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The effect of trade on the gender gap in labour markets: the moderating role of information and communication technologies

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ABSTRACT

This study analyses the impact of international trade on the gender gap in labour force participation while considering the moderating role of information and communication technologies (ICT). Our analyses of panel data from 79 developing economies over 2006–2019 reveal that international trade narrows gender gap, and the interaction between trade and ICT is likely to widen it. Further, the impact of these two parameters on the gender gap varies across economies by development level and region. Developing economies should strategically focus on trade promotion and adopt gender-equitable ICT development policies to narrow gender gap.

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1. Introduction

A high female labour force participation rate (FLFPR) can promote a country's economic development by increasing labour supply and productivity. A rising level of trade openness could expand the traded goods and services sectors, and create new employment opportunities (Cooray, Dutta, & Mallick, 2017). However, these benefits of trade may be gendered.

On the one hand, the gender equality effect of trade has been predicted by the Stolper–Samuelson theorem within Heckscher–Ohlin trade theory: A country will specialise in production and exports based on its abundantly endowed factor, and import scarce factor goods; the country's abundant factor owners gain from trade, while its scarce factor owners lose. In developing countries, international trade increases demand for their relatively abundant unskilled labour, where women account for the majority of unskilled labour force (The World Bank, 2020). In such countries, the wages and incomes of the female labour force will increase relative to

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that of the male labour force with a comparatively higher skill set. Besedeš, Lee, and Yang (2021), Cooray et al. (2017), Fatima and Khan (2019) and Kis-Katos, Pieters, and Sparrow (2017) suggest that trade has a positive impact on narrowing the gender gap in labour markets (hereinafter: gender gap).

On the other hand, the gender inequality effect of trade is described by the skill-based technological change hypothesis, which suggests a shift in the relative demand for more skilled workers. Trade liberalisation causes local companies to increase technology imports to combat rising competition. However, technological upgrades save labour costs and increase skilled workers' premium, resulting in a growing gap in wages and employment between skilled and unskilled workers. Cultural norms and gender-based discrimination restrict women's access to education and skills upgrade (Schouten, 2019), which is disadvantageous to them during trade-related technological changes. Cooray, Gaddis, and Wacker (2012), Kı zı lı rmak, Memiş, Saraçoğlu, and Voyvoda (2014), Meschi, Taymaz, and Vivarelli (2016) and Saure and Zoabi (2014) acknowledge this negative trade impact on FLFPR, which widens the gender gap.

Additionally, ICT is transforming the international trade landscape by connecting global businesses with consumers and expertly managing global value chains (Organisation for Economic Co-operation & Development, 2017a). This trend will affect labour, specifically the mode, quantity, and quality of jobs (OECD, 2017b). The interaction between ICT and trade may widen or narrow gender gap through the following mechanisms. First, a rise in ICT usage reduces transaction and trade costs (Fernandes, Mattoo, Nguyen, & Schiffbauer, 2019; Freund & Weinhold, 2004; Lendle, Olarreaga, Schropp, & Vézina, 2016; Yin & Choi, 2022a). The reduction in trade costs promote expansion of trade activities, which then provides women more opportunities to participate in global economic activities. Second, ICT removes time and mobility restrictions, enabling women traders to do business in different locations with flexible timing (World Trade Organisation, 2018). Third, the rise of digital transformation contributes to the rapid growth of online services sectors such as financial and customer services (Kireyeva, Kredina, Vasa, & Satpayeva, 2021; Nath & Liu, 2017; OECD, 2018a; Yin & Choi, 2022b). This growth provides more job opportunities for women, who have a comparative advantage over men in jobs requiring more non-routine and interactive task inputs (Deming, 2017; Krieger-Boden & Sorgner, 2018). However, if ICT-induced trade is skill-based and supplements skilled workers, it will increase the relative demand for skilled workers, who are predominantly male, and widen the gender gap (WTO, 2017).

Existing studies on the impact of trade or ICT on the labour market mainly focus on the overall employment effect (e.g. Biagi & Falk, 2017; Kılıçaslan & Töngür, 2019; Kpognon, Ondoa, & Bah, 2020; Kucera & Roncolato, 2011) and the impact on FLFPR (e.g. Alves & Steiner, 2017; Asongu & Odhiambo, 2020; Cooray et al., 2012). Studies focusing on its impact on the gender gap in developing economies are limited. Previous studies also lack an answer to whether and how interactions between ICT and trade affect gender gap.

This study contributes to the existing literature in the following aspects. First, by conducting empirical research on the relationship between international trade and gender gap with a focus on developing economies, it contributes to gender issues. To

determine the drivers of gender gap, we conduct separate regression analyses of FLFPR and the male labour force participation rate (MLFPR). Second, we analyse whether the interaction between trade and ICT narrows or widens the gender gap. Finally, we conduct multiple analyses to determine the existence of differences between least developed countries (LDCs) and other developing economies, as well as among African, Asian, and Latin American and the Caribbean (LAC) economies.

The remainder of this paper is organised as follows. Section 2 summarises the existing literature. Section 3 describes the methodology and data. Section 4 discusses our empirical results. Finally, section 5 presents the conclusions and implications.

