POLICY BRIEF #31

Digital Technology as an Instrument to Bridge the Gender Gap in Access to Labour Markets

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Economic Policies for Women-led Development

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Abstract

The gendered nature of digital access posits significant barriers to the utilisation of digital technology for increasing female labour force participation. This paper uses data from a nationally representative survey conducted by the NSSO in 2020-21 to investigate the gendered nature of access to digital technology, and more specifically, access to mobile phones and internet and the effect on female labour force participation rate. On the extensive margin (via increased coverage), overall access to mobile phones increases FLPR in rural India, while on the intensive margin (exclusive mobile access) FLPR improves only in urban India. Furthermore, the availability of internet at home increases the effect of mobile phone use on women's labour market participation in urban India. Lastly, digital literacy enhances the impact of mobile phone use on FLPR, but only in urban India. Based on these results, the authors propose actionable steps that governments, private sector and NGOs can collaboratively implement to enhance women's digital access and provide opportunities that can improve their labour market participation.

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Digital Technology as an Instrument to Bridge the Gender Gap in Access to Labour Markets

1. Introduction

Digitalization holds immense potential to boost women's labour force participation in South Asian economies, where they have historically lagged behind. Digital technologies have accelerated global economic growth and prosperity, and have been particularly impactful in enabling women and girls to overcome many long-standing challenges. Increased internet access and usage have been found to boost women's income and earning potential; provide them with greater freedom and increase their sense of equity (Intel and Dalberg, 2012).

However, access to digital technology is skewed against women or is "gendered" in nature, which has hampered the full realisation of its benefits for growth and development. For example, 70 percent of men use the internet globally compared with 65 percent of women.[1] These digital gender gaps stem from longstanding gender biases like financial limitations, patriarchal norms and lack of awareness, which lead to women's unequal access to devices, skills, and a safe digital environment (Tyers and Binder, 2021). Over the years, low and lower-middle-income countries (LMICs) have lost over US$1 trillion in GDP due to women's exclusion from the digital world (Alliance for Affordable Internet, 2021).

Closing the gender gaps in digitalisation has the potential to enhance socio-economic benefits. It has been estimated that closing the gender gap in mobile internet use across LMICs could add US$500 billion to their GDP by 2025 (Alliance for Affordable Internet (2021). In particular, labour market indicators are greatly impacted by digitalisation, (Buhrer and Hagist, 2017) as it reduces the transaction costs of job search, mitigates mobility barriers faced by women, and provides opportunities for virtual and gig work through online platforms. Given the large gender gap in employment, digitisation is a vital need to boost labour force participation among women. This need has been recognized under the in the UN's Sustainable Development Goals (SDGs).

> "Enhance the use of enabling technology, in particular information and communications technology, to promote the empowerment of women" has been specifically included as Target 5. B under SDG 5 (Gender Equality).

However, the SDG Digital Acceleration Agenda has shown that digital technologies strongly impact 6 targets (out of 9) under SDG 5.[2] Recent innovations have helped unleash the power of digital technologies to achieve SDG 5 targets - such as *Audiopedia* (a digital public good that offers accessible audio education on health and gender rights to disadvantaged women and girls) and USAID/Microsoft Airband (that brings meaningful connectivity and internet access to women in remote areas).

