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Digitization and Gender Income Gap Among Rural Migrants: Evidence from China

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Abstract: This article explores the role of digitization in the gender wage gap among rural migrants in China. With the rapid development of the digital economy, rural migrant workers have become an important part of society. Based on data source from National Health Commission of the People's Republic of China, we find that although digitization increases the overall income of rural migrant workers, it benefits males more than females, and the gender income gap among rural migrants is widening. According to our estimates, digitization significantly improves the mobility of females and requires more male physical workers than females, thus widening the gender income gap. Heterogeneity analysis shows that there are significant differences in the effect of digitization among those who have different education levels, marital status, ages, and the economic levels of the cities they have migrated to. The gender income gap widens when rural migrants have junior or high school education, are married, are young, and have migrated to cities with high economic development. Our findings highlight the effects of digitization across special social groups, providing micro-evidence of the digital economy's impact on the gender income gap and offering useful references for implementing digital strategies and public policies to social equity and sustainable development.

Keywords: digital economy, gender inequality, income

1. Introduction

The main purpose of this paper is to investigate whether digitization can affect the gender income gap among rural migrant workers. Although gender wage gap has declined these years [1], gender differences continue to play a significant role in occupations and industries, as well as in gender roles and the division of labor [2]. Worldwide, women's wages are still lower than men's [3]. As a significant demographic in China, the rural migrant workers numbered about 776 million in 2017 and accounted for 36.9% of total employment.1 They migrate to cities to sustain a livelihood and improve their living conditions, while also supplementing the urban labor force and enhancing the urban agglomeration economics. Although an increasing number of women are migrating autonomously for work, some papers indicate that women experience migration in very different ways compared to men throughout the migration process, including the pre-migration period, transit, and post-return phases [4; 5] and they may get a lower wage.

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With the advancement of Information and Communication Technology (ICT), digitization has become a crucial factor in economic development, transforming the way business is conducted and working conditions are structured [6]. Thus, this has led to an increasing need for employees who adapt to the transformation. As increasing numbers of surplus agricultural laborers in rural areas move to non-agricultural sectors, and with the necessity to narrow the income gap, we wonder whether digitization has altered the circumstances for this vulnerable group which had an obvious gender differential in transfer and wage in the traditional economic form.

Given the importance of digitization, many reviews and surveys have been conducted on the benefits of digitization to the gender gap. Technological advances reduce the amount of time women spend having and raising children, and encourage more women to enter the labor market, thereby reducing the gender wage gap[7]. In addition, technological development within-industry shifts that favored white collar relative to blue-collar worker, which will benefit women relative to men[8]. It offers a variety of opportunities for females to participate in labor markets, and entrepreneurship equally[9]. However, several researchers have discovered that the gender gap in accessing and utilizing ICTs may further exacerbate pre-existing gender inequalities especially in developing countries [10]. Especially as digital technology drives the growth of platform economy and the gig economy, studies have pointed out that women are more vulnerable to the adverse effects of gender-biased algorithms and platform design, leading to gender discrimination and gender occupational segregation[11; 12].

However, there's limited insight into its impact on the gender wage gap among migrant workers. Studying these disparities is crucial for understanding migrant worker development, urbanization, and the broader effects of urban agglomeration. In this study, we plan to use data on migrant workers and urban digitization levels to explore if advancements in digitization can reduce the gender wage gap, particularly with the rising number of female workers moving to cities. This study serves as a valuable reference for implementing digital strategies that promote social equity and sustainable development.