2. Literature review

2.1. International trade and the gender gap

Although several studies have examined the trade–gender gap nexus, their empirical results are inconclusive and fall under three perspectives.

The first view—demonstrated in the works of Bussmann (2009), Besedeš et al. (2021), Cooray et al. (2017), Fatima and Khan (2019), Gaddis and Pieters (2012), Hyder and Behrman (2012), and Kis-Katos et al. (2017)—is that the expansion of international trade narrows the gender gap. Hyder and Behrman (2012) find that increasing trade can narrow the gender gap in the Pakistani labour market because unskilled women are a relatively abundant resource, and the increase in FLFPR is concentrated in agricultural occupations. Kis-Katos et al. (2017) use tariff rate as an indicator of trade openness in Indonesia and confirm that a decline in input tariffs increases FLFPR, with less educated women entering traditionally male-dominated sectors. Fatima and Khan (2019), using data of 21 developing and emerging economies from 1995 to 2013, find that low-tech exports and high-tech imports led to the growth of women's employment in developing countries. Besedeš et al. (2021) find that trade liberalisation with China led to a reduction in the gender gap in the United States. Increased import competition from China negatively impacted the manufacturing sector with higher male participation, prompting more women to enter the labour market to compensate for income loss from the layoffs of men.

The second view is that the growth of trade leads to a decrease in FLFPR and widens the gender gap. Cooray et al. (2012), using a large dataset of a developing country, report that this negative impact is even stronger for young women, and explain that globalisation may lead to a potential rise in the skills premium, creating a strong incentive for young women to invest in education, which can decrease younger women's participation in the labour force. Saure and Zoabi (2014) develop a theoretical model and argue that the expansion of trade in female-dominated industries reduces FLFPR. As trade expands into female-dominated industries, the male labour force may shift from male-dominated to female-dominated industries. When this occurs, the marginal productivity of females decreases more than that of males, which leads to a widening of the gender wage gap and a decline in FLFPR. More recently, using firm-level data from Turkey for the period 1992–2001, Meschi et al. (2016) show that productivity gains through globalisation and technological upgrade

lead to an increase in relative demand for skilled labour and a reduction in unskilled labour in traditional manufacturing, widening the gap between both.

The third view is that the relation between international trade and gender gap is complex (Li, Su, Tao, & Hao, 2019; Meyer, 2006; Wamboye & Seguino, 2015). For example, Wamboye and Seguino (2015) investigate export and import effects on gender gap. By analysing data of 48 Sub-Saharan African countries over 1991–2010, they find that exports reduce women's relative employment and widens the gender gap. In their sub-regressions, they find that in mineral-exporting countries, a rise in imports increases women's relative employment, while exports have an opposite effect. Li et al. (2019), using data of Asian countries for the period 1990–2016 and applying a panel threshold method, find a non-linear relationship between trade openness and FLFPR: Trade openness has a positive (adverse) impact on FLFPR when it is below (above) the threshold value.

2.2. The moderating effect of ICT on the link between international trade and the gender gap

The literature on the trade–gender gap nexus is well developed, but prior studies ignore the moderating role of ICT in the relationship between trade and gender gap.

Many studies have shown that ICT can generate positive effects for women in the labour market (Alves & Steiner, 2017; Asongu & Odhiambo, 2019, 2020; Efobi, Tanankem, & Asongu, 2018; Kiyota & Maruyama, 2018; Lechman, 2019; The World Bank, 2004). Alves and Steiner (2017) use developing country data for the period 2000–2014 to examine how ICT and globalisation affect FLFPR. By comparing upper middle-income and lower middle-income countries, they find that internet use has a greater positive impact on the former, while trade is more positively related to the latter. Using manufacturing industry data in Japan, Kiyota and Maruyama (2018) examine the impact of ICT capital stock (i.e. electric computing equipment, applied electronic equipment, etc.) on the demand for female workers by skill group. They provide evidence of a positive impact of ICT capital stock on low-, middle- and high-skilled female workers. Efobi et al. (2018) analyse data from 48 African countries for the period 1990–2014 and find that rising use of ICT contributes to an increased FLFPR in Sub-Saharan Africa. Lechman (2019) find that an increase in internet use has a positive impact on female wage and salaried workers in developing countries.

With respect to the gendered effects of trade digitalisation, Gosavi (2017) analyse enterprise-level data in India and find that female-owned, export-oriented enterprises are more likely to use digital technology than those of their male counterparts. Using data of small and medium enterprises in Bulgaria, Pergelova, Manolova, Simeonova-Ganeva, and Yordanova (2019) document that women have a higher propensity to use digital technologies to grow their business to access the international market. In addition, using firm-level data of Italy, Manello, Cisi, Devicienti, and Vannoni (2020) acknowledge that firms with female executives participating in networks can significantly improve their performance; this effect is especially stronger in female-intensive and in innovative and digital intensive sectors. Sicat, Xu, Mehetaj, Ferrantino, and Chemutai (2020) use quantitative analysis to examine the gender dimension of

e-commerce trade. Analysing statistics from Alibaba, they find that e-commerce significantly lowered the cost of starting a business, with more than half of the registered enterprises dominated by women.

