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The impact of digital economy on women's employment: evidence from selected European and Asian countries

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Abstract

The rapid development of the digital economy has brought significant changes in various aspects, including production methods and the provision of services. These changes have reshaped workforce requirements and skills, presenting opportunities to enhance women's participation in economic activities. This paper assesses the impact of the digital economy on women's employment in several European and Asian countries. The study uses panel data encompassing 53 countries collected from the World Bank, ITU, and UNDP databases. The principal component analysis was employed to calculate a composite index measuring the development of the digital economy in these countries. This index was then used to assess the impact of the digital economy on women's employment through regression analysis of panel data. The results indicate that the digital economy positively impacts women's employment. However, the influence of the digital economy on women's employment varies among countries and different income groups. Specifically, the digital economy increases women's employment in high-income countries but has a negative impact on women's employment in middle-income countries. Based on the findings, this study proposes recommendations to policymakers for optimizing the potential of the digital economy.

Keywords: Digital economy, Women's employment, Employment structure

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1. Introduction

Gender equality is one of the 17 Sustainable Development Goals (SDGs), and it is always a matter of concern for all countries worldwide. Gender inequality in employment between men and women remains a persistent and challenging issue. From a labor force perspective, the gender gap in the labor market is a complex problem that has existed for a long time and particularly exacerbated since the emergence of the COVID-19 pandemic (ILO, 2020).

External factors such as the surrounding environment, economic context, and political landscape also generally impact the labor market and women's employment. Among these, the digital economy is also a significant factor affecting women's employment, especially when countries worldwide are pushing for digital transformation and developing digital economic infrastructure. Taking Vietnam as an example, according to a study by Tufts University, Vietnam ranks 48th out of 60 countries with rapid digital economic transformation globally and stands at the 22nd position in terms of digitalization speed (Chakravorti and Chaturvedi, 2017). According to the Ministry of Information and Communications, the total revenue of the information and communication sector was estimated at 3,893,595 billion VND in 2022, a 12.7% increase compared to 2021; the revenue of the ICT industry in 2022 reached 148 billion USD, showing an 8.7% growth compared to 2021.

With the rapid advancement of computer technology, the digital economy is gradually becoming a driving force for economic growth (Li *et al.*, 2021) and transforming the employment structure. Firstly, the digital economy can influence women's employment through gender-based labor structures. The development of the digital economy generates diversity in the foundational economy, enabling women to overcome barriers stemming from family responsibilities and be more willing to participate in the workforce (Chaudhary, 2021). Secondly, the growth of the digital economy, leading to an increased automation rate, can positively impact women's employment, as women are at a lower risk of being replaced by machines than men (Džbánková, 2017).

Simultaneously, Gómez *et al.* (2014) argued that widespread dissemination of information technology and digital skills through education would affect women's employment opportunities more favorably than men's. The application of technology in production also increases the demand for skilled labor, particularly emphasizing communication and coordination skills (with a preference for women) rather than just physical strength. Consequently, researching the impact of the digital economy on women's employment is essential to comprehensively evaluate this effect and provide recommendations for reducing gender inequality in the current employment structure.

Previous studies have analyzed and explored the impact of the digital economy on the labor market. However, earlier studies (Džbánková, 2017; OECD, 2017) primarily provided qualitative assessments and did not quantify this impact. Additionally, quantitative studies

(Chen, 2004; Nikulin, 2017; Nkoumou Ngoa and Song, 2021) were also limited to specific aspects of the digital economy and did not comprehensively reflect the overall influence of this factor on women's employment.

This study aims to assess the impact of the digital economy and the other factors affecting women's employment in Asia and Europe from 2010 to 2020. Firstly, data were collected from 53 countries in the selected area through the World Bank and UNDP databases to analyze the factors affecting this impact. Secondly, the study employs a novel measurement approach for the dependent variable "women's employment" compared to previous research. This research uses the ratio of "number of employed women/total number of employed" to measure women's participation in the labor market. This index demonstrates women's engagement in the labor market and reflects the gender disparity in employment and gender equality in employment issues. Thirdly, this paper employs the principal component analysis (PCA) method and computes indices to assess the development of the digital economy in European and Asian countries based on two sets of indicators: digital access capability and digital usage capability. Finally, the study utilizes a quantitative model to quantify the impact of the digital economy on women's employment.

The research assesses the various factors within the digital economy that influence women's employment to offer policy recommendations to bolster women's employment opportunities and promote gender equality within the workforce. Key contributions of the study include a critical reevaluation of core theories surrounding the digital economy and women's employment, an in-depth analysis of the current landscape of the digital economy and women's employment on a global scale, with a focus on Europe and Asia, the development of an econometric model alongside the gathering of secondary data to evaluate the impact of digital economic variables on women's employment, and the formulation of strategies and policies designed to harness the full potential of the digital economy, elevate female employment rates, and mitigate gender disparities in the workforce.

