Paper title: Addressing the gender digital divide

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Abstract

The existence of digital gender gaps is widely acknowledged, with approximately 2.6 billion individuals, predominantly women and girls, lacking internet access. In this paper, we examine the relationship between LFPR and digitalization for countries of the Asia Pacific using data from World Bank's Development Indicators for 1991 to 2023. We find that digitalization proves to be significant and positive in explaining LFPR. Digitalization is measured by individuals using the internet as a percentage of the population and mobile cellular subscriptions per 100 people by the total population. We also highlight the importance of the time-use of women in explaining LFPR. The data from time-use surveys in the Asia-Pacific region highlight that women predominantly spend time on unpaid domestic work, reducing their availability for employment, thus impacting LFPR negatively. The results show that the more hours a woman spends on activities such as unpaid domestic work and care services, the lower is her participation in the labour force in the Asia Pacific countries. Data on time spent on digital devices by women is sparse, reinforcing the need for better time-use surveys to inform labor policies.

1. Introduction

Gender disparities in digital access and usage are significant, as highlighted by UNICEF (2023a) and WEF (2023). For every 100 adolescent boys and young men using the internet, only 71 adolescent girls and young women do the same. Approximately 2.6 billion individuals, a majority of whom are women and girls, lack internet access. The digital gender divide refers to the "gap between individuals, households, businesses, and geographic areas at different socio-economic levels" (OECD, 2021). Statistics from 2022 reveal that globally that compared to 62% of men globally, 57% of women have access to the Internet (GDDI, 2022). The disparity is particularly pronounced in developing and low-income countries. Furthermore, in Least Developed Countries (LDCs), a mere 19% of women accessed the Internet in 2020, in stark contrast to the 86% figure in developed nations in 2019.

The gender digital gap extends beyond mere access to encompass meaningful digital utilization and the presence of constraining factors. Women often utilize mobile phones and the internet differently than men, experiencing restricted access to a narrower range of digital services, less frequent and intensive usage, and fewer incentives for online engagement.

Adolescent girls and young women are at a disadvantage with regard to internet connectivity, digital skills, and mobile phone ownership. Family gender biases often favor boys in acquiring digital skills, and wealthier families exhibit more pronounced gender gaps in digital skills, indicating that mere access does not ensure equitable skill development. This disparity limits women's digital participation and hampers their growth.

The literature on digitalization and economic growth, alongside labor productivity, highlights several key gender dimensions. Digitalization is recognized as a pivotal driver of global economic growth and job creation, contributing $193 billion to the global economy and creating six million jobs in 2011 (PwC, 2013). However, the benefits of digitalization are unevenly distributed across countries and sectors. Developed economies typically experience more significant productivity gains, whereas emerging economies see more job creation (Zhang et al., 2024).

Despite its potential, the New Digital Economy—comprising mobile technologies, the internet, and cloud services—has not yet significantly boosted productivity growth. This is partly because the technology is still in its early deployment stages, with anticipated productivity impacts expected as it becomes fully integrated. The macroeconomic effects of ICT on productivity and growth are mixed and moderate. In the 1970s, the spread of ICT coincided with slower economic growth in industrialized nations. Despite higher growth rates in the 1990s, the impact was more substantial in the US than in Europe or Japan. Subsequent slower economic development tempered initial enthusiasm (Byrne, 2022).

Increasing the digital inclusion of women and girls could boost global GDP by approximately US$524 billion by 2025. Recognizing digital technologies as a crucial conduit to gender equality, it becomes evident that the realization of the United Nations Sustainable Development Goals (SDGs) hinges on closing the digital gender gap. Until all women and girls have equitable access to and utilization of digital resources, achieving sustainable development will remain an elusive goal. Anyone not online is being left out of work and educational opportunities and missing out on potentially life-saving information and services. In developing countries, evidence suggests that existing socioeconomic gaps are deepening as a result of this digital transformation, especially for women.

Barriers to girls' and women's engagement in the digital realm include insufficient resources, lack of digital skills, societal norms, limited educational opportunities, inadequate infrastructure, affordability constraints, low digital confidence, and limited ownership of ICTs (Khera et al., 2022; ITU, 2022). The correlation between mobile phone ownership and Internet usage underscores the interconnected nature of these disparities. Female youth (ages 15-24 years) are 13% less likely to own a mobile phone (UNICEF, 2023). Addressing the gender gap in mobile phone ownership, given its significance as a primary tool for Internet access, holds promise for mitigating the broader Internet usage gender divide.

The allocation of time available to women remains an understudied aspect among these barriers. Understanding how time constraints impact women's ability to engage with digital technologies and develop digital skills is crucial for addressing the gender digital divide. Developing strategies to ensure equitable access to digital technologies and skills development for women and girls is essential for realizing the full potential of digitalization in promoting economic growth and improving labour productivity.

This paper examines the issue of the impact of digitalization on labour force participation of women in countries of the Asia Pacific for the period 1991 to 2023. The paper is organised in the following manner: the next section discusses the literature review drawing points from both the literature on the concept of time available to women and the impact of digitalization on the LFPR of women. Section 3 discusses the methodology used in the paper, the variables used in the econometric exercise, and the data sources. Section 4 presents the econometric exercise and the results of the exercise. The final section concludes with some implications for policy.

2. Literature review

Digital skills are essential for leveraging digitalization's benefits, yet there is a significant gender gap in digital skills. Women are often underrepresented in STEM fields and digital literacy programs, which can hinder their participation in the digital economy and limit their economic opportunities. In India, the Annual Survey of Education Report (ASER) (2023) observed that nearly 90% of all youth have a smartphone at home. However, males (43.7%) are more than twice as likely to own a smartphone compared to females (19.8%). Additionally, only 9% of households have a computer or laptop, and among those, 85% of youth are more likely to know how to use it compared to those without. Females are less likely to know how to use smartphones or computers than males.