In summary, through a review of the existing literature, we draw the following conclusions. (1) Prior studies on the gender dimensions of trade effects focus more on women rather than the gender gap. The existing literature on the impact of trade on the gender gap, including studies by Besedeš et al. (2021), Hyder and Behrman (2012) and Wamboye and Seguino (2015), focus either on an individual country or a group of countries in a specific region, and few studies investigate the trade–gender gap nexus in developing economies. (2) Previous literature on gender issues rarely considers the interaction between trade and ICT. The rapid development of digital transformation has revolutionised trade patterns and business processes, and the digital transformation of globalisation will change who participates, and where the economic benefits will flow (McKinsey, 2016; Sicat et al., 2020). Thus, it is important to explore how the digitalisation of trade affects the gender gap. (3) The existing literature provides little comparative information between economies, by development level or region. As trade patterns and ICT development levels differ significantly between LDCs and other developing economies, as well as among African, Asian, and LAC economies, we predict that each group will show differing impacts.

3. Empirical analysis

3.1. Empirical model

In Model 1, we focus on the effect of trade on gender gap. To determine the gender gap drivers, we also perform two additional regression analyses for FLFPR and MLFPR.

Model 1:

$$LABOR_{it} = \alpha_0 + \alpha_1 TRADE_{it} + \beta X_{it} + \varepsilon_{it}, \tag{1}$$

where $LABOR_{it}$ is the labour force participation rate (female, male, or gender gap). $TRADE_{it}$ indicates three trade variables: total trade (TT), goods trade (GT), or services trade (ST). X_{it} represents the control variables, namely, GDP per capita ($GDPPC$), education level (EDU), urbanisation rate (UR) and fertility rate (FER). The subscript i refers to the individual economy; t represents the year, and ε_{it} is the random error term.

In Model 2, we focus on the moderating effect of ICT on the relationship between trade and gender gap. For this purpose, we introduce interaction variables (i.e. the interaction between the moderator and independent variables) to test the moderating effects (Wang, Zhang, & Wang, 2018). Specifically, we introduce the interaction between ICT and trade into Model 2.

Model 2:

$$GAP_{it} = \alpha_0 + \alpha_1 TRADE_{it} + \alpha_2 ICT_{it} + \alpha_3 TRADE_{it} * ICT_{it} + \beta X_{it} + \varepsilon_{it}, \tag{2}$$

where GAP_{it} represents gender gap; $TRADE_{it}$ indicates total trade (TT), goods trade (GT), or service trade (ST); ICT_{it} represents the ICT indicators (i.e. internet use

INTER, mobile phone use *MOB*, or fixed broadband subscriptions *BROAD*); $TRADE_{it} * ICT_{it}$ denotes the interaction between the trade variables and ICT indicators (i.e. total trade × internet use, total trade × mobile phone use, total trade × fixed broadband subscriptions, goods trade × internet use, goods trade × mobile phone use, goods trade × fixed broadband subscriptions, services trade × internet use, services trade × mobile phone use, and services trade × fixed broadband subscriptions). X_{it} represents the control variables, which are the same as in Model 1. The subscript i refers to the individual economy; t represents the year, and ε_{it} is the random error term.

As mentioned by Wamboye and Seguino (2015), endogenous issues may exist between trade and gender gap owing to reverse causality; that is, gender equality in the labour market itself may affect economic growth rates and changes in trade shares. To address the endogenous issues, this study uses the instrumental variables generalised method of moments (IV-GMM) estimator. Consistent with the prior studies of Li, Zeng, Ye, and Guo (2021) and Nath and Liu (2017), we use the lagged values of the potential endogenous variables as instruments. Specifically, this study uses 1-2 lagged values of trade variables and ICT indicators as instruments in the estimation. All the results from Hansen's J test show that the null hypothesis cannot be rejected, thus confirming the instruments' validity. In addition, we employ individual and time fixed effect regressions to check the robustness of the main results.

3.2. Data sources

We use panel data from 79 developing economies for the period 2006–2019. As the impact may differ by development level, we classify these 79 developing economies into two subpanels: LDCs and other developing economies. In addition, we classify the sample into Asian, African, and LAC economies to examine whether the impact varies by region. The classification is based on the United Nations country classification.

3.2.1. Dependent variables

Our dependent variables consist of FLFPR and MLFPR, taken from the 'Key Indicators of the Labour Market' in the International Labour Organisation database. Following Erten and Metzger (2019), we use the male minus female labour force participation rate to measure the gender gap in the labour market.

3.2.2. Independent variables

The independent variables of interest are the trade variables (i.e. total trade, goods trade, and service trade) and the ICT indicators (i.e. internet use, mobile phone use, and fixed broadband subscriptions), which we draw from the World Development Indicators (WDI) database of the Word Bank.[1] Total trade is the ratio of exports and imports to GDP (in % of GDP). Goods trade is the ratio of goods exports and imports to GDP (in % of GDP). Service trade is the ratio of service exports and imports to GDP (in % of GDP). Internet use is the percentage of individuals using the Internet. Mobile phone use

Table 1. Summary of the descriptive statistics (before taking the logarithm).