This study employs the data from 2010 to 2020 to assess the impact of the digital economy on women's employment rates in the current context. In addition, the study utilizes PCA and computes indices to evaluate the digital economy's development in Europe and Asia based on infrastructure, digital access capability, and the degree of digital economic openness. Finally, this research employs a quantitative model to measure the influence of the digital economy on women's employment, diverging from previous studies that predominantly focused on the effects of conventional economic factors and qualitative analysis.

Following the introduction, the remainder of the study is structured as follows. A literature review is summarized in section 2. The research methodology and data are described in section 3. Section 4 presents and analyzes the research results. Finally, section 5 concludes the paper.

2. Literature review

2.1 Digital economy and digital economy's measurement

The digital economy is a new economic form that has emerged along with the rapid development of the information and communication technology (ICT) industry (Pan *et al.*, 2022). Digital economy can be defined as a range of economic activities, including the use of digitized information and knowledge as the main factor of production, the modern information network as an important operational space, and the effective use of ICT as an important driver of productivity growth and economic structure optimization (G20, 2016).

Various aspects of the digital economy, such as infrastructure, accessibility, and usability, were used in many prior studies to measure this form of economy. Gomes *et al.* (2022) and Xie and Zhang (2022) used indicators that include mobile-cellular telephone users, a percentage of people using the Internet, and fixed-broadband users. Maji and Laha (2020) integrated two dimensions to measure the digital economy: (i) access to digital services and (ii) usage of digital services. Zhang *et al.* (2022) suggested a more comprehensive way of measuring with three groups of indicators reflecting three aspects: digital economy infrastructure, digital economy openness, and digital technology innovation environment and competitiveness.

Previous studies that focused on evaluating the impact of the digital economy on women's employment primarily analyzed it through individual ICT technologies, including the Internet, mobile phones, fixed bandwidth, and computers (Asongu and Odhiambo, 2024; Nikulin, 2017; Valberg, 2019). On the other hand, Sovbetov (2018) supposed that the digital economy has developed strongly with the emergence of e-commerce and digital transactions so that the digital economy can be measured with three indicators: the number of e-commerce transactions per credit card, the volume of credit per card, and the country's internet penetration rate.

2.2 Effects of the digital economy on women's employment

In general, there have been many studies about the relationship between the digital economy or components of the digital economy, such as ICT, platform economy, sharing economy, gig economy, etc., and women's employment. Studies have been conducted in European countries such as the Czech Republic (Džbánková, 2017), Spain (Gomes *et al.*, 2022), Turkey (Sovbetov, 2018); in Asia-Pacific countries such as Australia (Churchill and Craig, 2019), India (Kasliwal, 2020; Chaudhary, 2021), Malaysia (Suhaida *et al.*, 2013); in South Asian countries (Islam, 2015); in African countries (Nkoumou Ngoa and Song, 2021); in group of countries (OECD, 2017; Nikulin, 2017; Guner, 2021). Besides, the research methods used are mainly qualitative analysis based on secondary data (Džbánková, 2017; OECD, 2017; Suhaida *et al.*, 2013), quantitative analysis based on survey data (Churchill and Craig, 2019) and quantitative analysis based on secondary data (Chen, 2004; Islam, 2015; Nikulin, 2017; Nkoumou Ngoa and Song, 2021).

The results of previous studies on the influence of the digital economy on women's employment have been inconsistent. Some academic works have shown a positive effect of this relationship. OECD (2016) indicated that nearly 5% of workers graduating from high

school face a high risk of being replaced by automation, and less than 40% of workers graduating from secondary school. Accordingly, female workers will face a lower risk of being replaced by automation than men because the number of women graduating from high school is higher than that of men in OECD countries (OECD, 2017). Analyzing the percentage of women working in IT and ICT-related industries in the Czech Republic, Džbánková (2017) showed that changes in production and the emergence of new technologies lead to a shortage of ICT professionals. Therefore, employers in this field are looking for female workers who are usually more alert, communicative, and motivated than their male colleagues. Similarly, the study of Gómez *et al.* (2014) in Spain argued that the widespread prevalence of new technology implies the emergence of tasks requiring coordination and communication rather than physical strength, which is more relevant for women. Suhaida *et al.* (2013) believed that women with high access to ICT could work from home or anywhere without going to the office, thus saving costs and travel time as well as increasing women's labor force participation rate. However, these studies just qualitatively analyzed the secondary data to find the results. Many studies have shown that e-commerce, the platform economy, and the gig economy brought flexible job opportunities for females. Sovbetov (2018) investigated the relationship between e-commerce activities and female employment rates in Turkey from 1994-2016. The results suggested that investing in internet infrastructure and encouraging e-commerce can positively impact online commerce activities in the short run and thus on female employment rates in the long run. Based on quantitative survey data on Australian men and women, Churchill and Craig (2019) found that both income and flexibility are reasons for both genders being drawn to the gig economy. High income is the primary motivation for men to work through platforms like Uber and Freelancer, while women use it mainly because they are bound by time to participate in other official jobs. Also, Kasliwal (2020) and Chaudhary (2021) indicated that the gig economy creates flexible jobs that are not constrained by space and time, and as a result, women can both take care of their families and earn money in their spare time.