The 2019 pandemic underscored the critical role of digital proficiency, as remote learning strategies became necessary. Digital proficiency, or the ability to use technologies effectively, became vital for education and remote work. However, in 2020, only 37% of youth aged 15 to 24 had internet access at home. While digitalization has the potential to significantly boost economic growth and job creation, the literature lacks specific insights into how these benefits are distributed across genders. More research is needed to understand the gender dimensions of digitalization and its impact on labor productivity and economic growth.

We discuss two aspects of the literature in the review: first, the concept of time and how unpaid and care work adds to women's time poverty. Second, we discuss the role of digitalization in labour force participation of women. In both these sections, we discuss literature from other regions and countries first before discussing the literature related to the Asia Pacific.

2.1 *The concept of time*

The role of time available to women has been relatively unexplored in the literature. Time-use Surveys (TUS) have typically measured unpaid work, but these surveys are not widespread, creating data gaps. Accurate data on unpaid work is essential for understanding gender inequalities in time allocation.

Bryson (2008) examines how time-use studies reveal critical insights into gender inequalities by documenting the allocation of time across different activities. She argues that time-use studies, which track how people spend their day, are a valuable tool for feminist analysis as they expose the unequal distribution of unpaid labor, particularly domestic and caregiving work, between men and women. She highlights that this unpaid work is often undervalued and largely invisible within traditional economic analyses, despite its essential role in supporting the paid workforce and sustaining societal well-being.

Connelly and Kongar (2017) highlight that, historically, unpaid labor—such as household work, caregiving, and community activities—has often been excluded from economic analysis. Feminist scholars have argued that ignoring these forms of labor skews our understanding of economic productivity, as traditional economic indicators (like GDP) only consider market-based work. Time-use studies, they argue, help correct this oversight by providing empirical data that quantifies unpaid labor, thereby giving visibility to the full spectrum of work that sustains families and communities.

Bryson (2007) discusses how time-use studies reveal the invisible yet essential labor that women perform, which is often unrecognized in traditional economic metrics. This hidden workload has significant implications for women's economic and social opportunities, affecting their access to paid employment, leisure time, and overall quality of life. By documenting these disparities, time-use studies challenge conventional economic frameworks that fail to account for unpaid labor, thus bringing to light the limitations of viewing productivity solely through market activities.

The document titled "Exploring Light Time-Use Approaches for Measuring Productive Activities" from the International Labour Organization (ILO) (2018) discusses the use of Light Time-Use Diaries (LTUD) in measuring various forms of work: paid and unpaid. The 2030 Agenda for Sustainable Development includes an indicator of the proportion of time spent on unpaid domestic and care work. This is where LTUDs come into the picture, LTUDs record time spent on a preselected list of activities (up to 30). The ILO and other international agencies are focusing on developing accurate and efficient methods to measure time use, particularly unpaid work, to fill data gaps and support policy-making aimed at addressing gender inequalities and other social issues. LTUDs often provide comparable data to full TUDs at an aggregate level but may differ at more detailed levels. LTUDs are better as they are cheaper and quicker to implement, and they reduce respondent burden. They often achieve higher response rates compared to full TUS. Attaching LTUDs to other surveys, like LFS, can leverage additional data and capture seasonal variations in activities.
The LTUD approach is a promising tool that offers many advantages, though it requires further development and testing to address the challenges identified. Traditional Labour Force Surveys (LFS) focused on employment and unemployment, often neglecting unpaid work. Sixteen countries have used LTUDs since the mid-1990s, either as standalone surveys or modules attached to other surveys.
United Nations (2021) highlights the importance of time-use surveys in capturing the full extent of women's contributions to the economy and society, which are often overlooked in traditional economic metrics. It underscores the need for policy interventions to redistribute unpaid care and domestic work more equitably. Additionally, it advocates for community engagement initiatives to challenge and change traditional gender norms that confine women to domestic roles. By addressing these issues, the report aims to promote gender equality and empower Afghan women to participate fully in the country's social and economic life.
Charmes (2015) compiles and analyzes data from 102 time-use surveys conducted in 65 countries covering regions such as the Middle East and North Africa, Sub-Saharan Africa, Asia, Latin America, Europe, North America, other developed and transition countries and focuses

on how people allocate their time to various activities.[1] The study aims to provide a comparative analysis of how men and women spend their time globally, focusing on paid and unpaid work, leisure, personal care, and other activities. The surveys were mostly sourced from national statistical agencies' websites. Surveys employed a diary method where respondents recorded activities in 10, 15, or 30-minute intervals over 24 hours. There are various challenges and limitations as well such as different countries using varied age groups and activity classifications, complicating comparisons. Some countries' surveys were not publicly accessible or lacked the detailed classification necessary for this study. The study offers a gender perspective on time use, highlighting the differences in how men and women allocate time to paid and unpaid work. Data is provided on various activities, including formal and informal work, care work, voluntary activities, leisure, and personal care. The study was updated in 2016 to include new surveys from Moldova, Macedonia, Tanzania, and the USA. Charmes (2015) further notes that the data used in studies do not include micro-data but are compiled from available reports. These surveys had to be national or large-scale regional, use a diary method to record activities, and include a detailed classification of activities.

Arroyo (2020) examines how digital inclusion affects gender relations, particularly in terms of time use. The study highlights that while the European Union has prioritized digital inclusion to enhance citizens' digital skills, there is a significant digital gender gap that impacts women's participation in the digital economy. Through qualitative analysis of interviews with 32 Spanish women involved in lifelong learning programs, the research reveals that digital inclusion has not sufficiently addressed gender inequalities in time use. These programs often fail to challenge traditional gender roles and the division of labor, limiting their effectiveness in promoting gender equality. The findings emphasize that digital inclusion alone does not lead to equitable time allocation between genders. To achieve meaningful progress, public policies must incorporate a gender perspective that promotes women's emancipation and challenges the conventional division of labor. The study calls for further empirical research on the intersection of digital inclusion and gender inequalities and recommends that policymakers design digital inclusion initiatives that specifically address and rectify gender disparities in time use.

ADB (2023) provides evidence of how time savings[2] can help gender equality. Based on data from Rajasthan in India which provided 173418 house service connections in 5 project towns, freeing women from the chore of water collection and thus saving time.