Variables	Obs.	Mean	Std. Dev.	Min	Max
GAP	1106	23.861	15.132	2.01	62.1
FLFPR	1106	52.611	16.437	12.54	87.16
MLFPR	1106	76.472	7.228	51.61	91.12
TT	1102	85.085	58.428	20.723	442.62
GT	1106	66.042	49.059	17.011	419.962
ST	1098	20.516	17.775	3.831	145.643
INTER	1007	31.371	25.629	0.294	99.702
MOB	1095	92.266	42.958	1.455	288.533
BROAD	1071	5.640	8.241	0.002	42.764
GDPPC	1106	7383.978	10083.37	448.254	59374.44
EDU	1106	7.102	2.557	1.3	13
UR	1106	55.203	22.899	15.462	100
FER	1106	3.145	1.392	0.918	7.592

Source: Authors.

is measured as mobile cellular subscription per 100 people. Fixed broadband subscription is measured as fixed broadband subscriptions per 100 people.

3.2.3. Control variables

We include several variables that are important in examining gender-specific labour force participation and gender gap as control variables based on the studies by Bussmann (2009), Cooray et al. (2017), The World Bank (2004) and Wamboye and Seguino (2015), namely, GDP per capita, education level, urbanisation rate, and fertility rate. GDP per capita is gross domestic product divided by mid-year population, measured in constant 2010 USD. Education level is the average years of schooling. Urbanisation rate is the ratio of urban population to total population (in % of total population), and fertility rate is the total number of births per woman. The data on education levels come from the Human Development Reports database; others are from the WDI database. All variables used for estimation are in their natural logarithmic forms. Table 1 presents the descriptive statistics.

4. Results and discussions

Table 2 shows the results of the impact of trade on gender gap, with two separate regressions for FLFPR and MLFPR. Table 3 reports the results of the interaction effect between trade and ICT on gender gap. Table 4 outlines the results of the analyses by development level and by region. We report the results from the IV-GMM estimates as our main results because they are more robust to the endogeneity issues.

4.1. Results from the basic specification

Regarding the effect of trade on the gender gap, the results from the IV-GMM estimates in Columns (4)–(6) of Table 2 show that the trade variables negatively affect the gender gap at the 1% significance level. Specifically, a 1% increase in total trade, goods trade, and services trade narrows the gender gap by 0.272, 0.143 and 0.123%, respectively.

For the FLFPR, the results in Columns (7)–(9) of Table 2 show that trade variables have positive signs and are significant at the 1% level. A 1% growth in total trade,

Table 2. The impact of trade on labour markets.

Dependent variable:	Gender gap						FLFPR			MLFPR		
Estimator:	FE			IV-GMM			IV-GMM			IV-GMM		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
LnTT	0.010			−0.272***			0.128***			0.005		
	(0.031)			(0.043)			(0.024)			(0.006)		
LnGT		0.004			−0.143***			0.062***			0.008	
		(0.029)			(0.042)			(0.022)			(0.006)	
LnST			0.052***			−0.123***			0.048***			−0.011**
			(0.020)			(0.029)			(0.017)			(0.004)
LnGDPPC	0.080	0.100**	0.096*	0.018	0.003	0.029	0.013	0.020	0.014	−0.008	−0.007	−0.003
	(0.050)	(0.050)	(0.050)	(0.039)	(0.041)	(0.040)	(0.021)	(0.021)	(0.022)	(0.006)	(0.006)	(0.006)
LnEDU	0.158*	0.144*	0.145*	−0.220***	−0.218***	−0.194**	−0.006	−0.005	−0.012	−0.006	−0.006	−0.005
	(0.081)	(0.082)	(0.082)	(0.077)	(0.078)	(0.079)	(0.036)	(0.036)	(0.037)	(0.011)	(0.011)	(0.011)
LnUR	0.360***	0.395***	0.392***	0.470***	0.494***	0.422***	−0.223***	−0.233***	−0.215***	−0.035***	−0.036***	−0.046***
	(0.132)	(0.134)	(0.133)	(0.081)	(0.082)	(0.086)	(0.041)	(0.041)	(0.046)	(0.010)	(0.010)	(0.010)
LnFER	0.455***	0.436***	0.427***	−0.517***	−0.488***	−0.435***	0.070	0.056	0.038	−0.049***	−0.048***	−0.047***
	(0.092)	(0.092)	(0.092)	(0.099)	(0.100)	(0.097)	(0.043)	(0.044)	(0.042)	(0.010)	(0.010)	(0.011)
Constant	0.134	−0.087	−0.167	3.065***	2.462***	2.190***	4.062***	4.355***	4.486***	4.569***	4.562***	4.626***
	(0.572)	(0.560)	(0.565)	(0.482)	(0.477)	(0.426)	(0.226)	(0.222)	(0.192)	(0.043)	(0.044)	(0.035)
Hansen's J statistics				0.306	0.140	0.466	0.244	0.007	0.230	0.053	0.225	0.092
Hansen's J p-value				0.580	0.708	0.495	0.621	0.930	0.631	0.818	0.635	0.761

Notes: FE means individual and time fixed effect estimator; IV-GMM means instrumental variables generalised method of moments estimator.
Standard errors are in parentheses in Columns (1)–(3), while robust standard errors are in parentheses in Columns (4)–(12). *, **, and *** denote significance at the 10%, 5% and 1% levels, respectively.
Source: Authors.