Moreover, based on international and regional secondary data, many scholars have studied the interaction between the digital economy and women's employment. Nkoumou Ngoa and Song (2021) empirically investigated this relationship in 48 African countries from 2001 to 2017. The results showed that ICT use, mobile phones, and the Internet significantly influence female labor force participation, which is enhanced by financial development and female education. Islam (2015) shared a similar view, using quantitative research with World Bank data from eight South Asian countries between 1995 and 2013. Nikulin (2017) conducted a panel study analysis for 60 selected developing countries from 2000-2014 and also confirmed the effect of ICT on female labor force participation, as well as emphasized the role of ICT in helping the labor market to become more inclusive, innovative, flexible, and transparent. In addition, the result indicated that in countries with higher GNI per capita, women's engagement in the labor market is lower. Chen (2004) used data from the 209 countries in the World Bank World Development Indicators (WDI) database from 1960 through 2002 to explore the role of ICT in gender equality. The result proved that increases in the level of ICT infrastructure led to improvement in the ratio of the female to male labor force activity rates.

Based on panel data analysis for 156 countries for the 1991-2014 period, Valberg (2019) also confirmed this conclusion and explained this effect mainly because of the increase in the participation of women in the labor force. This result also indicated that this impact is lower in developing countries.

In opposition to these above findings, there are also studies showing that the development of ICT and automation will negatively affect women's employment due to wage discrimination and gender stereotypes in technology-related fields. Segovia-Pérez *et al.* (2019), through survey data of more than 6,000 workers in ICT-related fields, argue that women working in ICT-intensive fields face challenges of wage discrimination higher than in other sectors. Based on panel data analysis of 11 industries in 14 developed and developing countries between 1993 and 2015, Izaskun (2022) showed that increased automation would reduce female participation in the labor force with low and high rates; the results are opposite to the average rate.

In summary, prior studies still have contradictions regarding the impact of the digital economy on women's employment. While some studies suggest that the digital economy creates jobs and helps women access jobs more easily, thereby narrowing the employment gap with men (Islam, 2015; OECD, 2017; Suhaida *et al.*, 2013), others suggest that it is easier for women to be replaced by automation (Izaskun, 2022; Segovia-Pérez *et al.*, 2019). Also, despite the diversification of ways to measure the digital economy in the previous studies, the research assessing the impact of the digital economy on women's employment almost reflected only a small aspect of ICT, which is a component of the digital economy (Chen, 2004; Nikulin, 2017; Nkoumou Ngoa and Song, 2021). In addition, these studies mostly measured women's employment by the percentage of women in the labor force (Nikulin, 2017; Nkoumou Ngoa and Song, 2021) and the labor structure by gender (Chen, 2004).

In this study, we explore the relationship between the digital economy and women's employment in selected European and Asian countries. To reflect the digital economy more comprehensively, we build digital economy metrics and assess their impact on the employment structure or equality in employment. Specifically, this research also compares this effect between two different income groups of countries.

3. Research methods

3.1 Measuring digital economy

Based on the scale reflecting the accessibility and usability of digital services of Maji and Laha (2020), digital economy was measured with six indicators: (i) fixed-telephone subscriptions per 100 people, (ii) mobile phone subscriptions per 100 people, (iii) international internet bandwidth (bit/s) per internet user, (iv) percentage of internet users per population, (v) fixed broadband subscription per 100 people, and (vi) mobile broadband subscription per 100 people. Due to lacking data, the indicator "the percentage of households with a computer" was removed from the final measurement. To combine these indicators, the PCA method suggested by Zhang *et al.* (2022) was employed. This process includes three steps.

First, the suitability test is based on the Kaiser-Meyer-Olkin (KMO) test and Bartlett's sphericity test. The data are considered suitable for principal component analysis if the KMO value is greater than 0.5 and Bartlett's test has a sig coefficient lower than 0.05.

Second, factor analysis is performed using the maximum variance rotation method and extracting the factors with eigenvalues greater than 1. From there, the extracted factors are estimated, and the combined index is calculated as follows:

$$Y = \frac{\lambda_1}{\lambda_1 + \lambda_2 + ... + \lambda_n} Y_1 + \frac{\lambda_2}{\lambda_1 + \lambda_2 + ... + \lambda_n} Y_2 + ... + \frac{\lambda_n}{\lambda_1 + \lambda_2 + ... + \lambda_n} Y_n, \quad (1)$$

where Y is the combined index; n symbols several principal components with eigenvalues greater than 1; Y_1, Y_2,..., Y_n are extracted principal components; 1, 2..., n represent the eigenvalue corresponding to the principal factor.