Reduction of time spent on chores or unpaid work can lead to favourable outcomes – to add In Mongolia, according to the 2019 TUS, working age women spent 291 minutes per day on unpaid domestic work, men spent 103 minutes. The gap between men and women in terms of time spent on unpaid work was higher in rural areas (Begzsuren et al., 2022). Increasing LFPR from 53.4% to 63.2% can increase annual per capita growth by 0.5%. over 30 years, this

[1] This document is a background paper for the 2015 Human Development Report, titled "Time Use Across the World: Findings of a World Compilation of Time Use Surveys," authored by Jacques Charmes.

[2] Time savings has been defined as the “total number of women and girls who spend less time on unpaid household or care work under ADB projects. Unpaid household or care work includes, but is not limited to, collection and transport of water, firewood, and other basic goods; growing and processing agricultural produce for household consumption; domestic and care services such as preparation of meals; volunteer work; care of the children, the sick, persons with disability, and the elderly.” (ADB, 2019a). Only women and girls with substantial time savings (an average daily time savings of more than 30 minutes) are counted for this indicator. The data on time savings may be obtained through dedicated surveys, wherever feasible. Estimates could also be used, based on established methodology.

increase could be 16.1%. They note that female labour force participation increases as unpaid work is reduced and shared by men.
The report "Time-Use Surveys and Statistics in Asia and the Pacific" from ILO and UNDP (2018) delves into the significance of time-use surveys for understanding how individuals allocate their time to various activities across the region. As noted above, these surveys are crucial for understanding the contributions of unpaid work, particularly those carried out by women. The report reveals that women in Asia and the Pacific disproportionately perform unpaid care and domestic work, which impacts their participation in the labor force and subsequently their access to educational and economic opportunities. The time-use data collected from these surveys provide critical insights that help policymakers design more equitable policies and programs.

2.2 *Digitalization and labour force participation*

GSMA (2021) reports a significant gender gap in mobile ownership. Handset affordability is a key barrier to owning mobiles. Mobiles are the primary way in which women particularly access the internet in LMICs. Among the LMICs, South Asia has the widest gap in mobile ownership. The gender gap is highest in Kenya, Pakistan and Bangladesh. Women mobile owners are more likely than men to own a basic handset. Also, older women are less likely to own devices and only 19% of women use mobile internet (based on information on Bangladesh).
Shuangshuang et al. (2023) study highlights the importance of female labour force participation rate (FLFP) in the socio-economic development of the country. It explores the relationship between digitalization, education, fertility, GDP, and female labour force participation (FLFP) in BRICS countries (Brazil, Russia, India, China, and South Africa) from 1990 to 2020. The research employs advanced panel data analysis techniques, such as cointegration, slope heterogeneity, and cross-sectional augmented autoregressive distributed lags (CS-ARDL) models, to assess these relationships. The study finds a positive correlation between digitalization and FLFP in BRICS countries, both in the short and long run. However, the long-run impacts are more substantial. Education significantly enhances FLFP, with higher education levels correlating with greater participation in the labour force. An increase in GDP is also positively associated with higher FLFP. High fertility rates negatively impact FLFP, consistent with findings from other global studies.
The Global Gender Gap Report 2023, published by the World Economic Forum, measures gender parity across 146 countries, focusing on four key dimensions: Economic Participation and Opportunity, Educational Attainment, Health and Survival, and Political Empowerment. 1. The global gender gap in 2023 stands at 68.4% closed. The report notes that at the current rate, it will take 131 years to achieve full parity. Iceland ranks highest with 91.2% of its gender gap closed, followed by Norway, Finland, New Zealand, and Sweden. No country has achieved full gender parity. 3. Regional Performance Europe leads with 76.3% parity, followed by North America (75%) and Latin America and the Caribbean (74.3%). The Middle East and North Africa are the furthest from parity at 62.6%. The Health and Survival gap is the most closed at 96%, followed by Educational Attainment at 95.2%. Economic Participation and Opportunity stand at 60.1%, while Political Empowerment lags at 22.1%. 5. Progress has been uneven, with some regions and dimensions showing improvements while others have regressed. The COVID-19 pandemic and other global crises have significantly impacted gender parity progress. 6. The report calls for renewed efforts to close gender gaps, emphasizing the need

for policy changes and initiatives to boost women's economic participation and leadership roles. The report provides a comprehensive analysis of gender parity trends and offers insights for policymakers to foster gender equality globally.

ADB (2018) suggests that gender and social issues are interlinked based on a study of the provision of 24-hour power supply to rural households in Madhya Pradesh in India. Access to energy can reduce time spent on household chores and increase women's income. The study suggests that caste, age, and social and marital status need to be considered to understand the social dimensions of gender. Women also tend to have older devices or no devices. This leads to their digital exclusion.

Hadzovic (2018) explores the significant and ongoing disparities between men and women regarding access and utilization of digital technologies. The author points out that women in developing countries face increased barriers to digital access. Subsequently, this affects their ability to participate in education, financial decisions, and cultural norms which are accessed digitally. The author illustrates that the limitation on women's professional growth does not just impact the individual, but also impacts the economic potential of a nation. The paper highlights that the digital gender gap in Bosnia and Herzegovina is reflective of broader global trends, with women facing significant barriers to accessing and benefiting from digital technologies. These barriers include limited access to education and training in digital skills, socio-economic constraints, and cultural factors that limit women's participation in the digital economy. Hadzovic argues for targeted measures which would promote digital literacy among women. Additionally, Hadzovic argues that policy should aim to provide women with affordable access to technology. These policies, in addition to others, would create supportive environments that encourage female participation in the digital economy. The author argues that bridging the digital gender gap is essential to achieving gender equality and ensuring inclusive and sustainable technological progress for all.

