Female Engagement in Asian Workforce: Exploring the Impact of ICT

Niroj Duwal [1,2*], Shreyeska Silwal [2]

[1] Nepal Open University, Nepal. Email: nirojduwal19@gmail.com

[2] St. Xavier's College, Nepal. Email: silwalshreyeska@gmail.com

* Corresponding Email: nirojduwal19@gmail.com

Received: May 2, 2024

Revised: June 19, 2024

Accepted: June 22, 2024

Online Published: June 30, 2024

How to cite this paper: Duwal, N. ., & Silwal, S. Female Engagement in Asian Workforce: Exploring the Impact of ICT. *Khwopa Journal,* 6(1), 79-99. https://doi.org/10.3126/kjour.v6i1.67218

DOI: https://doi.org/10.3126/kjour.v6i1.67218

ABSTRACT

The labor market in Asian countries has both challenges and opportunities for women to participate in the work force. The aim of this article is to investigate the association of ICT, female education, and fertility with the female labor force participation in 48 Asian countries from 2014 to 2021 in fixed effect model. The results reveal that there is positive and significant association of internet use with female labor force participation, whereas there is a negative relationship between mobile phone usage and female labor force participation which is only significant at ten percent. Similarly, the control variables, GDP and female secondary school enrollment have also positive relationship with female labor force participation. The fertility rate has negative association with female labor force participation. Furthermore, it is found that ICT has significantly affected to female labor participation in Central Asia and South-Eastern Asia. The findings of this article explain that the ICT has increased female labor force participation, their empowerments and returns in the Asian countries. However, it is applicable for the appropriate policies of ICT usage in such a way that it not only increases female labor force participation but also increases the productivity of female workforce. The policy makers should increase the skill-oriented applications in both mobile applications and internet browsers. There should be restrictions on certain applications in the devices which reduce work productivity thereby assuring increase in female labor force participation.

Keywords: Female labor force, ICT, Female educa-

tion, FEM

1. Introduction

Asia is a diverse continent in terms of culture, tradition, society, and economy. The work force also varies in the same manner. The variations across Asian countries are influenced by factors such as stereotyped gender roles, religious restrictions, lack of access to skills training for digital jobs, occupational gender segregation, and discriminatory practices by employers. The labor market in Asian countries has both challenges and opportunities for women to participate in the work force. According to neoclassical theory of labor supply, an individual decides to allocate her time for work when its utility is maximized. The decision of woman depends on the paid work value indicating relationship between earnings and labor force participation (Pencavel, 1986). Similarly, according to human capital theory of labor, the number of labor force participation is increased by investment in education, trainings, skills development by the labor (Mincer, 1974). Information, communication, and technology has increased the skills of labor force. There is empirical evidence of a rise in female labor force participation rate which increases overall productivity of the economy and enhances economic growth and development of the society. Even though there has been success in some areas, women's full potential in the job market is still mostly untapped (Xu, 2023).

The average female labor force participation rate in Asia has a modest increase of about six percentage points since 1990, demonstrating a gradual shift in the employment landscape for women across the region. Conversely, some countries have lagged in fostering female labor force participation. India, Indonesia, the Philippines, and Sri Lanka have sluggish improvements elsewhere in Asia (Banerji et al. 2018). This disparity highlights the complex interplay of economic, social, and cultural factors influencing women's employment in different Asian contexts. Social norms emphasizing women's domestic responsibilities and restricting their mobility are among the prominent constraints to increasing female labor force participation in these regions (Tanaka & Muzones, 2016).

In the landscape of Asian labor markets, the variance in female labor force participation (FLFP) is striking, with figures ranging from a low of 16% in Afghanistan to a high of 83% in Nepal until 2016. This contrast is mirrored in the male participation rates, which span from 52% in Timor-Leste to 89% in Nepal, highlighting a broader spectrum of labor engagement across genders (Tanaka & Muzones, 2016). Despite overarching economic growth, declining fertility rates, and improved education levels, women's participation remains notably low, underscoring the persistent challenges that hinder their fuller integration into the workforce.

Several key interventions have been found to improve FLFP across Asian countries. These include job quotas, making it easier for people to get information, raising the wages of workers, and putting in place free trade policies. Furthermore, it is acknowledged that countries like Japan and South Korea need to spend more on child-

care, especially for kids ages 6 to 11, so that women can continue to work (Kinoshita & Guo, 2015). Together, these strategies, along with a close examination of current policies and a push for more gender-equal economic reforms, could make FLFP a lot better, leading to long-term economic growth and more gender equality in the area.

The study fills a significant research gap by providing an empirical analysis of the impact of Information, Communications and Technology (ICT) on female labor force participation using panel data from 48 Asian countries over the period from 2014 to 2021. This all-around method looks at several important areas that earlier studies might not have fully investigated. This paper seeks to cover extensive geography, analyze longitudinal data, represent cross-sectional analysis, address the economic challenges and many more. The goal of this study is to investigate the impact of ICT on women's participation in labor force across the countries of Asia. The study will look at real-world data and methods like those used in previous empirical studies. It will look at how ICT helps with education, and job changes across sectors. By doing this, it will add to the larger conversation about women equality and economic growth in a world where labor market is dynamic.

2. Materials and Methods

2.1 Literature Review

This article reviewed various articles from journals, books, reports, web pages and so on with the purpose of studying linkage of ICT with the female labor force. There are several literatures which identified various factors that influence female labor force participation. This section is divided into three sub-sections as the major theme of the literature review.

2.1.1 Female Labor Force and ICT

By means of ICT people easily get access and share information which enhances the capacity of human work force (Obayelu & Ogunlade, 2006). After 1990 with brewing globalization there was rapid growth and evolution of ICT. Furthermore, many multinational corporations have increased their capacity, which was possible due to the means of ICT and foster economic growth (Laudon & Laudon, 2010). It is suggested from the various studies that ICTs are associated with social, cultural, and economic empowerment of women (Ambujam & Venkatalakshmi, 2009; Levis, 2011). With the help of ICTs, women along with men transform their knowledge to innovation and increase their productivity (Baglari, 2014; Davis, 2007). Thus, ICT increase women employability and increase their participation in economic development.