Finally, standardizing the data using min-max normalization on a scale of 0 to 100 to give the final measurement is presented as follows:

$$DE = 100 \times \frac{Y_i - Y_{min}}{Y_{max} - Y_{min}}, \quad (2)$$

where DE is the variable digital economy, i symbols several observations, Y_i represents the combined index of i-th observation, Y_{max} and Y_{min} represent the maximum and minimum index.

3.2 Research model and estimation methods

The technologies and processes associated with the digital economy are mainly based on advanced ICT (UNCTAD, 2017). ICT is an important driver, playing the role of digitization, networking, and enabling modern economic activities to become more agile and intelligent (G20, 2016). Thus, to investigate the relationship between the digital economy and women's employment, this research builds a regression model based on the model evaluating the impact of ICT on gender equality of Chen (2004) that explained gender equality by per capita real GDP, urbanization ratio, unemployment rate, average years of schooling, average years of schooling ratio and ICT. Following Ng and Muntaner (2018), Nikulin (2017), Nkoumou Ngoa and Song (2021), and Valberg (2019), besides the independent variable digital economy, this study uses the control variables including per capita GDP, fertility rate, urbanization rate, the difference in years of schooling, the share of female seats in parliament and country's income group. From equation (1), the final regression model is as follows:

$$WE_{i,t} = \beta_0 + \beta_1 DE_{i,t} + \beta_2 lnpGDP_{i,t} + \beta_3 FR_{i,t} + \beta_4 UR_{i,t} + \beta_5 DYS_{i,t} + \beta_6 SFP_{i,t} + \beta_7 IG_{i,t} + \varepsilon_{i,t}, \quad (3)$$

where i symbols the country; t symbols the year; WE is women's employment; DE is digital economy; $pGDP$ denotes per capita gross domestic product; FR denotes fertility rate; UR means urbanization rate; DYS means the difference in years of schooling; SFP represents the share of seats of female in parliament; IG represents income group; β_0 is a constant; β_1, β_2, β_3,

β_4, β_5, β_6, β_7 are the regression coefficients of *DE, pGDP, FR, UR, DYS, SFP, IG,* respectively; ε is the error term.

Digital economy (DE). The positive impact of the digital economy on women's employment is expressed through three channels: information, creating new jobs, and save time (Valberg, 2019). Although there are still views that the digital economy has a negative impact on women's employment (Brussevich *et al.*, 2019; Xia and Pei, 2021), based on the conclusions from quantitative studies showing a positive impact of the digital economy (measured by usability and accessibility approach to ICT) on women's employment (Chen, 2004; Nikulin, 2017; Nkoumou Ngoa and Song, 2021; Valberg, 2019), we still expect DE to have a positive coefficient.

Per capita gross domestic product (pGDP). Gross domestic product per capita represents a country's income and the average wage (Chen, 2004). Between income and motivation to work, participation in the labor market is affected by two types of effects: income effect and substitution effect. Blau (1987) suggested that low per capita income corresponds to low wages, causing companies to feel less pressure to increase production and subsequently reduce labor demand. On the other hand, according to Kuznets (1966), as the economy grows, the increase in per capita income will reduce the proportion of self-employed workers, thereby affecting the overall labor structure. Previous studies studying the influence of the digital economy on women's employment are also inconsistent in the sign of income. Nikulin (2017) confirmed the opposite effect due to women's reduced motivation to work. Meanwhile, Chen (2004) and Nkoumou Ngoa and Song (2021) showed the positive impact of this variable on female employment. Hence, pGDP is expected to have either positive or negative signs.

Fertility rate (FR). An increase in the fertility rate will cause women to spend more time with their children and families, thus reducing their participation in labor and employment. Studies assessing the impact of the digital economy on female employment, with the fertility rate as the control variable, also demonstrate this influence (Nikulin, 2017; Nkoumou Ngoa and Song, 2021). Therefore, FR is expected to have a negative relationship with WE.

Urbanization rate (UR). The higher the proportion of the urban population, the more opportunities they have to access employment opportunities and, hence, easier to get a job. Bag (2020) showed that living in rural areas creates a great barrier for women to move to industrial zones to work, making the employment rate of women in this area not high. Previous studies have also shown a positive effect of the urbanization rate as measured by the proportion of the urban population on female labor force participation (Aboohamidi and Chidmi, 2013; Nikulin, 2017). Hence, the effect of UR on WE is positive.

The difference in years of schooling (DYS). When women have equal average years of education compared to men, they will have more opportunities to access employment. Moock *et al.* (2003) indicated that people with a university degree would increase their salary by 11% compared to those with a college degree. Previous studies on the influence of the digital economy on gender equality in employment also show a positive impact of the years of

schooling ratio on women's employment (Chen, 2004; Valberg, 2019). Therefore, DYS is expected to have a positive coefficient.