UNDP (2022) provides an analysis of the disparities between men and women in accessing and utilizing digital technologies in Uzbekistan. The assessment highlights that women in Uzbekistan face significant barriers to digital inclusion. This is most apparent regarding their limited access to digital devices and the internet. This results in lower levels of digital literacy, and increased socio-cultural constraints. These barriers are more apparent in rural areas, where infrastructure and educational opportunities are less developed. The report identifies several factors contributing to the gender digital divide, such as economic disparities that limit a woman's ability to afford digital devices and services. Additionally, traditional gender roles have resulted in a prioritization of men's access to technology. Women often have fewer opportunities for formal education and training in digital skills, which hinders their participation in the digital economy. The assessment calls for targeted measures to bridge this divide. These include policy measures to improve digital infrastructure, initiatives to promote digital literacy among women, and programs to address socio-cultural barriers. By focusing on these areas, Uzbekistan can work towards achieving greater gender equality in digital access and usage. This would enhance the overall economic and social development of the country. The report underscores the importance of a coordinated effort involving government, private sector, and civil society to create an inclusive digital environment. Empowering women to have digital access ensures that they can fully participate in and benefit from digital advancements.

The report "Girls' Digital Literacy in the East Asia and Pacific Region" by UNICEF (EAPRO) (2023b) examines digital literacy among girls in Cambodia, Viet Nam, Indonesia, Lao PDR, and Timor-Leste. The study finds that mobile phones are the primary means of digital access, with

boys more likely than girls to own smartphones and engage in a broader range of digital activities. While access levels are similar for boys and girls when no marginalization factors are present, boys still have an edge in ownership and usage. Adolescents primarily use digital devices for entertainment and communication. Although both boys and girls recognize the importance of digital literacy, many possess only basic skills. Girls, in particular, lag behind boys in advanced digital competences, especially in STEM-related areas. Key barriers to digital literacy for girls include limited infrastructure, high data costs, instructional materials often not being in local languages, gender stereotypes, and safety concerns that restrict girls' digital use. Safety issues lead to more restrictions and self-limiting behavior among girls. Social learning, primarily support from peers, is crucial for developing digital literacy, while parental and teacher support is less significant. Many adolescents learn digital skills through self-exploration and online resources. The report suggests enhancing digital infrastructure, creating supportive learning environments, addressing socio-cultural barriers, and ensuring safety in digital spaces to improve digital literacy among girls in the East Asia and Pacific region.

Watson et al. (2018) observe that digitalization significantly impacts the labor force gender participation gap in the Indo-Pacific. While digital access and ICTs can empower women by providing opportunities for education, employment, and entrepreneurship, disparities persist. Women in the region often have less access to digital devices and the internet, and when they do, they face limitations in usage and skill acquisition. Addressing these gaps requires targeted policies, such as improving digital infrastructure, promoting digital literacy, and challenging societal norms to ensure equitable digital participation and economic opportunities for women.

United Nations (2016) advocates for disaggregating data by gender. Disaggregating data means breaking down statistical information to show how different genders are affected by various issues. It also highlights the importance of developing gender-specific indicators that can measure inequalities and outcomes relevant to both men and women. Additionally, the paper calls for ensuring that statistical methodologies are inclusive. This provides data to have a greater ability to capture the experiences of all genders. Integrating a gender perspective into statistics will not only enhance the accuracy of data but also improve the ability to accurately measure movement towards gender equality. This approach would enable policymakers and researchers to identify gaps more effectively, and ultimately design measures that are more responsive to advance gender equality.

3. Methodology

The paper uses panel vector autoregressive mode (VAR) to study the impact of digitalization on women's labour force participation in the Asia Pacific. [3] The research will be conducted in two parts: data analysis and econometric analysis.

3.1 Data Analysis:

[3] Panel VAR model was chosen as it addresses the issue of endogeneity (whereby explanatory variables are correlated with the error term can significantly bias results in econometric studies) by using lagged values of the variables as instruments, which helps mitigate biases that arise from simultaneous causality. This is particularly relevant when examining how digitalization not only affects labor force participation but is also influenced by it, as seen in various studies indicating that increased female employment can lead to greater investment in digital skills and infrastructure. The econometric model is discussed below.

Using data from time-use surveys (collected by the UN, World Bank, etc.), we will analyze the empirical evidence of time available for women for other activities including digital devices, and time available for them to upgrade digital skills. For example, the World Bank reports the proportion of time spent on unpaid domestic and care work (as a proportion of 24 hours) for both sexes. We examine data from time-use surveys for the countries of the Asia-Pacific region. This is necessary since data on time-use is not easily available. As shown in Table 1 below, the data on time-use is scanty and not available for a time duration spanning several years.

3.2 Econometric Analysis:

Based on the data scrutinized in the previous stage, an econometric analysis will be conducted to ascertain the causal factors contributing to the barriers faced by women in adopting digital technologies across select countries in the Asia Pacific region. The hypotheses explored will delve into the impact of digitalization on female labor force participation.

Utilizing data sourced from time-use surveys conducted by institutions such as the UN and the World Bank, we will empirically analyze the amount of time women dedicate to various activities, including the usage of digital devices, and the time allocated for enhancing digital skills

Panel vector autoregressive model (VAR) has been used in ascertaining the impact of digitalization. Since, panel data combines features of time series and cross section data. This technique has been used so that both cross section and the time series elements of the data can be exploited.

The following equation shows the basic model (Gujarati, 2003):

$Y_{it} = \beta_1 + \beta_2 X_{2it} + \beta_3 X_{3it} + e_i$ ……(1)

Where Y_{it} = dependent variable,

X_i = independent variable,

e_i = error term

i stands for the cross sectional unit

t stands for the time period

To account for variability due to each cross sectional unit, the assumption of the above equation is relaxed. The intercept of the above equation is modified but the assumption that the slope coefficients are constant across cross section is retained. The modified equation can be written as:

$Y_{it} = \beta_{1i} + \beta_2 X_{2it} + \beta_3 X_{3it} + e_i$ ……(2)

Where Y_{it} = dependent variable, as before

X_i = independent variable,

e_i = error term

i stands for the cross sectional unit

t stands for the time period

The difference between equation (1) and equation (2) comes from the subscript *i* in the intercept term. This suggests that the intercept term of the cross section may be different. This model is known as the fixed effects model. The term fixed effects are used to indicate that while the intercepts may vary across the cross section, each intercept is time invariant. The slope coefficients of the regressors do not vary across the cross section or time.