Moreover, ICTs access through mobile phone and internet has increased tremendously in the workplace and enhances workers' productivity. Herman (2020) found that there was a strong positive impact of digitalization and labor produc-tivity. Nikulin (2016) conducted a panel data analysis for 60 developing countries from 2000 to 2014 and the results re-vealed that use of both mobile phone subscriptions per 100 people and percentage of individuals using internet had a positive impact on female

labor force.

The empirical studies found that the use of ICT for job search and the use of ICT on employment. Islam (2015) found a positive impact of ICTs on female employment rate in eight south Asian countries using panel ARDL model. Dettling (2017) exhibited that the internet use had increased labor force participation in United States. Omotoso and Obembe (2016) found a positive relationship between mobile phone and internet, and female labor force participation. Watson et al. (2018) also revealed a positive impact of internet use on female labor force in Indo-Pacific. Ngoa and Song (2021) also found significant and positive relation of mobile penetration and internet use on female labor force in African countries. Asongu and Odhiambo (2020) have found similar positive relationship between use of ICT and female labor force participation. Relich (2017) found the positive and significant influence of ICT components on labor participation in European countries.

However, Valberg (2017) investigated in 156 countries regarding the impact of digital technology in female labor force participation. It was found that ICTs could not serve as catalysts for increasing female labor force participation rate in low-income countries. Samargandi et al. (2019) found that ICT has declined female labor force participation without interwoven financial development in Saudi Arabia, if financial development was included, then ICT has a positive impact on female labor force participation.

Due to the different samples and different methodologies encourages new research on the impact of ICT use on female labor force participation. Most of the Asian countries are still in the initial stages of ICT use and from the literature, the first hypothesis of this study is as follows:

Hypothesis 1: Use of ICT enhances female labor force participation in Asian countries.

2.2.2 Female Education, Fertility Rate and GDP, and Female Labor Force

The relationship between female labor force, female education and fertility rate have received much attention in economic literature. There is evidence of less labor force attainment by female due to the barriers to take care of their young children (Roser, 2014) and the female labor force participation is high with lower fertility rate. Skadesen (2017) revealed that the average educational attainment by female had greater impact on female participation in workforce.

The educational attainment enhances female labor force participation. Except primary education, secondary education, tertiary education, and higher education along with economic growth have positive and significant impact on female labor force participation (Faridi et al., 2009). In case of Botswana, Khanie (2019) and in case of India, Bhalla and Meher (2019) found that increase in the educational level by female improved the rate of female labor force participation respectively. Similarly, Onyeke and Ukwueze (2022) interpreted that the primary school enrollment, secondary school

enrollment by female has positive impact of female labor force participation in long run. Similar results were depicted by Ince (2010) in Turkey.

Baah-Boatenga et al. (2013) elucidated that education and fertility rate have influenced female labor force participation in Ghana. In 6 ASEAN countries, fertility rate improves workforce participation of female (Hartani et al, 2015). The highest and adverse impact was seen in Indonesia and in Thailand by female labor force participation.

Shuangshuang et al. (2023) elucidated the interconnections between female labor force, education, fertility, and GDP using data from 1990 to 2020. The results revealed the positive relationship between digitalization and female labor force participation. Education and GDP influenced positively on female labor force in the long run.

Nazah et al. (2021) estimated the effect of fertility and female education on female labor force participation using panel ARDL model from 1990 to 2018 and the results revealed that there is negative relationship between fertility rate and female labor force participation in short run but not in long run. Besides, it was also found that there was bidirectional panel causality between female labor participation and fertility, female labor participation and education.

Several studies revealed that there is a negative relationship between fertility and female labor force participation (Hupkau & Leturcq, 2017; Bloom et al., 2009; Nakagaki, 2018; Shittu & Abdullah, 2019) and so on. However, Aaronson et al. (2017) found that the effect of fertility rate was low on female labor force at a low level of development and negative at a higher level of development. Solomon and Kimmel (2009) found positive relationship between fertility rate and female labor force in case of Ethiopia. Whereas Abbas (2013) and Azimi (2015) stated similar positive relationship in case of Bangladesh and Pakistan, and in case of Iran respectively.

It was also found that educational attainment did not foster the female labor force participation in case of Pakistan (Heath & Jaychandran, 2016). It was also revealed that education did not escalate labor force participation of female and the reason behind was that mothers with education had to devote more time to nurture their children (Andrabi et al. 2012).

It was found that there is a considerable variation in female labor force participation by economic factors. Several studies stated that the female labor force is associated with cultural, social, and economic factors. It is claimed that female labor force is highly influenced by gross domestic product (GDP). There is positive association between GDP and female labor force (Duflo, 2012; Suhaida et al., 2013). However, some studies found weak association between GDP and female labor force participation (Khidirov & Mamadjonova, 2023; Mariel, 2022; Verick, 2014).

Hence, from the above literature, this study is motivated to investigate the impact of education, fertility rate and GDP on the female labor force participation in Asian countries due to variation in the relationship between them. Therefore, the second hy-

pothesis of the study is as follows:

Hypothesis 2: Female education, fertility rate and GDP improves female labor force participation in Asian countries.

2.2 Methods

2.2.1 Theoretical Framework

Female labor force is that proportion of women who are being employed and/or seeking employment. For the empirical analysis of this study, the female labor force participation can be explained theoretically based on the neoclassical model of labor supply and the human capital theory.

According to neoclassical theory of labor supply, an individual takes decision to supply her labor is determined by the allocation of the time between paid work and leisure. Such decision is considered when the individual maximises utility from the work and leisure to fixed time and budget constraints (Pencavel, 1986). The decision of a woman of engaging in the work depends on the paid work value and value of time for leisure which indicates that there is relationship between earnings and female labor force participation.