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1 ITU

2 UNDP

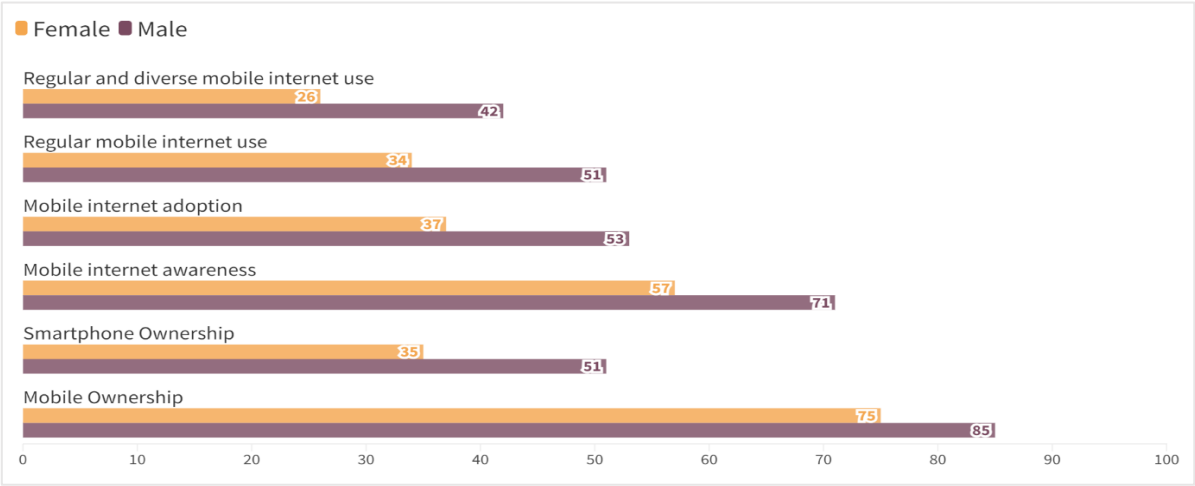
In the Indian context, the need to bridge gender gaps in digital connectivity is in alignment with the Government of India's mission of The National Digital Communication Policy (2018) that envisioned the transition of India to a digitally empowered society by fulfilling the ICT needs of the individuals and enabling universal and affordable digital infrastructure. It was under India's presidency that G20 leaders committed to halving the digital gender gap by 2030[3]. The robust digital public infrastructure (DPI) framework has helped India advance its development goals and bridge the gender gaps in account ownership. It has enabled the rollout of Direct Beneficiary Transfers (DBT) and The Government to Persons (G2P) payment program, that have enabled financial inclusion among rural women.

In pursuance of these goals, this policy brief evaluates the extent to which India's ICT revolution has been leveraged to enable female labour force participation in rural and urban India. The paper explores the extensive and intensive margin of this divide, by assessing extent of coverage and usage, to provide the most appropriate response by public policy. It prescribes a policy framework that can be implemented to utilize digital technologies for the economic empowerment of women. Section 2 assesses India's digital gender gaps; Section 3 provides a literature review and framework to understand the channels by which digital adoption leads to greater labour force participation; Section 4 presents an overview of empirical analysis and section 5 lays down the policy recommendations.

2. Gendered Digital Divide in India

The digital economy in India is estimated to be about 12 percent of the GDP and grown at 2.8 times the rate of growth of the rest of the economy.[4] This growth, however, has been limited to only a fraction of its population, as there is a stark rural-urban and gender divide in digital adoption. While 75 percent of women in India own mobile phones compared to 85 percent men, only 35 percent of women own smartphones (GSMA, 2024).

Figure 1: Digital Access: Difference between Men and Women in India



Source: GSMA Mobile Gender Gap Report, 2024

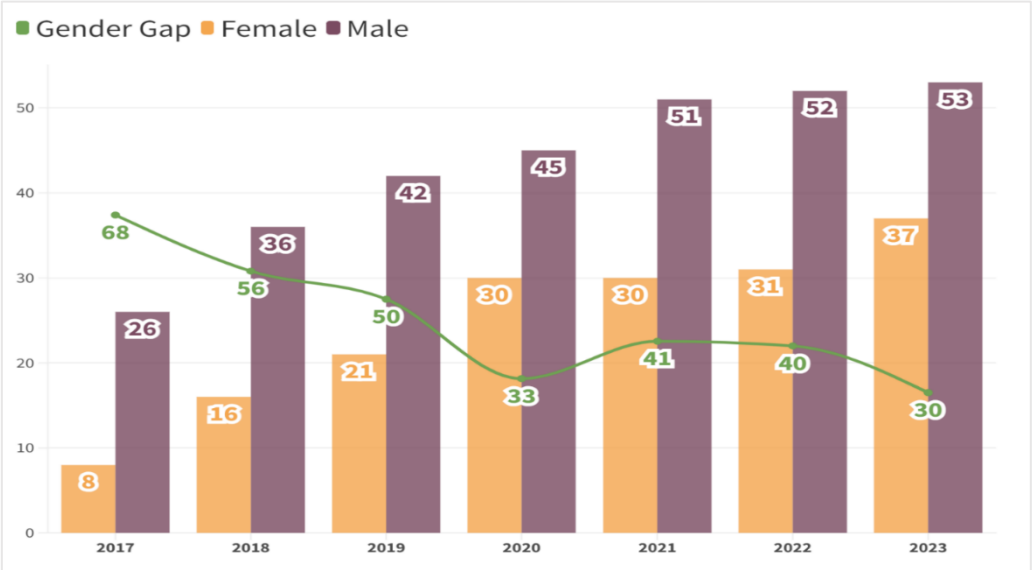
[3] https://www.mea.gov.in/Images/CPV/G20-New-Delhi-Leaders-Declaration.pdf