2. A model of gender gap

We assume that an enterprise needs two kinds of labor in the production process: physical labor and mental labor , and men and women provide the same mental labor, and men provide more physical labor than women [13]. We get the follow model:

$$L_p^f < L_p^m, L_b^f = L_b^m \tag{1}$$

Where L_p^f and L_p^m means physical labor provided by female and male respectively. L_b^f and L_b^m means mental labor provided by female and male. And we suppose that the share of manual labor provided by men and women are λ and $1-\lambda$ respectively:

$$L^f = (1-\lambda)L_p + L_b/2, L^m = \lambda L_p + L_b/2 \tag{2}$$

Where L^f and L^m are labor supply by male and female. Then we follow the gender income gap formula get:

$$gap = \frac{w_m(\lambda L_p + L_b/2)}{w_f[(1-\lambda)L_p + L_b/2]} \tag{3}$$

In this formula w_m and w_f are female's and male's average wage rates respectively. The development of digitization can benefit economic growth [14; 15] and raise the overall income level [16]. However, for rural migrants, their jobs are likely to be concentrated in low-paid, temporary or

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part-time work. Most rural migrants are concentrated in physical and service work, such as housekeeping, security, express delivery, and food delivery, industries which tend to prefer men over women because of gender labor force market segmentation [17; 18]. We take the partial derivative of gap with respect to L_p:

$$\frac{\partial gap}{\partial L_p} = \frac{L_b w_f w_m (2\lambda - 1)}{2\{w_f[(1-\lambda)L_p + L_b/2]\}^2} \tag{4}$$

According to (3), we conclude that if the demand for manual labor increases, the gender pay gap will widen. In addition, in the job market, women may face gender bias and discrimination, which not only limits their career options, but can also affect their salary levels [19]. In the process of digitization, these biases and discrimination may still exist or even be exacerbated. Moreover, digital technology may not really reach this group. As more women move in, they also face increasing challenges. Therefore, we think that the gender income gap is likely to widen among this particular group.

3. Methodology

3.1. Model and method

We use following OLS models to examine the impact of digitization to the income of rural migrants: This paper examines whether the digitization can alleviate the gender income gap. Therefore, we first examine the impact of the digitization on the income, and explores whether digital technology has improved the income level of rural workers. Then, we add gender and digital interaction to further test whether there are differences in the impact of the digitization on the income for rural migrants of different genders. Our regression models are described as follows:

$$\text{lnincome}_{ic} = \beta_0 + \beta_1 \times \text{dig}_c + \lambda \times Z_{ic} + \mu_{ic} + \xi_{ic} + \varepsilon_{ic} \tag{5}$$

$$lnincome_{ic} = \beta_0 + \beta_1 \times dig_c + \beta_2 \times dig_c \times gender_i + \lambda \times Z_{ic} + \mu_{ic} + \xi_{ic} + \varepsilon ic \tag{6}$$

Where i, c indicate identity and city respectively, lnincome is the log of income, dig is the digitization level. Gender is a dummy variable that 1 indicates female and 0 indicates male, Z is a vector of controls, μ_i, ξ_i are cities and occupation fixed variables, ε_{ic} is an idiosyncratic error term.

3.2. Data and descriptive statistics

Our quantitative analysis of rural workers is based on data source from National Health and Family Planning Commission of the People's Republic of China in 2017. The primary tool for data collection in this study was a questionnaire. Secondly, we use Entropy Weight Method to measure city's digitization level [20]. National statistics such as GDP, population, and the industrial structure of various cities were sourced from the Chinese Statistical Yearbook. We keep only the samples whose Household Register(hukou) are rural registration. Furthermore, we delete samples whose income data is missing. The final sample involves 103825 samples including 59412 male workers and 44413 female workers. Tabe l and Table 2 show the descriptive statistics.

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Table 1:descriptive statistics

variables	Definition	Mean	SD	Min	p50	Max
lnincome	(log) wage	8.1558	0.5853	6.3969	8.1605	9.9035
Dig	Digitization level	0.3610	0.1716	0.0000	0.3903	0.7363
Gender	Male=1; Female=0	0.5722	0.4948	0.0000	1.0000	1.0000
Hours	Working hours	58.0294	18.2777	8.0000	56.0000	98.0000
Year	Years of migrant	6.8827	5.8529	1.0000	5.0000	26.0000
Ages	Age of workers	36.3160	9.7398	19.0000	35.0000	66.0000
Marr	Married=1; Unmarried=0	0.8085	0.3934	0.0000	1.0000	1.0000
Numbers	Number of family	3.1971	1.1580	1.0000	3.0000	6.0000
Edu	Education years	9.7558	3.0952	0.0000	9.0000	16.0000
Lnpoplution	Population of the city they moved in	4.6948	1.2645	0.0000	5.1705	5.8051
lnGDP	(log) Real GDP	4.9354	0.9647	1.3863	5.2575	5.8522
industry	Industrial structure	226.6329	101.5176	1.0000	269.0000	337.0000