We have used a panel VAR model – the equation below shows the structure of the model (Canova and Ciccarelli, 2013):

$$y_{it} = A_{0i}(t) + A_i(l)Y_{t-1} + F_i(l)W_t + u_{it} \quad \text{… … ……(3)}$$

i = 1,…, N

t = 1,…., T

where u_{it} is the G × 1 vector of random disturbances and

$u_t = [u_{1t}, u_{2t}, \text{… … .}, u_{Nt}]' \approx iid^4\ (0, \sum)$

$F_{i,j}$ are G × M matrices for each lag.

And W_t is a M × 1 vector of exogenous variables

Our estimated equation is given below:

$$\ln LFPR_{it} = \beta_{1i} + \beta_2 \ln Digi_{2it} + \beta_3 GDP\ percapita_{3it} + \beta_4\ FERT_{4it} + \cdots + e_i \quad \text{……(4)}$$

Where $LFPR_{it}$ = labour force participation rate of women is the dependent variable,

$Digi_i$ = is the industry as an independent variable,

$GDP\ per\ capita_i$ = gross domestic product per capita is another independent variable,

e_i = error term

i stands for the cross sectional unit which in this case is the countries of Asia Pacific

t stands for the time period from 1991 to 2023.

Logarithmic values of the variables have been taken.

The dependent variable is the log of labour force participation for women between the ages of 15-24 (ILO estimates). The source of the data is the World Development Indicators (WDI). Alternatively, the log of labour force participation (national estimates) was also tried with similar results for internet use.

The independent variables used include:

[4] Independently and identically distributed

Digitalization – the main variable that we are looking at in this empirical exercise. We have taken the individuals using the internet as a percentage of the population. Digitalization is expected to have a positive impact on LFPR.

Fertility – The fertility rate, total (births per woman) has been included. Falling fertility rates are expected to be connected with higher LFPR according to Watson et al. (2018). However, Shuangshuang et al. (2023) expect a positive relation between these variables.

Expenditure on primary education as a percent of government spending - This variable is expected to be positively associated with LFPR (Watson, et al. 2018).

GDP per capita – We have taken GDP per capita at 2015 constant dollars from WDI to control for the level of economic development in the country. GDP per capita is expected to have a positive impact on LFPR (Watson, et al. 2018).

Female life expectancy at birth – This variable is expected to be negatively related to LFPR and is indicative of the health characteristics of the population (Watson, et al. 2018).

Trade GDP ratio - Following Cavalcanti and Tavares (2008), a country's external trade can help increase female workforce participation and should be positively associated with LFPR.

Agriculture value added – the share of agriculture to GDP could also be indicative of higher LFPR. Hence a positive sign is expected between these two variables (Watson, et al. 2018).

Services value added – the share of services to GDP. The services sector can offer more opportunities for women and hence is expected to positively impact LFPR.

Unpaid domestic work and care services - this variable is discussed in greater detail below in the results of the data on time-use. The more hours a woman spends on these activities, the lower is her participation in the labour force likely to be (Chakraborty and Sutradhar, 2023). Hence, we expect a negative relation between this variable and LFPR. This variable has been constructed in the following manner – we have used the data reported by the countries on unpaid domestic work and care services as an interaction term with the time dummy.

The definition of unpaid work from ADB's Tracking Indicators Definitions is the proportion of time spent on unpaid domestic and care work (in %).[5]

Mobile cellular subscriptions per capita - measured by mobile cellular subscriptions per 100 people by the total population**.** As an alternative to internet use, we have also tried this variable. It is also expected to aid LFPR.

[5] This is derived from an official SDG 5 indicator. The average time women and men spend on household provision of services for their consumption. Domestic and care work includes food preparation; dishwashing; cleaning and upkeep of a dwelling; laundry; ironing; gardening; caring for pets; shopping; installation, servicing, and repair of personal and household goods; childcare; and care of the sick, elderly, or disabled household members. The proportion of time spent on unpaid domestic and care work is calculated by dividing the daily average number of hours spent on unpaid domestic and care work by 24 hours. Data presented for this indicator are expressed as a proportion of time in a day. Weekly data is averaged over 7 days of the week to obtain the daily average time. Regional and subregional aggregates are weighted averages of country data using female and male populations as weights.

Literacy rate – while digital literacy is important for the use of digital products, literacy by itself should positively affect LFPR.

School enrolment - School enrolment, primary, female (% gross) has been used also. The expected sign of this variable is positive.

The descriptive statistics of the variables are given in the Appendix. The plot of log LFPR and log INTERNET USE is given below.