According to the human capital theory, a decision of investing on education by individual is considered by the cost and benefit of such investment. Moreover, the theory suggests that individual will invest in education, trainings, and skill oriented to increase their ability to get the opportunities through increased productivity in the labor market (Altonji & Blank 1999; Mincer (1974).

Both theories provide the explanation of how a decision of the labor force participation results from an optimal combi-nation of work and leisure. More specifically, female labor supply is most likely affected by allocating her time for work to maximize the utility. On the other hand, investment in human capital that is education predominantly affect female labor force participation. Not only the education but also fertility affects female labor force overtime and across countries. The theories majorly implicate the role of female education, fertility, and GDP on the female labor force participation.

2.2.2 Modelling Framework

The formal stance of the relationship between internet communication and technology, and female labor force participation in Asian countries was obtained a reduced form along the lines of that estimated by Cavalcanti and Tavares (2008), Dettling (2017), Watson et al. (2018) using panel regressions. The econometric model specification for this study is as follows:

$$LNFLFit = \alpha + \beta ICTit + \lambda Xit + \nu i + \mu i + \varepsilon it \quad (1)$$

Where, LNFLFit is natural logarithm of female labor force in country 'i' at time 't '. ICTit is usage of ICT (that is mobile phone subscription and internet usage) in country 'i' at time 't'. Both mobile phone usages and internet usages greatly influence job opportunities and contributes to female employment (Asongu & Odhiambo, 2020). Xit is the vector of control variables (female education, gross domestic product, and fertility

rate). νi, μi, and εit are the fixed temporal, effects, the country fixed effects and the error terms respectively.

Based on the literature such as Dettling (2017), Omotoso and Obembe (2016), Watson et al. (2018), Ngoa and Song (2021) and so on, the proxies of ICT are taken as mobile cellular subscriptions and individuals using the internet, which have positive impact on female labor force participation. Educational attainments also influence the female labor force participation. Bhalla and Meheer (2019), Onyeke and Ukwueze (2022), Roser (2014), Skadeson (2017) and so on considered female school enrollment in their studies and found a positive relationship with female labor force participation. Shuangshuang et al. (2023) revealed that GDP also contribute to increase female labor force participation. The studies such as Kupkau and Lecturcq (2017), Nakagaki (2018), Nazah et al. (2021), Shittu and Abdullah (2019) and so on have found that fertility rate has a negative relationship with female labor force participation. Based on the literature, this study considered mobile cellular subscriptions, individuals using the internet, GDP, gross female school enrollment and fertility rate were chosen as independent variables.

2.2.3 Data

The main objective of this study is to investigate the impact of ICT on the female labor force participation. The data for this study come from 48 Asian countries (Afghanistan, Armenia, Azerbaijan, Bahrain, Bangladesh, Bhutan, Brunei Darus-salam, Cambodia, China, Cyprus, Georgia, Hongkong, India, Indonesia, Iran, Iraq, Israel, Japan, Jordon, Kazakhstan, Kuwait, Kyrgyz Republic, Lao PDR, Vietnam,, Macao, Malaysia, Maldives, Mongolia, Myanmar, Nepal, Oman, Pakistan, Philippines, Qatar, Saudi Arabia, Singapore, South Korea, Sri Lanka, Syria, Tajikistan, Thailand, Timor-Leste, Turkey, Turkmenistan, United Arab Emirates, Uzbekistan, Vietnam and Yemen) covering the period 2014 to 2021.

The main source of data was World Bank World Development Indicators (2023). The definitions and sources are provided in Table 1.

Table 1. Description of the Variables

Variables	Explanation	Sources
LNFLF	Natural logarithm of Female Labor Force	WDI (2023)
MobSub	Mobile Cellular Subscriptions (per 100 people)	WDI (2023)
Internet	Individuals using the internet (percentage of total population)	WDI (2023)
LNGDP	Natural logarithm of Gross Domestic Product at constant 2015 US $	WDI (2023)
SSE	Female School Enrollment (percentage gross)	WDI (2023)
FerRate	Total Fertility Rate (births per woman)	WDI (2023)

Note: Author's own calculation.

3. Results and Discussion

The results obtained from the data analysis from 48 Asian countries follow from the descriptive statistics, inferential sta-tistics, and regression results in unbalanced panel.

3.1 Descriptive Statistics

The summary of descriptive statistics shown in Table 2 to examine the trend over the 8-year period of the data set used.

Table 2. Summary of Descriptive Statistics

Var-iable	Mean	Std. Dev.	Min	Max	Obs
LNFLF	14.659	1.871	10.852	19.685	384
Mobsub	126.395	50.243	46.02	420.853	384
In-ternet	59.987	27.916	7	100	369
LNGDP	25.233	1.958	21.163	30.394	360
SSE	89.331	19.088	29.048	135.521	269
Fer-Rate	2.326	.855	.772	5.56	384

Note: Author's own calculation.

From Table 2, the average of LNFLF was 14.66 from the 384 observations with the standard deviation of 1.87 and minimum and maximum proportion were 10.85 and 19.68 respectively. The mean of Mobsub was 126.40 per 100 people where the maximum and minimum were 420.85 and 46.02 with the standard deviation of 50.24 from 384 observations. The mean of Internet was 59.99 where the maximum and minimum values were 100 and 7 with the standard deviation of 27.91 from 369 observations. The average of LNGDP was 25.23 and the maximum and minimum values were 30.39 and 21.16 with the standard deviation of 1.96 from 360 observations. The mean of SSE was 89.33 and the maximum and minimum values were 135.52 and 29.05 with the standard deviation of 19.08 from 269 observations. The mean of FerRate was 2.33 and the maximum and minimum values were 5.56 and 0.77 with the standard deviation of 0.85 from 384 ob-servations.

Figure 1 shows the evolution of mobile cellular subscriptions (per 100 people), individuals using the internet (percentage of total population), and female labor force participation rate over the studied period from 2014 to 2021 in Asia.