Share of female seats in parliament (SFP). Gerring *et al.* (2005) argued that more women in legislative power will reduce discrimination and empower women more. When women engage in politics, they inspire and empower other women to join the workforce, leading to increased employment opportunities for women (Ng and Muntaner, 2018). Therefore, SFP is expected to have a positive sign.

Income group (IG). The inverted U-model shows that female labor force participation will decline during the early stages of the transition from agriculture to industrialization due to income effects, more labor-intensive industrialization, and input requirements (Goldin, 1994). In the later stage of industrial development, the participation of women will increase with the development of information and communication technology (Valberg, 2019). Valberg (2019) revealed the different impacts of the Internet and mobile phones on gender equality in labor across income levels. In particular, the Internet has the opposite effect on the low-income group and the same direction on the middle- and high-income groups. Besides, mobile phones have a negative effect on the low and medium-income group and a positive impact on the high-income group. Therefore, IG is expected to have an impact on WE.

Pooled ordinary least squares (POLS), fixed-effect (FE), and random effect (RE) estimation methods were employed to analyze how the digital economy impacts women's employment. Wald, Wooldridge, and Pesaran tests were used to test heteroskedasticity, serial correlation, and cross-sectional dependence, respectively. Additionally, fixed-effects models with Driscoll-Kraay standard errors were used to handle these defects. The sample was separated into two groups based on income, and the regression model was employed to analyze each group one by one.

3.2 Variables and measures

Names, measures, and expected signs of variables are presented in Table 1.

Table 1. Variable descriptions

Variables		Measures	Expected sign	Data sources
Women's employment	WE	$\frac{\text{Employed women}}{\text{Total employed laborers}}$		World Bank
Digital economy	DE	Combined index based on the scale of Maji and Laha (2020)	+	ITU
Per capita gross domestic product	pGDP	$\frac{\text{Gross domestic product}}{\text{Total population}}$	+/-	World Bank
Fertility rate	FR	$\frac{\text{Number of children born}}{\text{Number of women}}$	-	World Bank

Table 1. Variable descriptions *(continued)*

Variables		Measures	Expected sign	Data sources
Urbanization rate	UR	Urban population / Total population	+	World Bank
Difference in years of schooling	DYS	Female average years of schooling / Male average years of schooling	+	UNDP
Share of seats of females in parliament	SFP	Proportion of females in parliament	+	UNDP
Income group	IG	Value of 0 for low- and middle-income countries and 1 for high-income countries	+	World Bank

Source: Authors' compilation

3.3 Data collection and summary statistics

We used the International Telecommunication Union (ITU), the World Bank, and the United Nations Development Programme (UNDP) databases to collect data from all European and Asian countries from 2010 to 2020. After removing countries with massive amounts of missing values, we had a final sample of 583 observations (53 countries and 11 years). The list of sample countries is represented in Appendix A. We fixed the missing data by linear interpolation of panel data. These data are fixed broadband subscriptions (Myanmar from 2012 to 2014), international internet bandwidth (Kyrgyz Republic in 2020, Korea from 2019 to 2020, and Portugal from 2010 to 2012). Detailed sources of data are presented with variable descriptions in Table 1.

Table 2. Descriptive statistics

Variables	Obs.	Mean	Std. Dev.	Min	Max
WE	583	44.27	5.85	20.97	54.27
DE	583	34.80	10.99	0.00	100.00
pGDP	583	34460.35	22022.19	2830.28	116283.70
FR	583	1.70	0.47	0.84	4.30
UR	583	68.45	17.77	28.89	100.00
DYS	583	0.95	0.08	0.48	1.08
SFP	583	24.10	10.42	0.00	48.33
IG	583	0.63	0.48	0.00	1.00

Source: Author's calculation

The mean of WE is 44.27, which is less than 50% in this region. This rate is the lowest in India in 2018 and the highest in Armenia in 2020. Meanwhile, DE has an average value of

34.8 on a 100-point scale. Myanmar received the lowest value of 0 in 2010, and Hong Kong received the highest value of 100 in 2020.

Regarding lnpGDP, its mean value is 34460.35. This value is smallest in Myanmar in 2010 and largest in Luxembourg in 2016. In addition, the average value of FR in the selected countries in the study area is 1.7. Pakistan has the largest value in 2010 while Korea has the smallest value in 2020. UR has an average value of 68.45, which is more than 50%. This rate is lowest in Myanmar in 2010 and highest in two countries, Singapore and Hong Kong during the study period, from 2010 to 2020. Furthermore, the average value of DYS is 0.95, which is almost no difference. However, the minimum value in Pakistan in 2010 was only 0.48 (lower than 0.5). The highest value was in Estonia in 2014. SFP has an average value of 24.1, which is less than 30%. This value is as low as 0, in Hong Kong during the study period from 2010 to 2020. Meanwhile, the maximum value in New Zealand in 2010 is 48.33, which is also less than 50%. Finally, the IG has a mean value of 0.63, indicating that the proportion of high-income countries in the sample is higher than that of the rest of the income levels. Also, the standard deviation values of the research variables are all smaller than the mean, showing that the data coefficients of these variables are low on average or the data set used in this study is not highly dispersed.