Table 2: Male and Female descriptive statistic

	Female			Male		
	Mean	SD	p50	Mean	SD	p50
lnincome	7.9928	0.5581	8.0064	8.2776	0.5755	8.2940
Dig	0.3646	0.1718	0.3912	0.3584	0.1713	0.3895
Hours	57.1097	18.5247	56.0000	58.7169	18.0603	56.0000
Year	6.4923	5.5152	5.0000	7.1746	6.0768	5.0000
Ages	34.9653	9.5433	34.0000	37.3257	9.7630	36.0000
Marr	0.8009	0.3993	1.0000	0.8143	0.3889	1.0000
Numbers	3.1799	1.1565	3.0000	3.2100	1.1590	3.0000
Edu	9.6081	3.3875	9.0000	9.8662	2.8523	9.0000
Lnpoplution	4.6954	1.2600	5.1761	4.6943	1.2678	5.1591

The means of income and hours indicate that the income and working hours of male is higher than female. The average age of workers is 36. The education years is about 10 years, which is little difference in the male and female samples.

4. Results

4.1. Baseline regression

To test the effect of digitization development on the gender income gap across different genders, we first follow Model (5) to test whether digitization improves income, as shown in Columns (1)-(4). We find that the coefficient is significantly positive at the 1% level, indicating that the development of digitization does improve income among rural migrants. Furthermore, we follow Model (6) to add the variable 'sex_dig,' which is a cross-product variable. The estimation results are summarized in Columns (5) and (6). The coefficient on sex_dig here is -0.0331, negative and statistically significant at 10% level. And when adding occupation and city fixed effects, the coefficient is -0.03.7, still negatively significant. This implies that digitization does not improve women's wages and suggests a widening gender income gap among rural migrant workers with an increase in digitization.

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Table 3: baseline regression

	(1)	(2)	(3)	(4)	(5)	(6)
	lnincome	lnincome	lnincome	lnincome	lnincome	lnincome
dig	0.4822***	0.2556***	0.3191***	0.2381***	0.3335***	0.2534***
	(47.4110)	(7.6946)	(29.9782)	(7.2877)	(24.4419)	(7.4636)
Sexual	-0.2878***	-0.2640***	-0.2901***	-0.2600***	-0.2781***	-0.2489***
	(-81.6169)	(-76.5835)	(-83.3321)	(-75.7506)	(-35.0879)	(-32.9732)
sex_dig					-0.0331*	-0.0307*
					(-1.6871)	(-1.6569)
year			0.0015***	0.0005*	0.0015***	0.0005*
			(4.8440)	(1.7021)	(4.8451)	(1.7017)
ages			-0.0045***	-0.0031***	-0.0045***	-0.0031***
			(-22.1107)	(-15.6340)	(-22.1104)	(-15.6314)
eduyears			0.0291***	0.0290***	0.0291***	0.0291***
			(47.5304)	(46.5661)	(47.5311)	(46.5694)
lnpoplution			-0.0073***	-0.0367	-0.0073***	-0.0370
			(-5.3724)	(-0.0000)	(-5.3760)	(-0.0000)
lnGDP			-0.0074***	0.0487	-0.0074***	0.0486
			(-4.1592)	(0.0001)	(-4.1565)	(0.0001)
Industry			0.0005***	-0.0010	0.0005***	-0.0010
			(27.9300)	(-0.0001)	(27.9305)	(-0.0001)
Occupation FE		Yes		Yes		Yes
City FE		yes		yes		yes
_cons	8.1048***	8.1004***	7.9916***	8.1046	7.9864***	8.1002
	(1879.3058)	(68.5678)	(498.9430)	(0.0015)	(489.7322)	(0.0015)
N	103825	103825	103825	103825	103825	103825
adj. R2	0.078	0.199	0.124	0.225	0.124	0.225

Note: a.t statistics in parentheses. b.* p < 0.1, ** p < 0.05, *** p < 0.01

4.2. Endogeneity and robustness checks

In order to test the conclusion for endogeneity problems caused by missing variables, we added city-level variables. We add city level variables including human capital(humcap), total retail sales(sales) and total government revenue(governrevenue) which tabulated in Table4 Column (1). The result is also digitization significantly widen the gender income gap.