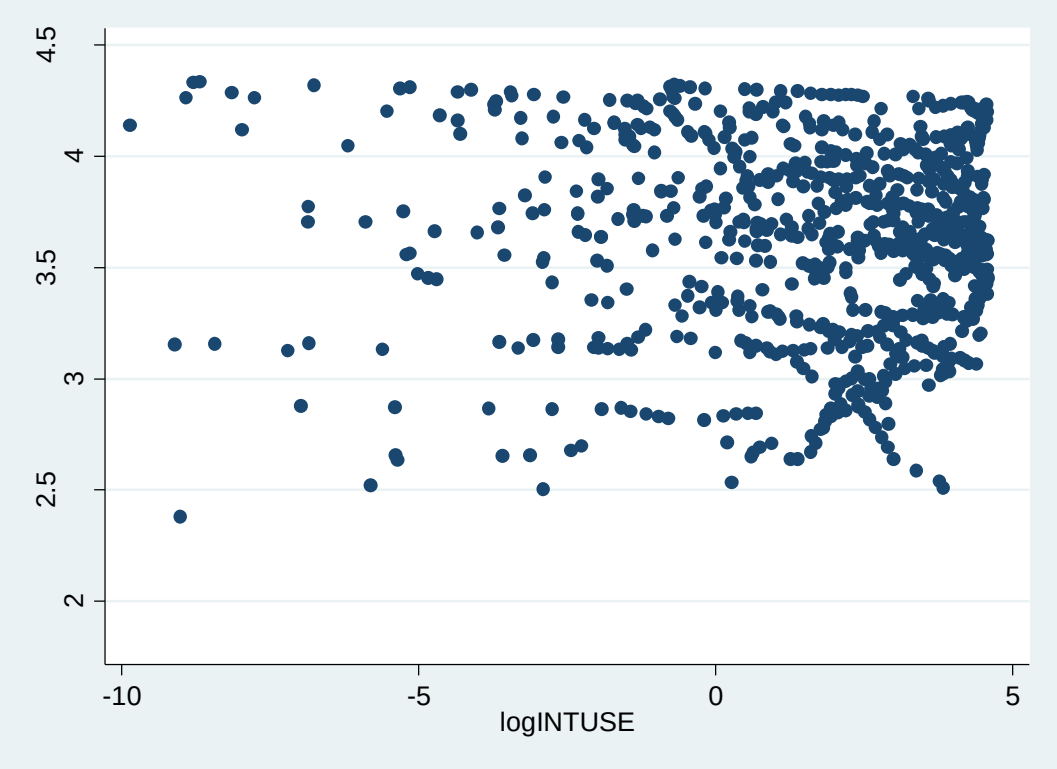

Figure 1: Scatterplot of log LFPR and log INTERNET USE.

4. Empirical findings

4.1 Results of the data on time-use

In table 1 below, we show the time-use data for women in the Asia-Pacific region. The objective of the data is to highlight the amount of time women have in a day that is available for employment or other work. Two points have to be noted about the data: first, data is not available for many countries – out of 41 countries in the region, the table reports data only for 14 countries. Second, the data for many countries is old -e.g. for Taiwan, the data is from 2004. This reinforces the point of time-use surveys made in the literature review above. For the majority of the countries that have reported the data, most of the time is spent on unpaid domestic work and care services. It is difficult to say what percentage of time in a day a woman spends on unpaid domestic work and care services since the definitions of some of the categories overlap and the total adds up to more than 1440 minutes.

Table 1: Time-Use Data of Women in Asia-Pacific (minutes per day)

	Employment-Related Activities[6]	Unpaid Domestic Work + Care Services[7]	Volunteering[8]	Personal Time[9]	Leisure + Socializing[10]
Afghanistan*	168	685	14	1502	
Bangladesh	120	348	6	654	
Cambodia	275	210			
India[11] (2019)*	333	299	99	723	
Japan[12]	310	213	3		
Malaysia (2019)	396	216		546	
Mongolia	238	290		912	
Nepal*	275	461	57	814	140
New Zealand (1999)	132	264			
Pakistan[13] (2019)	218	258			
Philippines[14] (2023)		136			
South Korea[15] (2019)		193			
Sri Lanka[16]	426	390	132		
Taiwan[17] (2004)	218	150			

Source: Various

Note: * the data exceeds the daily minutes in a day (over 1440 minutes) due to definitional overlap

Despite this, certain observations can be made about the time available to women and its implication for labour force participation rates: countries, where women spend a

[6] Employment-Related Activities: Work for the production of Systems of National Accounts

[7] Unpaid Domestic Work + Care Services: Work done within the house; includes household maintenance, cooking, care for family, etc.

[8] Volunteering: Unpaid work done in the community

[9] Personal Time: Non-productive time spent for oneself; including sleeping, eating, etc.

[10] Leisure/Socializing: Time spent doing activities for enjoyment and time spent socializing for enjoyment

[11] MOSPI (n.d.)

[12] https://www.stat.go.jp/english/data/shakai/2021/pdf/timeuse-a2021.pdf

[13] https://unstats.un.org/unsd/demographic/sconcerns/tuse/profile.aspx?id=127

[14] https://oi-files-cng-prod.s3.amazonaws.com/philippines.oxfam.org/s3fs-public/file_attachments/FINAL%20National%20Household%20Care%20Survey%20Report%202021.pdf

[15] https://kostat.go.kr/board.es?mid=a20111060000&bid=11762&act=view&list_no=385431

[16] https://nada.statistics.gov.lk/index.php/catalog/449

[17] https://ws.dgbas.gov.tw/win/dgbas03/ca/eng_social/analysis93.htm
https://blogs.ubc.ca/kamilakolpashnikova/taiwan-time-use-focus-on-housework-and-care-activities/

disproportionately large amount of time on unpaid domestic work and care services, had a lower amount of time for employment related activities. The data on unpaid domestic work and care services has been used as an interaction term in the econometric exercise and is discussed below.

Additionally, in Table 2 we report the data on time spent on digital devices by women in the Asia Pacific. We note again, the lack of data on this dimension in many of the countries of the Asia Pacific.

Table 2: Time-Use Data for Leisure and Socializing, and on Digital Devices by Women in Asia-Pacific (hours and minutes per day)

Countries	Time spent on Leisure + Socializing (or Personal time)	Time spent on Digital devices
Afghanistan	Less than two-thirds	
Australia	5 hours	
Bangladesh	1.97 (urban)and 2.19(rural)	3.01 (urban), 2.51(rural)
Bhutan	7 hours	
Cambodia	2.66	2.31
China	1.6	
India	2.31	2.75
Japan[18]	1.5	Less than 1 hour = 35.1% 1 to less than 3 hours = 38.3% 3 to less than 6 hours = 17.6% 6 to less than 12 hours = 6.8% 12 or more hours 2.2%
Mongolia	11.6 (personal self-care/maintenance + social)	1.7 (mass media)
Myanmar	3.9 for rural only	
Nepal	2.3	
New Zealand	15.85 (personal + leisure)	
Pakistan	2.36 (in social)	0.86
South Korea	59 minutes (common for both men and women)	2h 26 mins
Sri Lanka	1.9 hours	3
Thailand	1.35 hours	2.61 hours
Timor-Leste[19]		
Tuvalu	6.83	
Vietnam[20]		

Source: Various

[18] Some sources reported 4.9. See: https://stats.oecd.org/index.aspx?queryid=82791#.