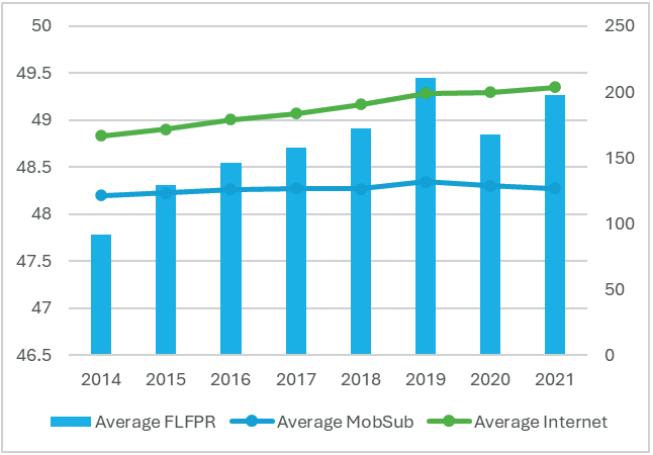

Figure 1. Trends of Female Labor Force Participation Rate and ICTs in Asia

The average female labor force participation rate over the studied period shows that there is gradual increase from around 47.8% in 2014 to about 49.3% in 2019. There was a slight drop in 2020 and increase to about again 49.3% in 2021. The rising trend in female labor force participation rate suggests a positive movement towards more female participating in the labor market over the studied period. This can be an indication of economic opportunities and potential change in society.

The average mobile cellular subscriptions have gradual increasing trend from nearly 121.39 per 100 people in 2014 to nearly 126.8 per 100 people in 2021. In 2019, it increases to nearly 131.69 per 100 people. The increase in mobile usage indicates that there is increasing access to mobile technology in Asian countries. This trend is likely stimulated by technological advancements, affordability of mobile devices and expansion of telecommunication networks in Asian coun-tries.

The average individual using the internet (percentage of total population) has steady increasing trend from around 45% to around 77% from 2014 to 2021. The significant increase in internet usage reflects that there is growing digitization within the population in Asian countries. The expansion of internet usage could be the advancement of technology which might have enhanced communication, access to information and online participation platforms. All these trends suggest positive developments in terms of female labor force participation and information, communication, and technology within the studied period in Asian countries.

3.2 Correlation Analysis

The degree and direction of relationship between the independent variables and dependent variable were studied with the help of correlation matrix as in Table 3. The values range from -1 to 1, where:1 indicates a perfect positive correlation, 0 indicates no correlation, and -1 indicates a perfect negative correlation.

Table 3. Correlation Matrix

Variables	LNFLF	Mobsub	Internet	LNGDP	SEE	FerRate
LNFLF	1.000					
Mobsub	-0.165	1.000				
Internet	-0.330	0.566	1.000			
LNGDP	0.775	0.143	0.182	1.000		
SSE	-0.128	0.611	0.616	0.195	1.000	
FerRate	-0.053	-0.489	-0.549	-0.320	-0.604	1.000

Note: Author's own calculation.

From table 3, it was found that there is a weak negative correlation between the LNFLF and Mobsub (-0.16), between LNFLF and Internet (-0.33). Whereas there is strong positive correlation between LNFLF and LNGDP (0.78). This suggests a high degree of association between these two variables. There is a weak negative correlation between the LNFLF and SSE (-0.13). There is a very weak negative correlation between LNFLF and FerRate (-0.05). It was also found that the independent variables such as SSE and Mobsub (0.61), SSE and Internet (0.62), Internet and Mobsub (0.57), and FerRate and SSE (-0.60) are moderately correlated. Therefore, such correlation between independent variables might invite multicollinearity problem in the regression model and the diagnostic test was essential to be carried out in the study.

3.3 Diagnostic Tests

The diagnostic tests are important for the reliability of the data set. This article employed Jarque-Bera normality test, variance inflation factor (VIF) and imtest, white for testing the data are normal distribution, multicollinearity and het-eroskedasticity.

Normality Test

The null hypothesis of the Jarque-Bera test is that the residuals of the regression model are normally distributed. The JB residual value is 5.29 with p-value 0.071. The p-value is greater than a significance level (0.05). Therefore, the residuals appear to be normally distributed.

Multicollinearity Test

The multicollinearity in the data were measured by Variance Inflation Factor (VIF) on how much the variance of an es-timated regression coefficient increases if the predictors are correlated. The result of VIF is shown in Table 4.

Table 4. VIF

Variable	VIF	1/VIF
SSE	2.17	0.459
Internet	1.88	0.532
FerRate	1.85	0.541
Mobsub	1.78	0.561
LNGDP	1.11	0.900
Mean VIF	1.76	

Note: Author's own calculation.

From Table 4 it was found that all the variables Mobsub, Internet, LNGDP, SSE and FerRate both have relatively low VIF values (less than 2.5), suggesting a less level of multicollinearity between these variables and possibly indicating that they share similar information. The overall mean VIF of 1.76. If the value of VIF is greater than 5, one can say there is a high level of multicollinearity. Since the VIF values are less than 5 for the variables, this study assures there is no evidence of multicollinearity problem.

Heteroskedasticity Test

The heteroskedasticity test is conducted whether there is homoskedasticity in the residuals in model or not by employing white's test. The chi-squared test statistics are 79.84 and the degree of freedom (df) are reported as 26. The probability (prob>chi2) value is 0.0000 (<0.05). This implied that there was evidence of heteroskedasticity in the data. The details are shown in Table 5.

Table 5. Cameron & Trivedi's decomposition of IM-test

Source	chi2	df	P-value
Heteroskedastici-ty	79.84	20	0.0000
Skewness	16.86	5	0.0045
Kurtosis	0.53	1	0.5024
Total	97.23	26	0.0000

Note: Author's own calculations.

From Table 5, it was found that the p-value (0.0000) is lowest, suggesting that there is significant evidence to reject the null hypothesis of homoskedasticity.

