GEG _{i,t+5} (Reg 2)	FEA _{i,t+5} (Reg 3)	GEG _{i,t+5} (Reg 4)	FEA _{i,t+5} (Reg 5)	GEG _{i,t+5} (Reg 6)	FEA _{i,t+5} (Reg 7)	GEG _{i,t+5} (Reg 8)
WTO member	0.071 (0.056)	-0.065 (0.056)	0.014 (0.057)	-0.042 (0.056)	0.067 (0.067)	-0.068 (0.066)	0.009 (0.067)	-0.045 (0.067)
Trade intensity (ln)			0.368*** (0.029)	-0.101*** (0.024)			0.374*** (0.029)	-0.101*** (0.023)
GDP per capita (ln)	0.490*** (0.033)	-0.147*** (0.028)	0.688*** (0.033)	-0.170*** (0.027)	0.491*** (0.033)	-0.148*** (0.028)	0.698*** (0.033)	-0.170*** (0.027)
Population (ln)	0.140 (0.090)	0.143* (0.082)	0.341*** (0.089)	0.163** (0.082)	0.142 (0.090)	0.144* (0.083)	0.358*** (0.089)	0.163** (0.082)
Fertility rate	-0.450*** (0.025)	0.137*** (0.025)	-0.444*** (0.025)	0.123*** (0.025)	-0.450*** (0.025)	0.137*** (0.025)	-0.446*** (0.025)	0.123*** (0.025)
Female voting years (ln)	0.233*** (0.040)	-0.090** (0.038)	0.257*** (0.039)	-0.070* (0.038)	0.234*** (0.040)	-0.090** (0.038)	0.263*** (0.039)	-0.070* (0.038)
Communist state	-0.083 (0.092)	0.058 (0.091)	-0.096 (0.092)	0.035 (0.091)	-0.085 (0.092)	0.058 (0.091)	-0.105 (0.092)	0.036 (0.091)
Developing country					0.012 (0.046)	-0.011 (0.046)	0.016 (0.046)	-0.011 (0.046)
WTO member × Developing					0.008 (0.056)	0.004 (0.056)	0.010 (0.056)	0.003 (0.056)
Constant	2.703* (1.502)	-1.089 (1.335)	-1.581 (1.480)	-1.347 (1.324)	2.650* (1.503)	-1.093 (1.338)	-1.942 (1.477)	-1.345 (1.326)
Observations	6,295	6,295	6,295	6,295	6,295	6,295	6,295	6,295
R ²	0.758	0.392	0.721	0.362	0.757	0.392	0.715	0.362
Adjusted R ²	0.758	0.392	0.721	0.362	0.757	0.391	0.715	0.361
F Statistic	739.345 ***	151.938 ***	1,242.931 ***	224.520 ***	742.416 ***	150.045 ***	1,302.820 ***	226.180 ***

Note:

*p<0.1; **p<0.05; ***p<0.01

Analysis: In Table 15, we adjust the *plm()* function to include random effects as opposed to fixed effects. Using a random effects specification yields higher R² and adjusted R² than in Tables 4 and 5, which use two-way fixed effects. We discuss these results in 6.4.

Appendix J: Relaxing the Assumption of Treatment-to-Effect Time

Table 16: Changing Leads in Model 1 (Female Educational Attainment)
Compiled by the authors using the *plm()* function with HAR standard errors RStudio

	<i>Dependent variable:</i>						
	FEA _{i,t} (0 years)	FEA _{i,t+2} (2 years)	FEA _{i,t+4} (4 years)	FEA _{i,t+5} (5 years)	FEA _{i,t+6} (6 years)	FEA _{i,t+8} (8 years)	FEA _{i,t+10} (10 years)
WTO member	0.039** (0.020)	0.040** (0.019)	0.040** (0.019)	0.040** (0.019)	0.038** (0.019)	0.035* (0.018)	0.030* (0.018)
GDP per capita (ln)	0.245*** (0.013)	0.231*** (0.012)	0.217*** (0.012)	0.209*** (0.012)	0.194*** (0.012)	0.165*** (0.012)	0.133*** (0.012)
Population (ln)	-0.635*** (0.040)	-0.588*** (0.039)	-0.547*** (0.038)	-0.529*** (0.038)	-0.507*** (0.038)	-0.460*** (0.039)	-0.402*** (0.040)
Fertility rate	-0.351*** (0.009)	-0.354*** (0.009)	-0.354*** (0.009)	-0.353*** (0.009)	-0.353*** (0.009)	-0.349*** (0.009)	-0.340*** (0.008)
Female voting years (ln)	0.022 (0.014)	0.030** (0.014)	0.037*** (0.014)	0.040*** (0.014)	0.042*** (0.013)	0.043*** (0.013)	0.041*** (0.013)
Communist state	0.198*** (0.033)	0.192*** (0.032)	0.178*** (0.031)	0.168*** (0.031)	0.155*** (0.030)	0.126*** (0.029)	0.095*** (0.028)
Fixed effects	Entity, Time	Entity, Time	Entity, Time	Entity, Time	Entity, Time	Entity, Time	Entity, Time
Observations	6,295	6,295	6,295	6,295	6,137	5,819	5,501
R ²	0.237	0.242	0.246	0.248	0.252	0.258	0.258
Adjusted R ²	0.208	0.213	0.218	0.220	0.224	0.229	0.227
F Statistic	313.472*** (df = 6; 6067)	322.394*** (df = 6; 6067)	330.212*** (df = 6; 6067)	333.694*** (df = 6; 6067)	332.258*** (df = 6; 5910)	324.945*** (df = 6; 5594)	306.445*** (df = 6; 5278)