4. Results and discussions

Firstly, we validated whether there might exist an endogenous relationship between the digital economy variable and other variables. This endogeneity issue can be addressed through causality testing or Hausman-Taylor estimation. By conducting the Durbin Wu Hausman test (p-value of 0.654), the results indicate no correlation between the digital economy and the random errors of the model, suggesting no endogeneity issue occurs.

Therefore, we estimated the model using RE and POLS. Subsequently, the Breusch-Pagan test was applied to examine the presence of random effects. The test results indicated the existence of random effects, leading to the selection of the RE model. Next, the Hausman test was employed to assess the suitability between the FE and RE models, revealing that the FE model is more appropriate. However, upon conducting consecutive tests: the Wald test for heteroskedasticity, the Wooldridge test for autocorrelation, and the Pesaran test for cross-sectional correlation, we concluded that the model suffers from all three types of deficiencies, including heteroskedasticity, autocorrelation, and cross-sectional correlation. To address these shortcomings, we estimated the regression model using the fixed effects method with Driscoll-Kraay standard errors.

The estimation results indicate that the digital economy variable has a positive impact on women's employment, which is consistent with previous studies by Chen (2004), Nikulin (2017), and Valberg (2019). These studies suggest that enhancing the application of ICT and digital economic development positively influences women's employment through various channels.

Table 3. Summary of regression results (POLS, REM, FEM, FEM with Driscoll-Kraay standard errors)

	POLS	RE	FE	Driscoll-Kraay FE
	WE	WE	WE	WE
DE	0.139**	0.0340**	0.0468**	0.0468**
	(6.00)	(4.17)	(6.06)	(5.49)
lnpGDP	-0.836*	-2.068**	-2.924**	-2.924**
	(-1.70)	(-4.67)	(-6.91)	(-7.21)
FR	-3.234**	-0.246	0.145	0.145
	(-8.60)	(-0.82)	(0.52)	(0.86)
UR	-0.0272*	0.123**	0.0948**	0.0948**
	(-1.88)	(5.08)	(3.13)	(4.07)
DYS	45.31**	3.060**	2.667**	2.667*
	(23.16)	(2.19)	(2.02)	(1.92)
SFP	0.0719**	0.0290**	0.0365**	0.0365**
	(4.68)	(3.04)	(4.18)	(5.62)
IG	-0.934*	-0.631**	-0.907**	-0.907**
	(-1.89)	(-2.39)	(-3.79)	(-4.19)
_cons	11.00**	52.98**	62.88**	62.88**
	(2.28)	(13.92)	(16.62)	(17.92)
N	583	583	583	583
R-squared	0.699		0.196	
Breusch and Pagan LM test			Prob > $chibar^2$ = 0.0000	
Hausman test			Prob>chi^2 = 0.0000	
Wald test			Prob>chi^2 = 0.0000	
Wooldridge test			Prob > F = 0.0000	
Pesaran test			Pr = 0.0013	

Notes: t-statistics are in parentheses. *, ** denote statistical significance at 10% and 5%, respectively.

Source: Authors' calculation

Firstly, through information accessibility, improved access and utilization of digital services enable easy access to job search and recruitment platforms, thereby increasing opportunities. SkyQuest (2022) forecasted a growth rate of around 6.1% annually for this platform market during 2022-2028. Fortune Business Insights (2019) data revealed that the ICT sector held a substantial share of the recruitment software market, accounting for nearly 20% in 2017, while the computer sector claimed over 20% in 2019. Consequently, both the general workforce and

women can access these platforms, enhancing their employment prospects. Employers can efficiently find suitable candidates, and candidates can discover suitable job opportunities. Additionally, the development of the Internet coincides with the rise of social media platforms such as Facebook, Twitter, and Instagram, leading to the more robust dissemination of movements and messages regarding women's rights (Crossley, 2015). This contributes to raising public awareness about the significance of women and gender equality. Consequently, female labor holds more influence in the job market as businesses, leaders, and recruiters increasingly recognize and value women's roles and skills. Moreover, women acknowledge their capabilities, shedding structural limitations and confidently engaging in the job market.

Secondly, the robust integration of ICT into the economy will generate new jobs across various sectors. The demand for female labor in positions requiring communication and other soft skills, rather than just physical strength, will increase. Additionally, sectors with a higher proportion of female labor, such as healthcare and social services, demand cognitive and communication skills, and have a lesser tendency towards automation (Dabla-Norris and Kochhar, 2018). Based on skill change calculations from 2003 to 2015, the OECD (2017) determined that employment growth primarily occurs in high-skill jobs, benefiting women more than men across the United States, Japan, and Europe.