3.4 Random Effect Model or Fixed Effect Model

Before the selection of fixed effect model or random effect model, the article

employed Breush and Pagan Lagrangian multiplier test with the chibar2 (01) value as 406.2 with p-value 0.0000 (<0.05). Thus, Pooled OLS was rejected and moved forward to fixed effect model or random effect model.

The Hausman test is used to choose the fixed effect model (FEM) or random effect model (REM). The null hypothesis is FEM is the best to describe the panel data. If the p-value is less than 0.05, then FEM is more appropriate and if the p-value is more than 0.05, then REM is more appropriate. The result of the Hausman test is presented as in table 4.

Table 4. Result of Hausman test

			Coefficients	
Variable	(b) Fixed	(B) Ran-dom	(b-B) Dif-ference	Sqrt(diag(V_b-V_B) S.E.
Mobsub	-0.00081	-0.01111	0.00030	
Internet	0.00181	-0.00002	0.00184	
LNGDP	0.13294	0.46173	-0.32879	0.031659
SSE	0.00094	-0.00081	0.00175	
FerRate	-0.13431	-0.108601	-0.02571	

Note: Authors' own calculation. b = consistent under H0 and Ha; obtained from xtreg, B = inconsistent under Ha, efficient under H0; obtained from xtreg.

From the result of table 4 the appropriate model for this study was Fixed Effect Model (FEM) since the p-value of FEM was 0.0000(<0.05).

Furthermore, when the model was checked by modified Wald test for groupwise heteroskedasticity in Fixed effect re-gression model, where the null hypothesis of sigma(i) square as the sigma square for all I, the chi-square (40) value had the p-value of 0.0000 (<0.05) indicating the presence of heteroskedasticity in the data.

Therefore, the relationship between independent variables and dependent variables was examined using robust FEM which is presented in table 5.

Table 5. Results of Fixed Effect Model

		Fixed Effect Model			Robust Fixed Effect Model			
Variable	Coefficient	Std. Err.	t	p-value	Coefficient	Std. Err.	t	p-value
Mobsub	-.001	0	-2.96	.003	-.001	0	-1.83	.076
Internet	.002	0	3.74	.000	.002	.001	2.63	.012
LNGDP	.133	.062	2.15	.033	.133	.082	1.61	.115
SSE	.001	.001	1.04	.258	.001	.001	0.69	.492
FerRate	-.134	.03	-4.47	.000	-.137	.045	-3.02	.004
Constant	11.62	1.536	7.57	.000	11.63	2.053	5.68	.000
Prob>F		0.0000	Sigma_u	1.6666				
R-squared within		0.4097	Sigma-e	0.4984				
R-squared between		0.3272	Rho	0.999				
R-squared overall		0.3387						

Note: Author's own calculation.

From table 5, the R-squared within was 0.4097 which means the model explained around 40.97 percent between LNFLF and the independent variables such as mobsub, internet, LNGDP, SSE and FerRate. FEM seemed to have good explanatory power with p-value 0.0000 (<0.05).

The results for the FEM indicate that almost all the variables expect SSE are significantly associated with female labor force. The coefficient for the ICT variables internet use is positive and significantly associated with female labor force. An increase of one unit in internet use is associated with a 0.002 unit increase in female labor force participation. This result confirms the first hypothesis of the study and is consistent with the findings of Nikulin (2017) in developing countries, Relich (2017) in European countries, Watson et al. (2018) in Indo-Pacific, Ngoa and Song (2021) in African countries.

It was found that another ICT variable, mobsub is negatively associated with female labor force participation. An increase of one unit in mobsub use is associated with a 0.001 unit decrease in female labor force participation. This result does not confirm on the hypothesis and is inconsistent with the findings of Nikulin (2017), Relich (2017), Watson et al. (2018), Asongu and Odhaimbo (2020), and Ngoa and Song (2021). But the result is similar to the findings of Valberg (2017). A probable interpretation of this result is that use of mobile phone reduces the working time and deviates them in other aspects rather than focusing on the work. Due to the rise in the social platforms, mobile usages are rapidly increasing to be engaged which might inferred taking leisure than involving in the work.

The coefficient of controlled variables LNGDP is positively and significantly associated with female labor force. One unit increase in the natural log of GDP is associated with a rise of 0.133 unit in female labor force. The coefficient of SEE

is statistically insignificant, though one unit increase in female secondary school enrollment is associated with an increase of 0.001 unit in female labor force. Surprisingly, the coefficient of FerRate is significant but has negative association with female labor force. A One unit increase in the fertility rate is associated with a decrease of 0.134 in the female labor force. These results confirm the second hypothesis of the study and consistent with the findings of Faridi et al. (2009), Hartani et al. (2015) in ASEAN countries, Nazah et al. (2021), Shuangshuang et al. (2023). The negative effect of fertility rate on female labor force participation in 48 Asian countries could be explained by the evidence that many females employed workers might have given maternity leave and/or causal leave to take care of their children which reduces the total supply of labor in the market. Another possible reason might be that the Asian countries have diverse cultural and religious values and norms which opposite female engagement in the workplace. Similarly, female enrollment in secondary school en-hances female productivity since education enrich knowledge and skills to empower female and give status in society. Hence, it can be inferred that female education increases female labor force participation in society. As Shuangshuang et al. (2023), this study also considered GDP as the proxy of economic growth which has positive and significant association with female labor force participation in Asian countries. It can be inferred that GDP plays a vital role in stimulating female to participate in labor force positively and significantly.

The robust fixed effect model appears to have similar coefficients to that of the coefficients of fixed effect model but with slightly different standard errors and p-value. The mobile cellular subscriptions were significant at 10 percent in robust fixed effect model and this study considered the robust FEM address heteroscedasticity and other violations of the assumptions of FEM.

This study also investigated the relationship between ICT and female labor force participation in each geographical regions of Asia. The diagnostic tests suggested the variables are normality distribution, no evidence of multicollinearity and no evidence of heteroscedasticity in the data of geographical regions of Asia. The Hausman test suggested that for each of geographical regions of Asia, FEM is best appropriate for the examination of the relationship between the desired variables. The result of FEM for each geographical regions of Asia is presented in Table 6.