[19] https://timor-leste.unfpa.org/sites/default/files/pub-pdf/2015%20Census%20Gender%20Dimensions%20Analytical%20Report.pdf

[20] https://unstats.un.org/capacity-development/UNSD-FCDO/vietnam/(accoring to this a time use survey is under work)

4.2 Results of the empirical exercise

Digitalization – this variable is significant and positive in several variants of the equation (4) (shown in Table 3). However, it is negative and significant only when regressed by itself. The inclusion of mobile penetration (mobile subscriptions by the total population) renders this variable insignificant.

Fertility – As discussed earlier, the fertility rate, which is given by the total (births per woman) has been included as an explanatory variable. In Table 3, we note that this variable is negative but not significant.

Expenditure on primary education as a percent of government spending - This variable is expected to be positively associated with LFPR (Watson, et al. 2018). However, we observe that from Table 3, it is negative and significant.

GDP per capita – We have tried both GDP per capita at 2015 constant dollars and GDP at 2015 constant dollars to control for the level of economic development in the country. GDP per capita at 2015 constant dollars is negative and significant as reported in table 3. We have not reported the results of the regression of GDP at 2015 constant dollars but is close to the results obtained for the GDP per capita at 2015 constant dollars.

Services value added – As expected, this variable is positive and significant in explaining LFPR.

Trade GDP ratio – this variable is expected to be positively associated with LFPR. However, in our estimation, it is negative and significant as can be seen from Table 3.

Agriculture value added – while a positive sign is expected from this variable, as reported in Table 3, this variable is negative and significant in one variant of equation 5.

Unpaid domestic work and care services – we note from Table 1 the results of the data on time-use by women in the Asia Pacific countries. This interaction term with the time dummy has a negative sign and is significant. Hence the hypothesis, that the more hours a woman spends on activities such as unpaid domestic work and care services, the lower is her participation in the labour force likely to be, is borne out in the data from the Asia Pacific countries.

Female life expectancy at birth – this variable has the expected sign but is insignificant.

Literacy – this variable has the expected sign but is insignificant.

Mobile cellular subscriptions per capita – This variable has the expected sign. However, when tried with internet use, the latter has a negative sign.

School enrolment – the sign of this variable is positive but is insignificant.

Table 3: Results of the regression

	(1)	(2)	(3)	(4)	(5)
Ln INTERNET USE	-0.01	0.00	0.01		0.03

	(-3.25)***	(0.22)	(2.35)***		(3.37)*
Ln GDP per capita		-0.25 (-10.56)***	-0.48 (-6.51)***	1.44 (1.90) ***	-0.51 (-6.94)***
Ln FERT			-0.07 (-0.87)	-0.04 (-0.13)	
Ln EDU (Expenses on primary education as %of Govt. expenditure)			-0.10 (-2.09) ***	0.28 (1.66)*	
Ln AGR VA			-0.63 (-1.27)	-0.31 (-1.63)	-0.10 (-1.93)***
Ln SERVICES VA			0.25 (2.15)**	-0.09 (-0.21)	0.22 (1.87)***
Ln TRADE GDP ratio			-0.15 (-3.48)***	- 0.29 (-2.53)***	-0.15 (-3.49)***
Ln LIFE EXPECT				-3.42 (-1.47)	
Ln MOBILE per capita				0.04 (0.84)	
Ln LITERACY				0.04 (0.28)	
Ln SCHOOL ENROLMENT				0.08 (0.31)	
INTERACT_UNPAID WORK					-0.11 (-2.40)***
Time dummies	-0.00 (-6.15)***	-0.00 (-0.97)	0.00 0.17	-0.07 (-2.46)***	0.01 (1.98)***
Constant	3.75 (276.74)***	5.74 (30.21)***	7.17 (8.77)***	8.61 (2.22)***	8.64 (9.10)***
No. of observations	821	800	213	31	213

Source: Authors' own

5. Discussion

The data and analysis from time-use surveys in the Asia-Pacific region highlight that women predominantly spend time on unpaid domestic work, reducing their availability for employment, thus impacting LFPR negatively. Data on time spent on digital devices by women is sparse, reinforcing the need for better time-use surveys to inform labor policies.

Digitalization (measured by individuals using the internet as a percentage of the population) proves to be significant and positive (reinforcing the results by Shuangshuang et al. (2023) and Watson et al. (2018) in explaining LFPR in various equations but becomes negative and insignificant when included with mobile penetration. Mobile penetration (measured by mobile cellular subscriptions per 100 people by the total population) as an alternative to internet use is positive and significant but loses significance when included with other variables.

The fertility rate, indicated by births per woman, shows a negative but insignificant impact on LFPR. Shuangshuang et al. (2023) reports a positive sign while Watson et al. (2018) report a negative sign for this variable. Contrary to expectations and as reported by Watson et al. (2018), expenditure on primary education negatively affects LFPR. However, it is positive and significant when included along with mobile penetration. GDP per capita has a negative,[21] significant correlation with LFPR but is positive and significant when included with mobile penetration. The services sector positively impacts LFPR, while the trade GDP ratio, unexpectedly, has a negative effect. The latter is contrary to the findings of Cavalcanti and Tavares (2008). Agriculture's share in value-added shows a negative significance in some cases, though Watson et al. (2018) report a positive sign. Unpaid domestic work significantly lowers women's labor force participation as also documented by Chakraborty and Sutradhar (2023). Female life expectancy and literacy, although expected to positively impact LFPR (Watson et al. 2018), are insignificant. Mobile cellular subscriptions align with expectations, but internet use shows a negative correlation. School enrolment (School enrolment, primary, female (% gross) is positively signed but insignificant.

Through the empirical exercise carried out in this paper, we note the corroboration of results obtained by Shuangshuang et al. (2023) and Watson et al. (2018). Shuangshuang et al. offer insights for policymakers on improving female labor force participation (FLFP) by promoting digitalization and education, considering the unique economic and social contexts of BRICS nations. The study emphasizes the importance of addressing socio-cultural norms and improving access to digital infrastructure to enhance women's participation in the labor force. We also note the importance of understanding the time-use of women particularly, unpaid work and care work.