[4] Business Standard

Additionally, 57% of women are "aware of mobile internet", but only 37% of women adopted mobile internet and 26% used it regularly (Figure 1). India has one the highest digital gender gaps in the world. In 2023, the average gender gap in mobile ownership in LMICs was 8% as compared to 12% in India, while the average gender gap in access to mobile internet in LMICs was 15% but a staggering 30% in India (GSMA, 2024).

There is however, a visible positive trend depicting a rise in women's mobile internet adoption and therefore a narrowing of the digital gender gap, owing largely to the availability of low-cost smartphones with internet in India (see Figure 2).[5]

Figure 2: Mobile Internet adoption in India (% of total adult population)



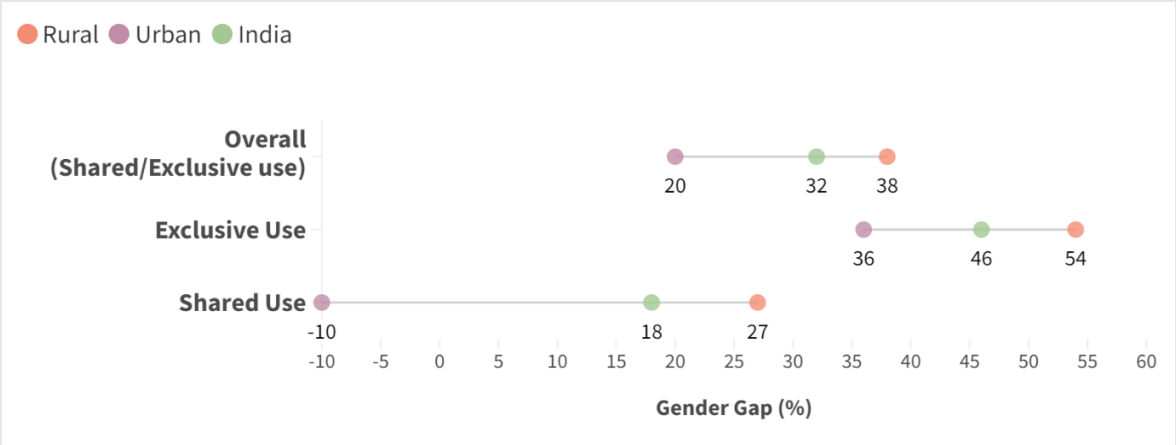
Source: GSMA Mobile Gender Gap Report 2024 and 2023

Another aspect of the differences within a household regarding access to a mobile phone is the extent of use, in terms of it being shared or used exclusively. A shared resource would always be less available to women of the household, and consequent to the lower access the benefit to women will be less. Data from the Government's Multiple Indicators Survey shows that the share of women having access to exclusive mobile phones (22%) is much lower than those having overall access to mobile phones, which is close to 57%. The gender gap is higher in terms of exclusive access (46%) than overall access (32%) and much higher than the gender gap in shared mobile (18%).

The gender gap is augmented between rural and urban areas where the focus is on the exclusive use of mobile phones. In urban areas, the gender gap in shared use is negative, indicating that more women than men share mobile phones. (Figure 3).