Table 6. Results of Fixed Effect Models of Geographical Regions of Asia

Variable	Eastern Asia	Central Asia	South- Eastern Asia	Southern Asia	Western Asia
Mobsub	0.001	0.000	-0.001***	0.001	-0.002***
	0.001	0.000	0.000	0.001	0.001
	1.230	-0.600	-2.500	-0.420	-2.770
Internet	-0.001	0.002**	0.001***	0.002	0.003
	0.001	0.001	0.000	0.001	0.002
	-0.780	2.310	4.350	1.220	1.300
LNGDP	0.498***	-0.052	-0.012	0.292*	0.024
	0.149	0.124	0.043	0.167	0.199
	3.350	-0.420	-0.280	1.750	0.120
SSE	0.002	0.002	0.001	0.003	0.002
	0.002	0.002	0.000	0.004	0.003
	0.960	0.690	1.370	0.960	0.830
FerRate	0.045	0.025	-0.161***	-0.121	-0.117
	0.077	0.044	0.032	0.099	0.162
	0.580	0.560	-5.010	-1.230	-0.720
Constant	1.691	15.859	15.800***	8.125***	13.112***
	4.148	2.898	1.104	4.145	4.831
	0.410	5.470	14.310	1.960	2.710
Prob	0.000	0.000	0.000	0.000	0.000
R-squared within	0.5322	0.6017	0.7251	0.5847	0.5847
R-squared between	0.9227	0.9967	0.0032	0.6902	0.6902
R-squared overall	0.9038	0.9122	0.034	0.7348	0.7348

Note: Author's own calculations. ***, **, *: statistical significance at 1%, 5% and 10% respectively. ( ) represents standard error and [ ] represents t-statistics.

From Table 6, R-squared overall value of Eastern Asia, Central Asia, South-Eastern Asia, Southern Asia, and Western Asia are 0.9038, 0.9122, 0.034, 0.7348 and 0.7348 respectively which describe the model explains the relationship between female labor force participation and mobile usage, internet usage, gross domestic product, secondary school enrollment and fertility rate. The least abled explanations of the variables were found in case of Southern Asia.

In Eastern Asia, the role of ICT, mobile usage and internet usage have not significantly associated with the female labor force participation, but the gross domestic product has statistically significant relationship with labor force participation. One unit rise in gross domestic product rises 0.5 unit in female labor force participation. Other variables such as gross domestic product, female secondary school enrollment and fertility rate have insignificant relationship with female labor force participation.
In Central Asia, internet usage has significant and positive association with female labor

force participation. One unit rise in internet usage increases 0.002 unit in female labor force participation. The mobile usage has insignificant association with female labor force participation. Other variables such as gross domestic product, female secondary school enrollment and fertility rate have no significant relationship with female labor force.

In South-Eastern Asia, Internet usage has positive and significant association with female labor force participation. A rise of one unit in internet usage increases 0.002 unit in female labor force participation. Fertility rate has negative and sig-nificant association with female labor force participation. An increase in one unit in fertility rate decreases 0.16 unit in female labor force participation. Other variables such mobile usage, gross domestic product, and female secondary school enrollment have insignificant relationship with female labor force participation.

In Southern Asia, the role of ICT is insignificant that is the internet usage and mobile usage have statistically significant relationship with female labor force participation. Similarly, female secondary school enrollment and fertility rate have also insignificant association with female labor force participation. Only gross domestic product is found to be significant at 10 percent. One unit rise in gross domestic product increases 0.29 unit in female labor force participation.

In Western Asia, only mobile usage is statistically significant which is negatively associated with female labor force par-ticipation. One unit rise in mobile usage decreases 0.002 unit in female labor force participation. There is insignificant relationship between internet usage, gross domestic product, female secondary school enrollment, fertility rate, and female labor force participation.

The ICT has significantly affected to female labor participation in Central Asia and South-Eastern Asia.

4. Conclusions

The objective of this study was to investigate the impact of ICT on female labor force participation in Asia using panel data of 48 countries for a period from 2014 to 2021. The fixed effect model is best to describe association of ICT; mobile use and internet use on the female labor force participation from the Hausman test. The JB test and VIF confirm that the variables are normal distribution and no evidence of multicollinearity but there was evidence of heteroskedasticity. Therefore, robust fixed effect model is the best to describe the association between the ICT and female labor force participation. The results reveal that there is positive association between internet use and female labor force participation but there is negative association of mobile use in female labor force participation. It may be meant that female use their mobile on-the-job reduces their productivity and belongingness with the workplace and/or they might have to be alert about their children who are at home. The possible reason may be the engagement more time in the social medias. No doubt, the internet use during on-

the-job or off-the-job increases their productivity since they inherent more knowledge, skills, and information. The fertility rate has negative association with female labor force which is consistent with previous literature, and it may imply that they have given maternity leave and/or causal leave to take care of their children which reduces the total supply of labor in the market. Female education has positive relation with female labor force participation, and it implies that education build female to be independent and capable to be fit in the labor market. Similarly, GDP has also positive relation with female labor force participation which means that GDP influence female to participate in labor market. In case of geographical regions, there is significant relationship between ICT and female labor force participation in central Asia and south-eastern Asia.

From the results of this article, it is implicable for the appropriate policies of ICT usage in such a way that it not only increases female labor force participation but also increases the productivity of female workforce. The policy makers should increase the skill-oriented applications in both mobile applications and internet browsers. There should be restrictions on certain applications in the devices which reduce work productivity. Similarly, the policies to increase the female to participate in workforce may be the provision of childcare facilities, family-friendly working environment, and work from home. It is still in need to emphasis on the female education since they have roles of taking care of their children, nurture them and make them the active productive future workforce.