Furthermore, thanks to ICT, women can save time due to increased flexibility in their work. According to Statista, on average, 79% of European women engage in household chores or cooking daily, compared to 34% of men. Additionally, ILO (2018) indicated that women spend around four times as much time as men on unpaid care work in Asian countries. Through access to and utilization of digital services, women can balance family care responsibilities and economic participation to earn additional income. Churchill and Craig (2019) indicated that high income is a major motivator for men to engage in work through platforms like Uber and Freelancer, while women primarily use such platforms due to time constraints posed by other formal jobs.

Contrary to previous findings suggesting higher fertility rates decrease women's labor force participation (Nikulin, 2017; Nkoumou Ngoa and Song, 2021; Valberg, 2019), this study yields opposite results. Modern childcare services and household technologies like dishwashers increase women's workforce involvement. In the digital economy, foundational development offers women more flexibility and better balance between work and caregiving. Rodríguez-Modroño *et al.* (2022) showed that popular platform jobs in historically low participation countries (Spain, Italy) and low-wage countries (Portugal) impact women's employment.

The research findings demonstrate that as the urban population ratio increases, employment opportunities for women also correspondingly rise, aligning with the initial theoretical framework and consistent with prior studies (Aboohamidi and Chidmi, 2013; Nikulin, 2017). Similarly, the disparity in years of education reflects the level of education, and it is evident that higher education levels correspond to higher employment rates. This result is in line with reality, the theoretical foundation, and previous research (Chen, 2004; Valberg, 2019). The study's outcome also indicates that increased female participation in the legislature leads to greater gender equality

in women's employment, showcasing the role of women in the state and contributing to the formulation of policies that impact the community. This impact is consistent with the theories initially proposed by Ng and Muntaner (2018), Gerring *et al.* (2005). The rising ratio of women in legislative positions can lead to the introduction of new socioeconomic development policies and empower women, reducing discrimination and encouraging their political involvement (Gerring *et al.*, 2005). Thus, this positively affects the labor force, particularly with a positive influence, opening opportunities for women in the employment structure.

Table 4. Estimation results separated by income group

	Overall	**High income**	**Middle income**
	WE	**WE**	**WE**
DE	0.046**	0.064**	-0.068**
	(5.49)	(8.97)	(-4.50)
lnpGDP	-2.924**	-4.123**	0.433
	(-7.21)	(-5.44)	(0.61)
FR	0.145	-0.255**	-0.168
	(0.86)	(-2.25)	(-0.32)
UR	0.094**	0.047**	0.204**
	(4.07)	(2.76)	(3.68)
DYS	2.667*	18.32**	-3.244
	(1.92)	(5.73)	(-1.27)
SFP	0.036**	0.003	0.070**
	(5.62)	(0.74)	(3.82)
_cons	62.88**	66.14**	29.66**
	(17.92)	(8.17)	(6.61)
N	583	385	198

Notes: t-statistics are in parentheses. *, ** denote statistical significance at 10% and 5%, respectively.

Source: Authors' calculation

Based on the income group division by the World Bank in 2021 for the data of 2020, the middle-income group has an average GNI per capita ranging from 1,046 to 12,695 USD, while the high-income group has an average GNI per capita exceeding 12,695 USD. According to this classification, the high-income group comprises 35 countries, corresponding to 385 observations, and the middle-income group includes 18 countries, corresponding to 198 observations. After conducting model selection tests and addressing model deficiencies, the team proceeded to remedy the shortcomings by estimating the fixed effects model using Driscoll-Kraay standard errors for both datasets. The results revealed that the variable DE remained statistically significant

in both income groups. However, it exhibited a positive impact on the dependent variable in the high-income group and a negative impact on the middle-income group.

There are distinct impacts observed between high- and middle-income countries, consistent with Valberg (2019). Data from the World Bank database revealed that the female unemployment rate in high-income countries within the research area consistently surpasses that of males. However, in middle-income countries, the disparity is less significant, and in some years, the male unemployment rate is higher than that of females. Therefore, employment access opportunities in middle-income countries are more evenly distributed between both genders. Gender bias, wage disparities, working hours, and the substantial caregiving responsibilities of women persist, particularly in lower-income countries, resulting in men benefiting more from the digital economy. The GDP per capita is a measure of a country's average income. Regression analysis reveals an inverse link between GDP per capita and women's employment. Nikulin (2017) finds that higher women's income in high-income countries often leads to decreased labor market participation. Statista data show that around 79% of European women engage in daily household chores, while only 34% of men do. ILO (2018) shows that Asian women spend significantly more time on caregiving than men. Increasing GDP per capita in upper-middle income countries does not necessarily result in reduced labor force participation. Unemployment subsidy policies are less emphasized compared to developed nations. Verick (2014) also indicated a U-shaped relationship between GDP per capita and female labor participation.