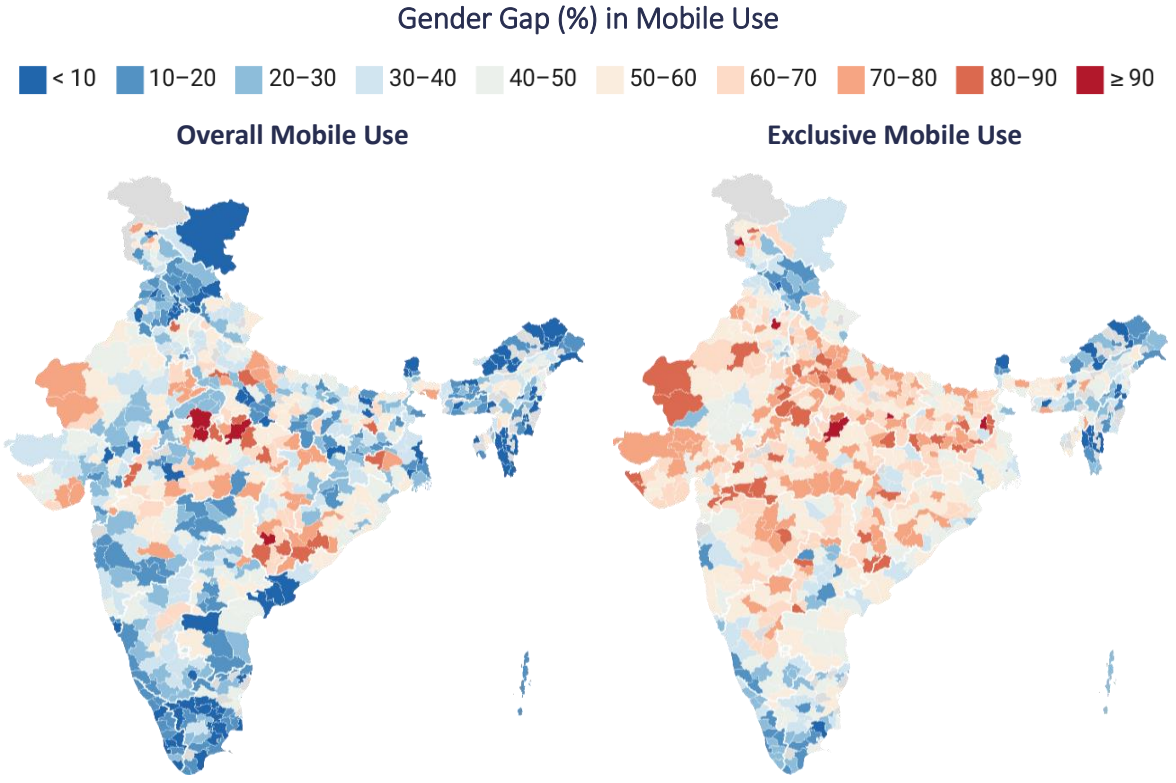
[5] YourStory

Figure 3: Gender gap in intensity of mobile phone use in India



Source: MIS Survey, NSS 78th Round 2020-21

Figure 4: Distribution of Mobile Phone among females across districts of India

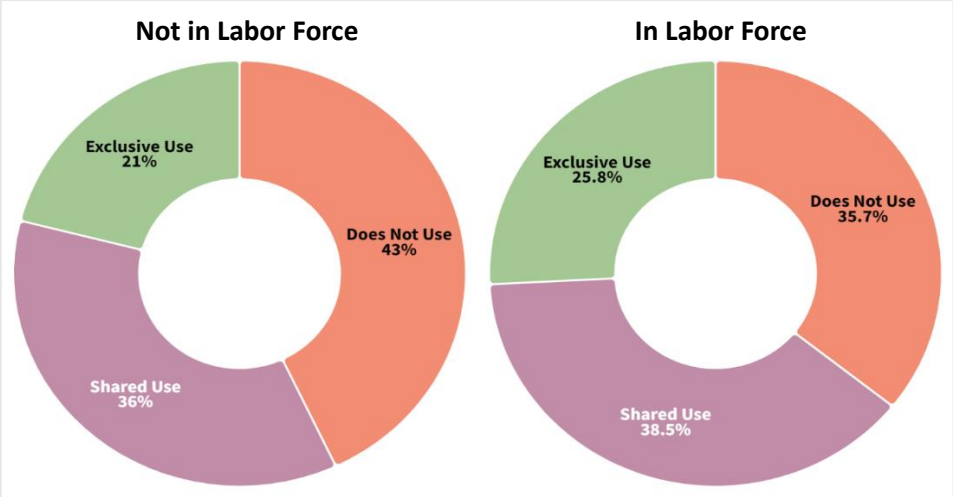


Note: Gender Gap = (% of Male using a mobile phone - % of Females using a mobile phone)/ (% of Males using a mobile phone). Source: NSS 78th Round