Then we perform a series of robustness test. Firstly, considering the faster development speed and higher quality of the digital economy, and its more pronounced impact on individual income. We exclude samples from developed city which include Beijing, Shanghai, Guangzhou and Shenzhen. The results, as shown in columns (2) of Table 7, indicates that the estimated coefficients of gen_dig is consisting with baseline regressions, suggesting that men are more significantly influenced by the digital economy and the gender income gap are widening with the development of digitization.

The baseline regress verifies whether industrial digitization reduces the gender wage gap by introducing a cross-multiplying term between gender and digitization level. The model assumes that the coefficients of other control variables do not change with gender. In order to avoid the influence of other control variable coefficients with gender on the results, the samples were divided into "female" and "male", respectively to test the impact of digitalization on income. The test results are

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shown in Table 4 where (3), (5) and (7) are male and (4), (6) and (8) are female. The regression coefficient of digitization in the female subsample is significantly lower than that in the "male" subsample. In addition, we conducted Chow test. The results are also shown in Table4. All of the results are significantly rejecting the hypothesis that there is no significant difference between the regression coefficients of the two groups. These results show that at the 1% significance level, there is a statistically significant difference between genders, and that women are affected negatively by digitization on income. And the improvement of regional digitization has a significantly greater promoting effect on the wage growth of male migrants than female migrants, which is conducive to widening the gender wage gap.

Table 4: Endogeneity and robustness checks

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	lnincome	lnincome	lnincome	lnincome	lnincome	lnincome	lnincome	lnincome
gen_dig	-0.0307*	-0.0772***						
	(-1.6569)	(-3.3458)						
dig	0.2534***	0.2294***	0.4925***	0.4684***	0.2545***	0.2496***	0.2439***	0.2420***
	(7.4636)	(4.8974)	(36.1221)	(30.7125)	(5.6264)	(5.1565)	(5.5316)	(5.1052)
Gender	-0.2489***	-0.2363***						
	(-32.9732)	(-27.9094)						
humcap	0.0005							
	(0.0001)							
sales	0.0003							
	(0.0001)							
Governrevenue	-0.0615							
	(-0.0000)							
Occupation FE	Yes	Yes			Yes	Yes	Yes	Yes
City FE	Yes	Yes			Yes	Yes	Yes	Yes
Other controls	Yes	Yes					Yes	Yes
Chow Test			3331.36***		19.08***		3.12***	
_cons	7.6634	6.8764	8.1011***	7.8220***	8.2098***	7.4109***	7.9126	10.6369
	(0.0097)	(1.5315)	(1495.9621)	(1272.3319)	(61.2011)	(28.9156)	(0.0009)	(0.0003)
N	103825	93789	59412	44413	59412	44413	59412	44413
adj. R2	0.225	0.209	0.021	0.021	0.152	0.162	0.179	0.192

Note: a.t statistics in parentheses. b.* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

5. Discussion

Income may be influenced by the mobility of work as duration is a key attribution to job [21]. Workers will be hit in terms of unemployment if they work at a precarious or unsuitable careers, especially immigrants [22]. As people who have a stable work have a higher wage level. In highly digitalized cities, where job requirements are often higher, rural laborers, typically with lower education levels, may find it more challenging to find a stable job. This situation could lead them to migrate across multiple cities in search of job opportunities or to work in industries characterized by high mobility. We hypothesize that this situation disproportionately impacts women. In addition, more stable jobs that emerge from digitization for rural migrant workers might be inclined to favor men, especially those manual works. Therefore, it influences women's life and employment stability. Consequently, the development of digitalization affects women's wages and exacerbates the gender pay gap.