Table 3. Moderating effect of ICT on the gender gap in labour markets.

Dependent variable:	Gender gap																	
Estimator:	FE									IV-GMM								
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)
LnTT*LnINTER	0.028**									0.242**								
	(0.011)									(0.108)								
LnGT*LnINTER		0.027**									0.123							
		(0.012)									(0.105)							
LnST*LnINTER			0.022***									0.076						
			(0.008)									(0.056)						
LnTT*LnMOB				0.039**									0.198					
				(0.016)									(0.244)					
LnGT*LnMOB					0.008									0.081				
					(0.017)									(0.290)				
LnST*LnMOB						0.051***									−0.048			
						(0.012)									(0.173)			
LnTT*LnBROAD							0.008									0.029		
							(0.007)									(0.037)		
LnGT*LnBROAD								0.003									0.019	
								(0.007)									(0.033)	
LnST*LnBROAD									0.016***									−0.017
									(0.005)									(0.019)
Constant	0.849	1.007	0.311	0.269	−0.428	−0.801	−0.180	−0.302	−0.802	6.711***	4.344***	3.139***	6.512	3.506	1.067	3.605***	3.020***	2.719***
	(0.637)	(0.651)	(0.636)	(0.658)	(0.696)	(0.586)	(0.597)	(0.594)	(0.602)	(1.666)	(1.596)	(0.720)	(4.978)	(5.570)	(2.412)	(0.550)	(0.533)	(0.454)
Hansen's J statistics										1.476	0.368	0.267	1.431	0.744	0.761	1.121	0.532	0.262
Hansen's J p-value										0.478	0.832	0.875	0.489	0.689	0.684	0.571	0.767	0.877

Notes: FE means individual and time fixed effect estimator; IV-GMM means instrumental variables generalised method of moments estimator.
Standard errors are in parentheses in Columns (1)–(9), while robust standard errors are in parentheses in Columns (10)–(18). All other control variables are also included in the regressions but are not reported. *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively.
Source: Authors.

Table 4. Analyses by development level and by region.

Categories:	Development level		Region		
Dependent variable:	LDC	Other	Africa Gender gap	Asia	LAC
	(1)	(2)	(3)	(4)	(5)
LnTT	−0.307***	−0.084**	−0.517***	−0.577***	0.222***
	(0.117)	(0.040)	(0.094)	(0.064)	(0.049)
LnGT	−0.245**	0.001	−0.263***	−0.520***	0.433***
	(0.115)	(0.040)	(0.078)	(0.069)	(0.045)
LnST	0.021	−0.034	−0.347***	−0.303***	−0.021
	(0.080)	(0.029)	(0.093)	(0.041)	(0.028)
LnTT*LnINTER	0.151	0.217	−0.053	0.484***	−0.492
	(0.260)	(0.225)	(0.206)	(0.169)	(0.523)
LnGT*LnINTER	0.001	0.176	−0.145	0.295*	−0.576
	(0.217)	(0.227)	(0.186)	(0.179)	(0.444)
LnST*LnINTER	0.118	0.001	−0.129	0.118*	−0.324***
	(0.180)	(0.120)	(0.180)	(0.071)	(0.102)
LnTT*LnMOB	0.870	−0.789**	0.371	0.651	−1.978
	(1.078)	(0.382)	(0.507)	(0.472)	(1.405)
LnGT*LnMOB	1.202	−1.146**	0.690	0.634	−4.608
	(1.008)	(0.495)	(0.558)	(0.510)	(3.147)
LnST*LnMOB	0.0002	−0.507*	0.320	0.012	−0.340
	(0.455)	(0.282)	(0.374)	(0.282)	(0.222)
LnTT*LnBRAOD	0.136	−0.080*	−0.082	0.227***	−0.261
	(0.328)	(0.048)	(0.116)	(0.060)	(0.172)
LnGT*LnBROAD	0.036	−0.089*	−0.010	0.104*	−0.066
	(0.324)	(0.047)	(0.113)	(0.061)	(0.139)
LnST*LnBROAD	−0.045	−0.079***	−0.052	0.017	−0.217***
	(0.125)	(0.030)	(0.057)	(0.030)	(0.041)

Notes: The results are examined using an IV-GMM estimator. Robust standard errors are in parentheses. All other control variables are also included in each regression, but only the results for the primary variables are reported to save space. *, **, and *** denote significance at the 10%, 5% and 1% levels, respectively.
Source: Authors.

goods trade, and services trade increases the FLFPR by 0.128, 0.062 and 0.048%, respectively. For the MLFPR reported in Columns (10)–(12) of Table 2, we find that services trade negatively affects the MLFPR at the 5% significance level: a 1% growth in services trade leads to a 0.011% reduction in the MLFPR.

To test how the interaction between trade and ICT affects the gender gap, we examine nine interaction terms. The results with IV-GMM estimates in Columns (10) of Table 3 show that the interaction of total trade and internet use has a positive impact on the gender gap. This implies that the increase of total trade combined with a rising level of internet use leads to a 0.242% increase in gender gap. The other interaction terms mostly show positive signs, but are not significant.