The hypothesis is that exclusive access to mobile phones would imply greater access to the labour force opportunities, one would expect to see more women with exclusive access to be within the labour force. Data from the MIS shows that 25 percent of women in the labour force have exclusive access to a mobile phone, compared to 21 percent who are not in the labour force. Moreover, we would also expect that the proportion of women having no access

to mobile phones is higher for those who are out of the labour force. Data from the MIS corroborates this evidence where 43 percent of those not in the labour force do not use a mobile phone, compared to only 35 percent of those in the labour force who do not use a mobile phone (see Figure 5).

Figure 5: Intensity of Mobile use across employment status



Source: MIS Survey, NSS 78th Round 2020-21

Therefore, in India, while the state of digital access is itself limited the gender bias in access is even more concerning. The gender gap is augmented whenever we move from shared to exclusive use or from the extensive to the intensive margin, which potentially has a restrictive impact on women's ability to use digital technology to access the labour market and participate in economic growth.

3. Digital technologies and women's labour force participation

Women's participation in the labour markets has remained low in emerging markets and developing economies (EMDEs). Compared to nearly 60 percent in high-income countries, FLPR is less than 40 percent in LMICs and even lower for India (33 percent).[6]

Various Barriers to Women's Labour Market Participation:

- Time spent on child care
- Time spent on domestic work
- Social and cultural norms
- Mobility challenges
- Lack of employable skills and gender-biased workplaces

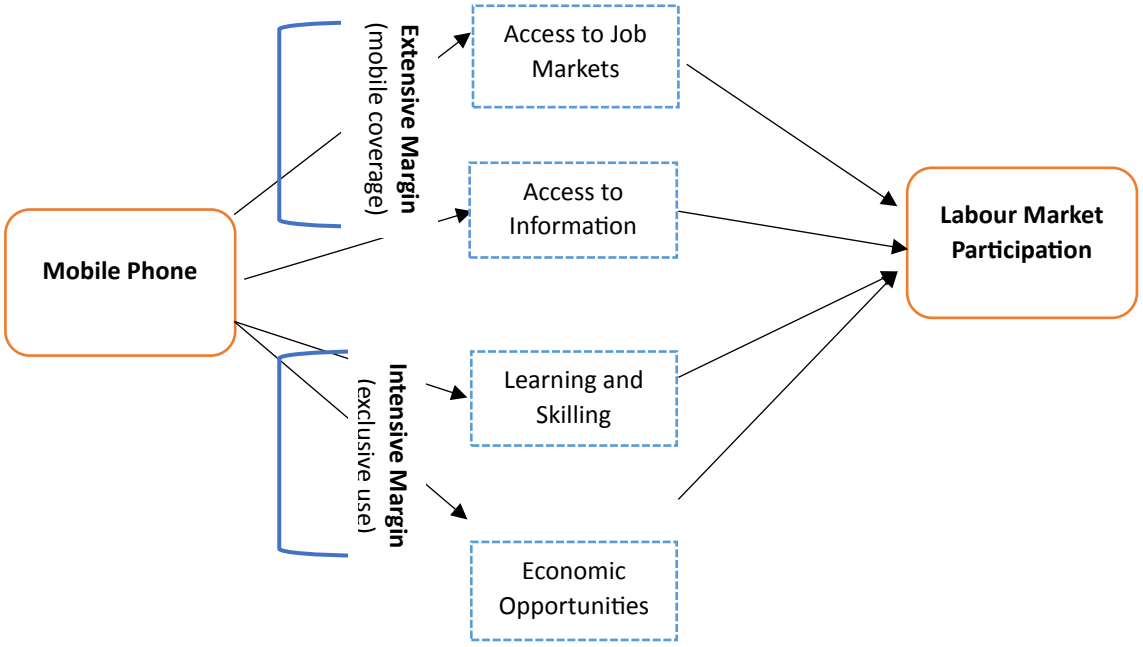
Digitalization and digital technologies have shown great potential in addressing many of these barriers. There is ample evidence that investment in technology can boost employment and productivity. For instance, Yang (2022) shows that AI technology is positively associated with productivity and employment. Cross-country studies have demonstrated that internet availability can enhance labour market outcomes

[6] World Development Indicators, 2023, World Bank

(Paunov and Rollo, 2015; Chun and Tang, 2018; Viollaz and Winkler, 2020, Hjort and Poulsen, 2019). Specifically, the presence of Information and Communication Technologies (ICT) infrastructure has been positively linked to increased FLPR even in developing economies (Asongu and Odhiambo, 2022; Viollaz and Winkler, 2022; Ngoa and Song, 2021; Nikulin, 2017).