Note:

*p<0.1; **p<0.05; ***p<0.01

Table 17: Changing Leads in Model 1 (Gender Education Gap)
 Compiled by the authors using the *p/m()* function with HAR standard errors RStudio

	<i>Dependent variable:</i>						
	GEG _{i,t} (0 years)	GEG _{i,t+2} (2 years)	GEG _{i,t+4} (4 years)	GEG _{i,t+5} (5 years)	GEG _{i,t+6} (6 years)	GEG _{i,t+8} (8 years)	GEG _{i,t+10} (10 years)
WTO member	-0.051*** (0.010)	-0.048*** (0.010)	-0.044*** (0.010)	-0.043*** (0.010)	-0.040*** (0.010)	-0.036*** (0.010)	-0.033*** (0.010)
GDP per capita (ln)	-0.113*** (0.006)	-0.108*** (0.006)	-0.104*** (0.006)	-0.101*** (0.006)	-0.095*** (0.006)	-0.084*** (0.006)	-0.073*** (0.006)
Population (ln)	0.354*** (0.020)	0.352*** (0.020)	0.349*** (0.020)	0.348*** (0.020)	0.349*** (0.020)	0.349*** (0.021)	0.339*** (0.021)
Fertility rate	0.100*** (0.005)	0.106*** (0.005)	0.112*** (0.005)	0.115*** (0.005)	0.119*** (0.005)	0.125*** (0.005)	0.129*** (0.004)
Female voting years (ln)	-0.047*** (0.007)	-0.048*** (0.007)	-0.048*** (0.007)	-0.048*** (0.007)	-0.047*** (0.007)	-0.043*** (0.007)	-0.036*** (0.007)
Communist state	-0.036** (0.017)	-0.033** (0.017)	-0.028* (0.016)	-0.025 (0.016)	-0.021 (0.016)	-0.012 (0.016)	-0.001 (0.015)
Fixed effects	Entity, Time	Entity, Time	Entity, Time	Entity, Time	Entity, Time	Entity, Time	Entity, Time
Observations	6,295	6,295	6,295	6,295	6,137	5,819	5,501
R ²	0.154	0.157	0.161	0.163	0.167	0.176	0.181
Adjusted R ²	0.123	0.126	0.130	0.132	0.135	0.143	0.147
F Statistic	184.596*** (df = 6; 6067)	188.673*** (df = 6; 6067)	194.139*** (df = 6; 6067)	197.480*** (df = 6; 6067)	197.601*** (df = 6; 5910)	198.854*** (df = 6; 5594)	194.948*** (df = 6; 5278)

Note:

*p<0.1; **p<0.05; ***p<0.01

Analysis: In the first sensitivity test, we relax the assumption from 5.2.1; that the dependent variable should be leaded five years. In Tables 16 and 17, we use Regs 1-2 from Model 1 (the baseline model) and alter the leads to no lead, two years, four years, six years, eight years and ten years. The original five-year lead is represented in the center-most column in both tables.

Tables 16 and 17 show that the R² does not change drastically between leads. The modest variation R² increases over time, indicating that the most considerable effect of WTO accession on the dependent variables is short-term rather than immediate. Consequently, we argue that leading the dependent variables is suitable. Nevertheless, we note that the significance level drops for leads 8 and 10 for female educational attainment. Thus, we argue that a five-year lead seems to be a suitable trade-off to get the highest R² and significance level. Moreover, the magnitudes and significance levels are equivalent to a five-year lead. Conclusively, we argue that assuming a five-year lead is appropriate and does not erode the robustness of the model.