In summary, our results show that the growth of international trade benefits women but hurts men, which leads to a reduction in the gender gap in developing economies. This is in line with the studies by Besedeš et al. (2021) and Hyder and Behrman (2012), which find a positive role of international trade in narrowing the gender gap in Pakistan and the United States, respectively. We find that services trade leads to a reduction in MLFPR but an increase in FLFPR. This may imply that the increased trade in services favours women who have a comparative advantage in the service sector.

In addition, the interaction between ICT and trade leads to an increase in the gender gap in developing economies. Although studies such as Asongu and Odhiambo

(2020), Efobi et al. (2018), Kiyota and Maruyama (2018), and Sicat et al. (2020) support the positive impact of ICT or e-commerce trade on female labour, our results differ from their findings to a certain extent when we tested the interactions. This could be attributed to the following reasons. First, a reduced access to digital infrastructure compared with that of men limits female participation in the digital economy (Global System for Mobile Communications Association, 2020; The International Telecommunication Union, 2019). Second, the gender gap in education and skills limits women from benefiting from technological advances (Sicat et al., 2020; Wyche & Steinfield, 2016).

4.2. Subsample regression analysis

To explore whether this impact varies by development level and by region, we examine the impact of trade and its interaction with ICT on the gender gap with a comparative analysis of LDCs and other developing economies, as well as a regional comparison of Africa, Asia, and LAC.

For LDCs, the results in Column (1) of Table 4 show that total trade ($b = -0.307$; $p = .009$) and goods trade ($b = -0.245$; $p = .033$) negatively affect the gender gap; most of the interaction terms between the trade variables and ICT indicators show positive signs but are not significant. For other developing economies, the results in Column (2) of Table 4 show that total trade has a negative impact on the gender gap ($b = -0.084$; $p = .037$); the interaction terms of trade variables with mobile phone and fixed broadband present significant and negative signs on the gender gap.

For African economies (in Column 3 of Table 4), both total trade ($b = -0.517$; $p = .000$), goods trade ($b = -0.263$; $p = .001$), and services trade ($b = -0.347$; $p = .000$) are negatively related to the gender gap, but most of the interaction terms between trade and ICT have no significant impact. For Asian economies (in Column 4 of Table 4), total trade ($b = -0.577$; $p = .000$), goods trade ($b = -0.520$; $p = .000$), and services trade ($b = -0.303$; $p = .000$) negatively affect the gender gap; the interaction terms between the trade variables and internet use and fixed broadband show a positive impact on the gender gap. For LAC economies (in Column 5 of Table 4), total trade ($b = 0.222$; $p = .000$) and goods trade ($b = 0.433$; $p = .000$) are positively related to the gender gap; the interaction terms between services trade and internet use and fixed broadband have a negative impact on the gender gap.

Comparing the impact in economies grouped by development level and by region provides some interesting insights. First, our results show that trade has a negative impact on the gender gap in both LDCs and other developing economies, with a greater impact in the former than the latter. Hence, the expansion of international trade contributes to a greater reduction of the gender gap in LDCs. The interaction between trade and ICT shows a negative impact in other developing economies, but no impact in LDCs. This result implies that the growth of international trade combined with a rising ICT level delivers additional benefits to close the gender gap in other developing economies, but the interactions have not effectively narrowed the gender gap in LDCs. This may be because most LDCs still lag other developing economies in ICT development indicators such as broadband internet and mobile access, making it less likely for residents to use digital technologies for economic

purposes, thus limiting these economies from benefitting from the digital economy (United Nations Conference on Trade & Development, 2020).

Second, when we divide the full sample by region, we find that trade has a negative impact on the gender gap in African and Asian economies, but a positive impact in LACs. This means that the expansion of international trade narrows the gender gap in African and Asian economies, but widens the gender gap in LACs. In particular, we find that trade in goods has a greater impact on narrowing the gender gap in Asian economies, which may be explained as follows. In many African and Asian economies, particularly in Asia, export-oriented industrialisation and labour-intensive production tend to result in higher demand for unskilled women than for men. In contrast to Asian and African economies, where the industrial sector is expanding and female employment opportunities are increasing substantially, manufacturing growth in most LAC economies remains slow, and many traditional manufacturing jobs have been decimated (Tejani & Milberg, 2016).

Additionally, the interaction between trade and ICT has a negative impact on the gender gap in LACs, but a positive impact in Asian economies, and no impact in African economies. This implies that the growth of international trade with a rising level of ICT contributes to the narrowing of the gender gap only in LAC economies. This may be because women in LAC economies have higher-quality education and skills than those in other developing economies (International Labour Organisation, 2020a), enabling them to participate in and benefit from the digital economy. For African and Asian economies, although some countries such as China show high growth in women's participation in e-commerce activities, the majority of the women in these two groups still have relatively lower education and skill levels than do men, which keeps them mostly in labour-intensive jobs (Mbaye & Gueye, 2018; The World Bank, 2014). For Asian economies, the great digital divide between men and women may even widen the gap between genders in the labour market, as technological advances may only benefit certain groups with high skills and better access to ICT (ILO, 2020b).