A limitation of this paper relates to the points on data on time-use that have been noted above – the data is available only for 14 countries out of 41 countries in the region as reported in Table 1. Also, the data for many countries is old and reinforces the point of time-use surveys made in the literature review.

The United Nations (2016) emphasizes the critical need to incorporate gender analysis into statistical data collection and interpretation to address and understand gender inequalities comprehensively. Traditional statistical methods often fail to capture gender-specific experiences and disparities, resulting in incomplete and biased data that can misinform policy-making. By integrating a gender perspective, statistics can more accurately reflect the realities of both men and women, providing a stronger foundation for policies aimed at promoting gender equality. This approach enables a more nuanced understanding of social, economic, and political dynamics, essential for advancing gender equality and achieving sustainable development goals.

Furthermore, the United Nations (2021) recommends implementing gender-responsive policies such as parental leave, affordable childcare services, and flexible work arrangements. The integration of time-use data into national statistical systems is also crucial to ensure that

[21] GDP per capita is expected to have a positive impact on LFPR (Watson, et al. 2018). However, as Sedik et al. (2019) report, while digital innovation has led to GDP growth, the effect has been uneven. Disparities in technology adoption and regulatory environment has meant that digitalization has not always led to GDP growth.

policy decisions are informed by an understanding of gender dynamics. The International Labour Organization (ILO) identifies several challenges ahead, including the development of an appropriate list of activities that balance detail and practicality, deciding on sample design, data collection modes, and strategies, and using data from parent surveys like the Labor Force Survey (LFS) to improve time-use data. Including variables such as 'for whom' the work is done can better classify activities. Further development and testing of light time-use diary (LTUD) methodologies are needed to create future guidance.

6. Conclusion and policy recommendation

The paper explores the connection between digitalization, women's time poverty, and their participation in the labor force, highlighting a significant correlation among these three factors. Digitalization offers numerous opportunities for growth and development. However, these opportunities are not equally accessible to everyone. Women, in particular, face significant barriers to digital access, which exacerbates existing gender disparities. As a result, women often lag behind in benefiting from digital advancements. Women's time poverty is a crucial issue because it significantly impacts their ability to take on responsibilities beyond their core duties. When women are burdened with unpaid care responsibilities, they experience time poverty, and they have less time for personal development, or career advancement, and leisure activities. This limitation not only affects their well-being but also hinders their full participation in the labor force and broader societal contributions. Addressing time poverty is essential for promoting gender equality and empowering women to reach their full potential. Therefore, women's participation in the labor force is influenced not only by the opportunities available to them, which are often gender-biased due to the digital gender divide, but also by a comprehensive understanding of how women allocate their time. This includes a significant focus on unpaid work and care responsibilities. Recognizing and addressing these factors is crucial for creating equitable opportunities and enabling women to fully engage in the workforce. The paper appropriately highlights the significance of time use surveys in fully capturing women's contributions to the economy and society. It in turn emphasizes the need for a more equitable redistribution of unpaid care and domestic work. This raises the critical issue of social norms that guide gendered role of men and women and the necessity of challenging them to achieve gender-transformative change. This is a significance challenge for inclusive digital transformation.

In conclusion, the persistence of digital gender gaps is a well-acknowledged issue that cannot be resolved merely through access to the internet and digital resources. Access alone does not ensure equitable digital skills, with gender biases even present in affluent households hindering the digital inclusion of women and girls (UNICEF, 2023). Empowering women and girls through information and communication technologies (ICTs) yields multifaceted benefits for society, enabling them to establish enterprises, expand market reach, secure higher-paying employment, pursue education, access essential health and financial services, engage in information exchange, and participate actively in public discourse.

6.1 Policy recommendations

Tackling the digital gender gap necessitates a comprehensive strategy that includes gender-sensitive data collection, the implementation of gender-responsive policies, and the promotion of digitalization and education. These measures are essential for advancing gender equality and ensuring that women and girls can fully participate in and benefit from the digital economy.

This paper reiterates that there is limited data on the time women spend using digital devices, underscoring the need for improved time-use surveys.

Recommendation: Improve time-use data collection & incorporate them into policy making: Regularly collect and analyze time-use data to inform labor policies that recognize the value of unpaid care work. This data should be used to design gender-responsive labor policies.

In this paper, we show that while internet use alone has a mixed impact, when combined with broader economic development (as shown in regressions 3 and 4), digital infrastructure enhances FLFP. Therefore, ensuring that women have equal access to these services will help them leverage digital tools for economic empowerment.

Recommendation: Expend digital access (digital infrastructure, mobile & internet access) while integrating digital literacy and skills programs targeted specifically at women, including STEM education.

In summary, addressing the digital gender gap requires a multifaceted approach, incorporating gender-sensitive statistics, implementing gender-responsive policies, and promoting digitalization and education. These steps are crucial for advancing gender equality and enabling women and girls to participate in and benefit from the digital economy fully.

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Appendix A: Descriptive Statistics

Variable	Observations	Mean	Standard Deviation	Minimum	Maximum
Log LFPR	1056	3.64	0.45	1.79	4.42
Log INTUSE	821	1.70	2.76	-9.86	4.58
Log GDPCAP	979	8.15	1.38	5.11	11.13
Log GDP	979	24.45	2.68	19.44	30.47
Log FERT	1024	0.97	0.44	-0.25	2.04
Log EDU	268	3.64	0.30	2.91	4.31
Log AGRVA	955	2.28	1.39	-3.63	4.17
Log SERVA	898	3.90	0.21	3.22	4.35
Log TRDGDP	870	4.28	0.62	2.75	6.08
Log LIFE	1024	4.27	0.11	3.84	4.47
Log MOB	907	-1.98	2.71	-13.01	0.64
Log LIT	153	4.27	0.38	2.83	4.61
Log SCHENRLPRI	781	4.60	0.22	1.41	5.04
Log LFPRNE	485	3.64	0.433	2.24	4.55