Appendix K: Evaluating the Use of GATT as a Proxy for WTO

Table 18: Excluding GATT Years (Models 1 and 2)

Compiled by the authors using the *plm()* function with HAR standard errors RStudio

	<i>Dependent variable:</i>			
	Female educational attainment (Reg 1)	Gender education gap (Reg 2)	Female educational attainment (Reg 3)	Gender education gap (Reg 4)
WTO membership (excl. GATT)	0.065*** (0.022)	-0.076*** (0.012)	0.064*** (0.022)	-0.076*** (0.011)
Trade intensity (ln)			0.122*** (0.010)	-0.066*** (0.005)
GDP per capita (ln)	0.209*** (0.012)	-0.101*** (0.006)	0.274*** (0.013)	-0.136*** (0.007)
Population (ln)	-0.523*** (0.038)	0.341*** (0.020)	-0.454*** (0.038)	0.304*** (0.020)
Fertility rate	-0.361*** (0.009)	0.124*** (0.005)	-0.355*** (0.009)	0.121*** (0.005)
Female voting years (ln)	0.042*** (0.014)	-0.050*** (0.007)	0.046*** (0.013)	-0.052*** (0.007)
Communist state	0.163*** (0.031)	-0.020 (0.016)	0.165*** (0.031)	-0.021 (0.016)
Fixed effects	Entity, Time	Entity, Time	Entity, Time	Entity, Time
Observations	6,295	6,295	6,295	6,295
R ²	0.249	0.167	0.266	0.187
Adjusted R ²	0.221	0.136	0.238	0.156
F Statistic	334.593*** (df = 6; 6067)	202.364*** (df = 6; 6067)	313.278*** (df = 7; 6066)	199.311*** (df = 7; 6066)

Note:

*p<0.1; **p<0.05; ***p<0.01

Table 19: Excluding GATT Years (Models 3 and 4)Compiled by the authors using the *plm()* function with HAR standard errors RStudio

	<i>Dependent variable:</i>			
	Female educational attainment (Reg 5)	Gender education gap (Reg 6)	Female educational attainment (Reg 7)	Gender education gap (Reg 8)
WTO membership (excl. GATT)	0.077*** (0.025)	-0.081*** (0.013)	0.076*** (0.025)	-0.081*** (0.013)
Trade intensity (ln)			0.122*** (0.010)	-0.066*** (0.005)
GDP per capita (ln)	0.210*** (0.012)	-0.102*** (0.006)	0.274*** (0.013)	-0.137*** (0.007)
Population (ln)	-0.524*** (0.038)	0.342*** (0.020)	-0.454*** (0.038)	0.304*** (0.020)
Fertility rate	-0.361*** (0.009)	0.124*** (0.005)	-0.355*** (0.009)	0.121*** (0.005)
Female voting years (ln)	0.042*** (0.014)	-0.050*** (0.007)	0.046*** (0.013)	-0.052*** (0.007)
Communist state	0.162*** (0.031)	-0.019 (0.016)	0.164*** (0.031)	-0.020 (0.016)
Developing country	0.019* (0.011)	-0.009 (0.005)	0.021** (0.010)	-0.009* (0.005)
WTO member × Developing	-0.020 (0.019)	0.008 (0.010)	-0.019 (0.019)	0.008 (0.010)
Fixed effects	Entity, Time	Entity, Time	Entity, Time	Entity, Time
Observations	6,295	6,295	6,295	6,295
R ²	0.249	0.167	0.266	0.187
Adjusted R ²	0.221	0.136	0.238	0.157
F Statistic	251.430*** (df = 8; 6065)	152.086*** (df = 8; 6065)	244.194*** (df = 9; 6064)	155.379*** (df = 9; 6064)

Note:

*p<0.1; **p<0.05; ***p<0.01

Analysis: In the second sensitivity test, we relax the assumption from 5.2.2 that we can use GATT accession as a proxy for WTO accession for the years before 1995. In Tables 18 and 19, we exclude GATT accessions from the WTO_{it} variable. First, the R^2 coefficients are similar to the original model specification. Second, as the magnitude for WTO accession in Tables 18 and 19 compared to the original model, there is an indication of time dynamic effects of WTO accession. In other words, those who accede in the years between 1995 and 2015 face a higher effect on the dependent variables than those who accede in any period between 1970 and 2015, which means that there is variation in the magnitude of WTO accession between the cohorts acceding between 1970 and 1995 and between 1995 and 2015. Time-dynamic effects may also exist in the subperiods between 1995 and 2015. As this is a limitation of our model, we discuss using time-dynamic DID models in 8.1 and recommend controlling for this as an extension to our study (see Section 9). However, we still argue that we can use GATT to get an ATT if we note that we are making inferences for the period between 1970 and 2015.