4.3. Further analysis: testing the impact on informal employment by gender

Some studies acknowledge that trade increases overall employment and real wages (Kılıçaslan & Töngür, 2019; OECD, 2018b; WTO, 2017). In particular, growth in international trade is more likely to create jobs for women with higher wages and better working conditions, thereby contributing to a decline in women's informal employment. Therefore, we examine the employment effect of trade by gender in developing economies. Owing to unavailability of data on formal employment rates, we only test the impact on female (FIER) and male informal employment rates (MIER), and the results are reported in Table 5. A 1% increase in total trade reduces the FIER by 0.074% and the MIER by 0.085%. The growth of the goods trade sector relates to a decrease in the MIER (0.090%), but has no impact on FIER. A rise in services trade contributes to a greater reduction in FIER (0.145%) than in MIER (0.063%).

Table 5. Further analysis of the impact on informal employment rate by gender.

Dependent variable:	FIER (1)	MIER (2)
LnTT	−0.074**	−0.085**
	(0.037)	(0.040)
LnGT	−0.038	−0.090**
	(0.039)	(0.041)
LnST	−0.145***	−0.063**
	(0.030)	(0.032)
LnTT*LnINTER	1.395	1.246
	(1.029)	(0.949)
LnGT*LnINTER	0.267	0.249
	(0.751)	(0.635)
LnST*LnINTER	0.597	0.670
	(0.819)	(0.839)
LnTT*LnMOB	−1.576	0.601
	(2.264)	(1.940)
LnGT* LnMOB	−0.650	−0.126
	(1.511)	(1.572)
LnST* LnMOB	1.048	0.421
	(1.532)	(1.465)
LnTT*LnBRAOD	0.418	0.379
	(0.370)	(0.336)
LnGT* LnBRAOD	0.241	0.165
	(0.204)	(0.192)
LnST* LnBRAOD	0.074	−0.010
	(0.100)	(0.103)

Notes: The results are examined using an IV-GMM estimator. Robust standard errors are in parentheses. All other variables are also included in each regression, but only the results for the primary variables are reported to save space. *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively.
Source: Authors.

Moreover, as mentioned above, developments in ICT release time and mobility constraints for women, and many women are involved in home-based self-employment (e.g. female entrepreneurs in e-commerce trade). Therefore, we further examine whether and how the interaction between trade and ICT affects informal employment by gender. The results reported in Table 5 show that most of the interaction terms between trade and ICT are positive, but not statistically significant.

4.4. Further analysis: testing the role of education

Based on the existing literature, we suggest that education is an important factor in narrowing the gender gap through ICT and trade. According to Antonio and Tuffley (2014), Hafkin and Huyer (2007) and Scuotto, Serravalle, Murray, and Viassone (2019), women workers with high education have the skills required for doing business in the global market through digital technologies. The results above show that international trade mitigates the gender gap. Therefore, we further test whether improvements in ICT combined with a high education level may help in increasing international trade and narrowing the gender gap. To do this, we set the following regression models:

$$TRADE_{it} = \alpha_0 + \alpha_1 ICT_{it} + \alpha_2 HEDU_{it} + \alpha_3 ICT_{it} * HEDU_{it} + \beta X_{it} + \varepsilon_{it} \quad (3)$$

$$GAP_{it} = \alpha_0 + \alpha_1 ICT_{it} + \alpha_2 HEDU_{it} + \alpha_3 ICT_{it} * HEDU_{it} + \beta X_{it} + \varepsilon_{it}, \quad (4)$$

Table 6. Further analysis on the role of education.

Dependent variable:	Trade			Gender gap
	TT	GT	ST	
	(1)	(2)	(3)	(4)
LnINTER*HEDU	0.107**	0.028	0.278***	−0.338***
	(0.045)	(0.046)	(0.064)	(0.065)
LnMOB*HEDU	0.467***	0.459***	0.448***	−0.613***
	(0.113)	(0.119)	(0.150)	(0.109)
LnBROAD*HEDU	0.013	−0.054*	0.116***	−0.291***
	(0.027)	(0.028)	(0.038)	(0.034)

Notes: The results are examined using an IV-GMM estimator. Robust standard errors are in parentheses. All other variables are also included in each regression, but only the results for the primary variables are reported to save space. *, ** and *** denote significance at the 10%, 5%, and 1% levels, respectively.
Source: Authors.

where $TRADE_{it}$, GAP_{it}, and ICT_{it} are the same as in Models 1 and 2. $HEDU_{it}$ represents a high education level. Here, we construct this education variable based on average years of schooling. Following Donou-Adonsou (2019), we calculate the mean schooling years across our sample and define $HEDU_{it}$ as a dummy variable that equals 1 when the average schooling years in a given economy in year t is higher than the mean value (7.102) and 0 otherwise. Thus, economies coded as 1 are considered to have a higher level of education than economies coded as 0. $ICT_{it}*HEDU_{it}$ is the interaction between the ICT indicators and education (i.e. internet use × high education, mobile phone use × high education, and fixed broadband subscription × high education). X_{it} denotes the control variables, namely, GDP per capita (*GDPPC*), urbanisation rate (*UR*), and fertility rate (*FER*).

The results in Table 6 show that the interaction terms (*ICT*HEDU*) have positive signs on international trade, and are broadly significant. This implies that the growth in ICT use, together with a higher education level, increases the volume of international trade. In addition, the results of the interaction terms (*ICT*HEDU*) have significant negative signs on the gender gap, indicating that the increase in ICT use, together with a higher education level, narrows the gender gap.