Author Contributions: Conceptualization, N.D., and S.S.; methodology, N.D.; software, N.D.; validation, N.D., and S.S.; formal analysis, N.D..; investigation, N.D., and S.S.; resources, S.S.; data curation, N.D.; writing—original draft preparation, N.D., and S.S.; writing—review and editing, N.D., and S.S.; visualization, N.D., and S.S. All authors have read and agreed to the published version of the manuscript.

Acknowledgments:

Conflicts of Interest: We, Niroj Duwal and Shreyeska Silwal declare no conflict of interest.

References

Aaronson, D., Dehejia, R., Jordan, A., Pop-Eleches, C., Samii, C., & Schulze, K. (2017). The effect of fertility on mothers' labor supply over the last two centuries (NBER Working Paper No. 23717). *National Bureau of Economic Research. doi:* 10.3386/w23717

Abbas, A. (2013). *Determinants of women's labor supply in Bangladesh and Pakistan* (Master's thesis). Retrieved from https://www.diva-portal.org/smash/get/diva2:667855/FULLTEXT01.pdf

Altonji, J.G., & Blank, R.M. (1999). *Race and gender in the labor market.* In O. Ashenfelter & D. Card (Eds.), *Handbook of Labor Economics* (pp. 3143–3259). Elsevier.

Ambujam, N.K., & Venkatalakshmi, K. (2009). The function of information and

technology in empowerment of women. *Proceedings of the 2nd IEEE International Conference on Computer Science and Information Technology,* China, IEEE (pp. 385-387). doi: 10.1109/ICCIT.2009.5234705

Andrabi, T., Das, J., & Khwaja, A. I. (2012). What did you do all day? Maternal education and child outcomes. *Journal of Human Resources,* 47(4), 873–912. doi: 10.1353/jhr.2012.0029

Asongu, S.A., & Odhiambo, N.M. (2020). Inequality and gender inclusion: Minimum ICT policy thresholds for promoting female employment in Sub-Saharan Africa. *Telecommunications Policy,* 44(4), 1-14. doi: 10.1016/j.telpol.2019.101900

Azimi, E. (2015). The effect of children on female labor force participation in urban Iran. *IZA Journal of Labor and Development,* 4(1), 1-11. doi: 10.1186/s40175-015-0030-x

Baah-Boateng, W., Nketiah-Amponsah, E., & Frempong, R. (2013). The effect of fertility and education on female labour force participation in *Ghana. Ghana Journal of Economics,* 1, 119–137.

Baglari, J. (2014). Information and Communication Technology (ICT) and women empowerment. *International Journal of Advanced Research in Management and Social Sciences,* 3(9), 80–89.

Banerji, A., Hlatshwayo, S., Gjonbalaj, A., & Le, A.V. (2018). Asian women at work. Finance and Development. International Monetary Fund. https://www.imf.org/en/Publications/fandd/issues/2018/09/female-labor-force-participation-in-vietnam-banerji

Bhalla, R., & Meher, S. (2019). Education, employment, and economic growth with special reference to females in Kerala. *The Indian Journal of Labour Economics*, 62, 639–658. doi: 10.1007/s41027-019-00197-2

Cavalcanti, T., & Tavares, J. (2008). Assessing the engines of liberation: Home appliances and female labor force participation. *The Review of Economics and Statistics,* 90(1), 81–88.

Davis, S. S. (2007). Empowering women weavers? The Internet in rural Morocco. *Information Technologies & International Development,* 4(2), 17–23.

Dettling, L.J. (2017). Broadband in the labor market: The impact of residential high-speed internet on married women's labor force participation. *International Labor Review,* 70, 451-482.

Duflo, E. (2012). Women empowerment and economic development. *Journal of Economic Literature,* 50(4), 1051–1079. doi: 10.1257/jel.50.4.1051

Faridi, M.Z., Malik, S., & Basit, A. (2009). Impact of education on female labour force participation in Pakistan: Empirical evidence from primary data analysis. *Pakistan Journal of Social Sciences,* 29(1), 127–140.

Hartani, N. H., Bakar, N. A. A., & Haseeb, M. (2015). The nexus between female labour force participation (FLFP) and fertility rate in selected ASEAN countries: Panel cointegration approach. *Modern Applied Science,* 9(8), 29-39. doi: 10.5539/mas.v9n8p29

Heath, R., & Jayachandran, S. (2016). The causes and consequences of increased female education and labor force participation in developing countries (NBER Working Paper 22766). *National Bureau of Economic Research.* doi: 10.3386/w22766

Herman, E. (2020). The influence of ICT sector on the Romanian labor market in the European context. *Procedia Manufacturing,* 46, 344-351. doi: 10.1016/j.promfg.2020.03.050.

Hupkau, C., & Leturcq, M. (2017). Fertility and mothers' labor supply: new evidence using time-to-conception (CEP Discussion Paper No. CEPDP1463). *Center for Economic Performance* (CEP). http://eprints.lse.ac.uk/id/eprint/69045

Ince, M. (2010). How the education affects the female labour force? Empirical evidence from Turkey. *Procedia - Social and Behavioral Sciences*, 2(2), 634–639. doi: 10.1016/j.sbspro.2010.03.076

Islam, M.S. (2015). Impact of ICT on women empowerment in South Asia. *Journal of Economic and Financial Studies*, 3(3), 80-90. doi: 10.18533/jefs.v3i03.166

Khanie, G. (2019). Education and labor market activity of women: the case of Botswana. *Journal of Labor and Society*, 22(4), 791–805. doi: 10.1111/wusa.12455

Khidirov, N., & Mamadjonova, S. (2023). Factors influencing the choice of profession by Uzbek women. *Proceedings of BIO Web of Con-ferences*, 65, 06004. EBWFF. doi: 10.1051/bioconf/20236506004

Khidirov, N., & Mamadjonova, S. (2023). The impact of women's labor resources on economic growth in Uzbekistan. *Proceedings of E3S Web of Conferences*, 402. doi: 10.1051/e3sconf/202340209030

Kinoshita, Y., & Guo, F. (2015). What can boost female labor force participation in Asia? (IMF Working Papers No. 056). *International Monetary Fund*. doi: 10.5089/9781498329750.001

Laudon, K., & Laudon, J. (2010). *Management Information System.* Pearson.