5. Conclusions

The study investigates the factors influencing women's employment in Europe and Asia, encompassing both digital and non-digital economic factors. By examining the wider research environment related to the impacts of the digital economy on employment issues, female employment, and the role of various other factors, a research framework was established to quantitatively gauge the impact of the digital economy on women's employment. This proposed framework variables include the digital economy, GDP per capita, urbanization rate, birth rate, difference in years of schooling, and the share of female seats in parliament. Based on data spanning from 2010 to 2020 from 53 countries, the research results reveal a positive association between the digital economy and women's employment. It is also found that Europe holds a leading position globally, boasting more advanced digital economic infrastructure than Asia. Furthermore, the research shows different impacts among income groups, with high-income nations displaying positive effects and low-income nations exhibiting negative effects when examining the impact of the digital economy on women's employment. Based on the study's outcomes, several recommendations for governmental bodies and policymakers are made.

Firstly, to enhance women's employment rates, encouraging their participation in the labor force is a prioritized solution. This is particularly crucial in developing countries with lower incomes where the female labor force participation rate is significantly lower than that of males. Research findings have indicated a reverse impact of the digital economy on women's employment rates in these countries. Therefore, if the labor force participation rate isn't improved, the development of the digital economy might not bring substantial benefits to

women and could even widen the employment gap. Diversifying flexible job opportunities in terms of time and location is necessary to enable women to balance earning money and household duties. Therefore, management authorities should propose solutions for developing infrastructure and providing digital access: improving internet speed, ensuring cybersecurity, and promoting the use of mobile phones, computers, and other devices for women to access job opportunities or work without spatial and temporal constraints. The government should also encourage businesses to adopt flexible operational approaches without compromising work efficiency. Furthermore, reinforcing education and awareness campaigns will enable women to change subjective perspectives and encourage societal shifts in viewpoints. This practical approach is essential for eradicating biases about women's societal roles.

Secondly, digital infrastructure and skills are crucial factors in reducing gender inequality in the labor market. The digital economy creates numerous employment opportunities and alters the labor structure, enabling remote work through the Internet. Developing the digital economy necessitates the establishment of inclusive and regionally balanced infrastructure development. Information infrastructure stands as a fundamental and essential element for the digital economy. Promoting infrastructure development in mountainous areas, and ensuring high-speed connectivity and internet access, especially for women facing technological barriers, is imperative. Focusing on infrastructure and telecommunications development in developing countries and regions serves as a driving force for digital platform expansion, where governments can monopolize the telecommunications market to invest resources in digital infrastructure. Additionally, companies can mitigate gender disparities in labor by implementing policies that promote flexible working hours, providing supportive equipment for employees, and ensuring that talented individuals without access to necessary work tools are not left behind. Firms should also employ digital tools and software for managing, evaluating, and measuring work, fostering flexible working hours and remote work opportunities to increase women's access to employment.

Thirdly, providing women with the necessary skills to meet market demands is essential in the digital economy era. As the digital economy evolves, the labor market's demands change accordingly, with job trends and work forms shifting. Equipping women with the requisite knowledge to meet these requirements is crucial. Governments should invest in encouraging educational institutions to invest in and create new, updated training programs, minimizing training costs to enable women's access to education. According to the World Bank data (as of August 2022), the post-secondary enrollment rate remained relatively low in Vietnam, with only 28.6% of the population enrolling in post-secondary education in 2019, lower than neighboring countries and an average enrollment rate of 55.1% in middle-income countries. Education costs serve as a significant barrier to post-secondary education decisions. Government initiatives and education promotion through training programs and vocational knowledge dissemination are critical for harnessing the long-term potential of the digital economy. For high school graduates, the government can establish talent scholarships for women and disadvantaged students to ensure equal access to knowledge for all individuals.

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Appendix A. List of sample countries

High-income countries		Upper-middle income countries	Lower-middle income countries
Australia	Iceland	Albania	India
Austria	Italy	Armenia	Indonesia
Belgium	Japan	Azerbaijan	Kyrgyz Republic
Switzerland	Korea, Rep.	Bosnia and Herzegovina	Myanmar
Cyprus	Lithuania	Belarus	Pakistan
Czech	Luxembourg	China	Vietnam
Germany	Latvia	Georgia	
Denmark	Netherlands	North Macedonia	
Spain	Norway	Montenegro	
Estonia	New Zealand	Malaysia	
Finland	Poland	Thailand	
France	Portugal	Türkiye	
United Kingdom	Romania		
Greece	Singapore		
Hong Kong SAR	Slovak Republic		
Croatia	Slovenia		
Hungary	Sweden		
Ireland			

Source: Authors' compilation based on the World Bank country classifications by income level for 2020