5. Conclusions and implications

This study analyses the impact of international trade on the gender gap based on data from 79 developing economies for the period 2006–2019. To examine this impact, we (1) analysed how international trade (i.e. total trade, goods trade, and services trade) affects the gender gap, with separate regressions on FLFPR and MLFPR; (2) explored the moderating role of ICT on the relationship between international trade and the gender gap by introducing the interaction terms between trade and ICT, and investigated whether they narrow or widen the gender gap; and (3) conducted sub-regressions by development level and region, and investigated whether the impact varies between LDCs and other developing economies, and among economies in Africa, Asia, and LAC.

Our findings are summarised as follows. First, the expansion of international trade narrows the gender gap. In particular, we find that services trade leads to an increase in FLFPR but a decrease in MLFPR. Second, the interaction between trade and ICT

is more likely to widen the gender gap. Third, the impact varies significantly across developing economies categorised by development level and by region. Specifically, the regression results analysed by development level show that trade leads to a greater reduction of the gender gap in LDCs than in other developing economies, while the interaction between trade and ICT reduces the gender gap only in other developing economies and has no impact in LDCs. Moreover, the regression results by region show that the growth in international trade narrows the gender gap in African and Asian economies, but widens the gender gap in LACs. The interaction between trade and ICT reduces the gender gap in LACs, but increases the gender gap in Asian economies and has no impact in African economies.

Our results have the following policy implications. First, the increased volume of international trade favours women more than men, thus helping to narrow the gender gap in developing economies. To alleviate the gender gap, the government should take more measures to open up, so as to improve women's participation in the labour market. Policies promoting international trade should focus more on emerging services that benefit women. No one can deny that the fourth industrial revolution is the main driving force behind economic development. Therefore, each economy's trade policies should be geared toward fostering high-tech industries such as artificial intelligence, big data, and self-driving car exports, and the export of fourth industrial revolution-related products, in order to increase FLFPR. It is relatively easier for women to find ICT-based jobs than jobs requiring manual labour, and as the fourth industrial revolution develops, FLFPR will increase, which can facilitate overall economic growth.

Second, trade, combined with a rising level of ICT, tends to widen the gender gap in developing economies. To benefit from the opportunity presented by the development of ICT and international trade, the government should implement policies to improve women's access to digital tools and reduce the digital divide between men and women. Policies aimed at promoting women's access to higher education and improving their digital skills are also needed to enable women to participate in the digital economy successfully.

Third, the trade effect on the gender gap varies across economies by development level and by region. The growth of international trade narrows the gender gap more in LDCs than in other developing economies. To mitigate the gender gap, the government should continue to adopt policies that promote trade. In addition, international trade reduces the gender gap in African and Asian economies, but increases the gender gap in LACs. To close the gender gap, it is necessary for LACs to implement gender-inclusive trade policies and develop more trade sectors that may benefit women such as the emerging services.

Finally, the interaction between trade and ICT has different impacts on the gender gap across economies by development level and by region. Trade's interaction with an increasing ICT level, narrows the gender gap in other developing economies but not in LDCs. For LDCs, to take full advantage of the digital transformation of trade, the government needs to adopt more investment policies on developing their information infrastructures, lower the access price, and improve the penetration of digital technologies. In addition, trade's interaction with ICT reduces the gender gap in

LACs but not in African and Asian economies. For African and Asian economies, governments need to implement a comprehensive strategy that combines trade with digital technologies, to reduce the gender gap. This may provide women equal access to digital technologies, enhance women's digital skills, and support women's participation in e-commerce. In particular, it is important for the government of Asian economies to adopt policies that reduce the digital divide between men and women and achieve gender equality.

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Note

1. The Word Bank's data come from different sources and have slightly different statistical caliber.

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Appendix A: Economies included in the sample (* indicates the LDC list)

Africa	Asia	Latin America and the Caribbean
Algeria	Brunei Darussalam	Bahamas, The
Egypt, Arab Rep.	Cambodia*	Barbados
Morocco	China	Belize
Tunisia	Fiji	Jamaica
Cameroon	Hong Kong SAR, China	Costa Rica
Comoros*	Indonesia	Dominican Republic
Kenya	Lao PDR*	El Salvador
Madagascar*	Malaysia	Guatemala
Uganda*	Mongolia	Mexico
Tanzania*	Philippines	Nicaragua
Angola*	Korea, Rep.	Panama
Botswana	Singapore	Argentina
Lesotho*	Solomon Islands*	Bolivia
Mauritius	Thailand	Brazil
Namibia	Timor-Leste*	Chile
South Africa	Vanuatu*	Colombia
Zambia*	Vietnam	Ecuador
Benin*	Bangladesh*	Paraguay
Burkina Faso*	Bhutan*	Peru
Cabo Verde	India	Uruguay
Cote d'Ivoire	Nepal*	
Gambia, The*	Pakistan	
Ghana	Sri Lanka	
Liberia*	Bahrain	
Mali*	Israel	
Niger*	Jordan	
Nigeria	Kuwait	
Senegal*	Oman	
Togo*	Saudi Arabia	
	Turkey	

Source: Authors' calculations based on the United Nations country classification.