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We change the dependent variable to 'mobility,' measured by the question, “How many cities have you moved to?”. The results, presented in Table 5, Column (1), show that women have moved to more cities than men.

Plus, compared to women, men may engage in more physical jobs [15]. We focus on samples engaged in labor-intensive jobs, including 'Security,' 'Cleaning,' 'Farming, Forestry, Animal Husbandry, Fishery, Water Conservation, Production Personnel,' 'Housekeeping,' 'Building,' 'Express,' 'Production,' 'Decorating,' 'Food,' and 'Transportation.' We define the dependent variable as whether the workers are physical workers (1 physical workers, 0 means non-physical workers) and employ probit regression. Columns (2) and (3) reveal that digitization significantly reduces women’s employment in these physical jobs, while it enhances men’s employment. The marginal effect on male employment is 1.05%. Therefore, we conclude that digitization considerably exacerbates the gender income gap by increasing the precariousness of women's work and life, as well as by boosting men's employment in physical labor.

Table 5: channels to influence the income gap

	(1)	(2)	(3)
	mobility	Female	Male
sex_dig	0.1683***		
	(2.6388)		
dig	-0.5707***	-0.4024**	0.2095***
	(-4.8866)	(-2.0907)	(2.9542)
sex1	-0.5255***		
	(-20.2417)		
Controls	Yes	Yes	Yes
Occupation FE	Yes	Yes	Yes
City FE	Yes	Yes	Yes
Margin Effect (Power Distance)		-0.0029**	0.0105***
		(-2.0594)	(2.9487)
_cons	6.3826	-4.2185***	-2.8405***
	(0.0003)	(-13.4974)	(-25.1655)
N	103825	44413	59412
adj. R2	0.081		

Note: a.t statistics in parentheses. b.* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

6. heterogeneity

6.1. The role of education

Education is also a key influencing factor to rural migrants’ employment. Generally speaking, digitization will more beneficial to brainworkers or white-collar workers [8] which are influenced by the time of education. We divided the samples by different education levels and found that workers with 6-15 years of education experience a wider gender income gap and there are more male than female workers at this level of education (see Finger1.). Therefore, digitization significantly widens the gender income gap among rural migrant workers who have 6-15 years of education.

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Table 6: different education levels

education	(1)	(2)	(3)	(4)
	<6	6-9	9-15	>15
gen_dig	0.0083	-0.0307*	-0.0307*	-0.0140
	(0.1807)	(-1.6569)	(-1.6569)	(-0.1744)
dig	0.1649*	0.2534***	0.2534***	0.4549***
	(1.6816)	(7.4636)	(7.4636)	(3.6787)
Gender	-0.2352***	-0.2489***	-0.2489***	-0.2754***
	(-13.6622)	(-32.9732)	(-32.9732)	(-7.5683)
Controls	Yes	Yes	Yes	Yes
Occupation FE	Yes	Yes	Yes	Yes
City FE	Yes	Yes	Yes	Yes
_cons	8.2254	8.1002	8.1002	13.2047**
	(0.0002)	(0.0015)	(0.0015)	(2.2813)
N	18315	103825	103825	4131
adj. R2	0.220	0.225	0.225	0.337

Note: a.t statistics in parentheses. b.* p < 0.1, ** p < 0.05, *** p < 0.01

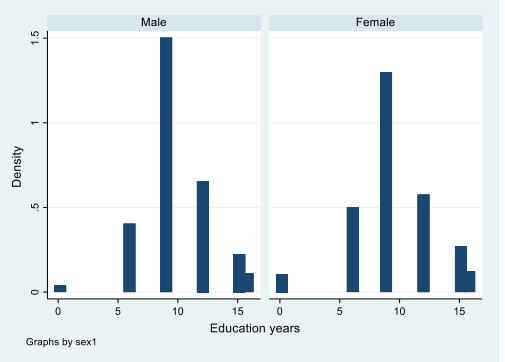

Figure 1: education years of rural migrants

6.2. The heterogeneity of digitization performance among rural migrants on a comparative perspective.

Migrant workers' career choices and working hours are often shaped by traditional gender roles, especially for married women who typically assume more household and childcare duties. This limits their potential for income growth [23]. Conversely, unmarried women, generally younger and better educated, face fewer family obligations, enabling them to leverage digital technology for more flexible employment options. Consequently, they are often employed in higher-paying roles, positively impacting their earnings. Married women might opt for part-time work or take career breaks for familial commitments, impeding their professional advancement and income prospects [24].