Levis, M.S. (2011). Working toward women's economic empowerment: Using information and communication technology in developing areas to market traditional crafts. In Jacko, J.A. (eds) Human-Computer Interaction. Users and Applications. HCI 2011. Lecture notes in computer science, 6764. Springer. doi: 10.1007/978-3-642-21619-0_35

Mariel, E. O. C. (2022). Do female education and labor force participation contribute to economic growth in Afghanistan? *Open Journal of Business and Management,* 10(3), 1148–1159. doi: 10.4236/ojbm.2022.103061

Mincer, J.A. (1974). The Human Capital Earnings Function. In Mincer, J.A. *Schooling, Experience, and Earnings* (pp. 83-96). NBER.

Mishra, V., Nielsen, I., & Smyth, R. (2010). On the relationship between female labour force participation and fertility in G7 countries: evidence from panel cointegration and Granger causality. *Empirical Economics,* 38(2), 361–372. doi: 10.1007/s00181-009-0270-1

Nakagaki, Y. (2018). Fertility, female labor participation and income in East Asia. *International Journal of Development Issues,* 17(1), 69–86. doi: 10.1108/ijdi-06-2017-0106

Nazah, N., Duasa, J., & Arifin, M.I. (2021). Fertility and female labor force participation in Asian countries; panel ARDL approach. *Journal of Economic and Development Studies,* 22(2), 272–288. doi: 10.18196/jesp.v22i2.11142

Ngoa, G.B.N., & Song, J.S. (2021). Female participation in African labor market: The role of information and communication technologies. *Telecommunications Policy,* 45(9), 1-12. doi: 10.1016/j.telpol.2021.102174

Nikulin, D. (2016). The impact of ICTs on women's economic empowerment. In H. Kaur, E. Lechman, & A. Marszk (Eds.), Catalyzing de-velopment through ICT adoption: The developing world experience (pp.12-24).

Obayelu, A., & Ogunlade, I. (2006). Analysis of the uses of information communication technology (ICT) for gender empowerment and sus-tainable poverty alleviation in Nigeria. *International Journal of Education and Development using Information and Communication Technology,* 2(3), 45–69.

Omotoso, K.O, & Obembe, O.B. (2016). Does household technology influence female force participation in Nigeria? *Technology in Society,* 45, 78–82. doi: 10.1016/j.techsoc.2016.02.005

Onyeke, Q.O., & Ukwueze, E.R. (2022). Trade openness and female labour force participation rate in Nigeria. *Journal of Xi'an Shiyou University,* 18(3), 433–457.

Pencavel, J. (1986). Labor supply of men: A survey. In O. Ashenfelter & R. Layard (Eds.), *Handbook of Labor Economics* (Vol. 1, pp. 3–102). Elsevier.

Relich, M. (2017). The impact of ICT on labor productivity in the EU. *Information Technology for Development,* 23(2), 1-17. doi: 10.1080/02681102.2017.1336071

Roser, M. (2014). Fertility rate. Our World in Data. https://ourworldindata.org/fertility-rate

Samargandi, N., Al Mammun, M., Sohag, K., & Alandejani, M. (2019). Women at work in Saudi Arabia: Impact of ICT development and so-cio-economic factors. *Technology in Society,* 59(2), 1-10. doi: 10.1016/j.techsoc.2019.101187

Shittu, W. O., & Abdullah, N. (2018). Fertility, education, and female labour participation: dynamic panel analysis of ASEAN-7 countries. *International Journal*

of Social Economics, 46(3), 1-18. doi: 10.1108/IJSE-11-2017-0559

Shuangshuang, Y., Zhu, W., Mughal, N., Aparcana, S. I. V., & Muda, I. (2023). The impact of education and digitalization on female labour force participation in BRICS: an advanced panel data analysis. *Humanities and Social Sciences Communications*, 10(1), 1-10. doi: 10.1057/s41599-023-02020-2

Skadsen, C. (2017). Fertility and female labor force participation: the role of legal access to contraceptives. Stevenson Center for Community and Economic Development to Stevenson Center for Community and Economic Development—Student Research. 29. Retrieved from https://ir.library.illinoisstate.edu/scced/29

Solomon, B., & Kimmel, J. (2009). Testing the inverseness of fertility and labor supply: the case of Ethiopia (IZA Discussion Papers, No. 3949). Institute for the Study of Labor (IZA). http://nbn-resolving.de/urn:nbn:de:101:1-20090209192

Suhaida, M. A., Nurulhuda, M. S., & Yap, S.-F. (2013). Access to ICT as moderating factor to women's participation in the labor force: A conceptual framework. *International Journal of Trade, Economics and Finance*, 4, 197-201. doi: 10.7763/IJTEF.2013.V4.285

Tanaka, S., & Muzones, M. (2016). *Female labor force participation in Asia: Key trends, constraints, and opportunities.* ADB Briefs 71. Asian Development Bank.

Topel, R. H. (1988). Review of Handbook of Labor Economics, by O. Ashenfelter & R. Layard. *Journal of Economic Literature,* 26(4), 1790–1792. http://www.jstor.org/stable/2726895

Valberg, S. (2017). Information and Communication Technology and the Global Labor Market. (Master's thesis). University of Oslo, Department of Economy.

Verick, S. (2014). Female labor force participation in developing countries. (IZA Discussion Papers, No. 2014/87). Institute for the Study of Labor (IZA). doi: 10.15185/izawol.87

Watson, T., Corliss, M., & Le, M. (2018). Digitalisation and women's workforce participation in the Indo-Pacific. *Australian Journal of Labour Economics,* 21(1), 45–74.

Xu, R. (2023). Japan's economy would gain with more women in science and technology. International Monetary Fund. https://www.imf.org/en/News/Articles/2023/11/13/cf-japans-economy-would-gain-with-more-women-in-science-and-technology