We compare married and unmarried workers which shows in Tabel 7 that digitization reduces the gender income gap among singles. For married individuals, however, the gap widens, underlining the struggle married women face in juggling work with home duties. While digitization theoretically offers more opportunities and flexibility, in reality, it benefits unmarried women more, exacerbating the income disparity with their male counterparts.

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Table 7: heterogeneity of digitization performance among rural migrants

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Married	Unmarried	Young	M-age	Older	lGDP	HGDP
sex_dig	-0.0618***	0.0945***	-0.0379*	0.0292	0.1229	0.0168	-0.0807***
	(-2.9310)	(2.6068)	(-1.8419)	(0.6800)	(0.6837)	(0.6154)	(-3.1753)
dig	0.2819***	0.1961***	0.2817***	0.1703**	0.0581	0.3013***	0.0873
	(7.1296)	(3.1622)	(7.4115)	(2.2428)	(0.2392)	(7.5338)	(1.3105)
sex1	-0.2670***	-0.2014***	-0.2571***	-0.2351***	-0.2276***	-0.2756***	-0.2194***
	(-31.1738)	(-13.3866)	(-30.5489)	(-13.7082)	(-3.0957)	(-25.8727)	(-20.3200)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Occupation FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
City FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
_cons	8.3017*	7.0199	7.3453	9.2018	19.6997**	7.9952	15.1884***
	(1.7793)	(0.0003)	(0.0012)	(0.0002)	(2.5163)	(0.0011)	(20.3900)
N	83947	19878	80537	21768	1520	52907	50918
adj. R2	0.244	0.222	0.218	0.220	0.325	0.231	0.219

Note: a.t statistics in parentheses. b.* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

According to the World Trade Organization (WTO) categorizing them as young (under 44), middle-aged (45-59), and elderly (60 and above), our findings in Table7 Column 3-5 indicate that digitalization has a notable impact on the younger workforce.

The gender wage disparity among rural migrant workers is also influenced by the economic advancement of their destination cities. In cities with advanced economies, the job market tends to offer a wider array of high-paying technical, managerial positions, typically occupied by men, while women often find themselves in lower-paying service roles. This discrepancy can lead to a pronounced gender pay gap, as our findings in Column (6) and (7) reveal a substantial negative effect of digitalization on women's income in economically prosperous cities.

7. Conclusion

This paper examines the causal relationship between digitization and the gender income gap among rural migrant workers. The empirical results show that digitization has significantly negative effects on the gender income gap, indicating that it can increase men's income while lowering women's income. This phenomenon can be explained in two ways. First, digitization may exacerbate the precariousness of women's jobs and life. Second, the adoption of digital technology may increase male employment in physical jobs and decrease female employment. These findings are consistent with the model. Furthermore, we extensively investigate whether the effects are influenced by factors such as years of education, marital status, age, and the level of regional economic development. Through empirical analysis, we conclude that digitization increases the gender income gap among rural migrant workers with middle and high school education, those who are married, those migrating to highly developed cities, and younger workers. Therefore, for the unique group of rural migrant workers, we believe that the government and relevant organizations should intensify efforts in skill training and education, especially for female residents of rural areas. A key focus should be on enhancing digital competencies and professional skills to help this group adapt to the demands of a digital economy. Secondly, reducing gender discrimination and providing more equal employment opportunities for female migrant workers are essential to narrow the gender income gap. Thirdly,

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specific policy support should be provided to mitigate the negative impacts of digitization on the gender income gap.

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