The mechanism through which digital technology across countries can influence labour market outcomes is still being studied (Frey and Osborne, 2017). We provide a framework to assess how ICT can improve labour market participation among women. The framework shows how increased coverage (extensive margin) and increased use at the intensive margin can potentially impart labour market participation among women. There are various channels by which digital infrastructure impacts female labour market participation, which can be categorized into (a) Connectedness (b) Information and awareness, (c) Skilling, and (d) Access to Opportunities (Figure 6). The first two channels are defined as the channels through which the extensive margin (mobile availability) work, while the last two channels are the ones through which the intensive margins (exclusive use) work.

Figure 6: Framework to describe the use of ICT to improve female labour market participation



Source: Framework created by EPWD@ICRIER.

***Access to job markets*:** In India, especially in rural India, women's mobility and communication possibilities are greatly restricted due to patriarchal norms, which greatly limits their interaction with the world outside the household. Digital infrastructure can address women's mobility challenges that have prevented them from working outside the homes. For one, mobile phones, as digital infrastructure, complement mobility via roads (physical infrastructure), especially as women can remain connected and have a safety net while

travelling. In urban areas, mobile applications, like those for ride-hailing, public transport planning and safety also enhance mobility and enable women to travel for work.

Secondly, digital technologies have bridged women's communication and networking gaps without having to step outside the house, allowing them to maintain social and professional connections, access emotional support, and engage in virtual networks. Social networking has provided women a platform for sharing experiences, seeking advice, finding a voice, and accessing mentors and role models.

***Access to Information on Jobs*:** The time and effort spent searching for jobs is a significant barrier for job seekers, especially women whose resources are limited. Traditionally, job information was disseminated through word-of-mouth, newspapers, or job boards, which often disadvantage women whose mobility restrictions limit their ability to access such networks. Digitalization corrects the information asymmetries and has improved access to information to search for jobs and employment (Aker and Fafchamps, 2014). Digital tools like job search websites and professional networks also improved access to information to search for jobs and employment (Aker and Fafchamps, 2014; Shimamoto et al., 2015). Online job searches are especially beneficial for women as they offer accessibility, cost-effectiveness, flexibility, autonomy, and a reduced risk of discrimination (Sarı and Rızvanoğlu, 2023). A survey by Intel and Dalberg in LMICs found that nearly half of the respondents used the web to search for and apply for a job, and 30 percent had used the Internet to earn additional income (Intel and Dalberg, 2012).

***Access to Skilling and Learning**:* To succeed in the labour market, people need a broad range of hard and soft skills. However, many developing economies face major skills gaps because their education systems do not equip people with the requisite employable skills.[7] Women especially lag in access to skills, despite the significant improvements in basic education and literacy. The reason is that skilling and upskilling can be costly (both in terms of money and time), and require mobility that is severely constrained for women, especially in rural areas.

ICTs aid the provision of more flexible and interactive learning resources that were not available in the erstwhile traditional means of education (Asongu et al., 2019). Digital technology has empowered and enabled women access to education and skill training. Mobile phones have become repositories of knowledge, enabling women to access online courses, educational platforms, knowledge-based content and informational videos.

Especially during the COVID-19 pandemic, online learning became crucial for women facing limited access to traditional educational institutions. This access has allowed women to upskill for the labour market, pursue entrepreneurship opportunities, and explore new career paths, irrespective of their geographical location.

[7] *https://www.deginvest.de/DEG-Documents-in-English/About-DEG/What-is-our-impact/Bridging-Skills-Gaps_DEG_2016.pdf*

Moreover, attaining digital literacy enhances the chances of labour market participation. Wang et al., (2023) finds that digital literacy has significant non-agricultural employment-promoting effect among households in China.

***Access to Economic Opportunities**:* Digital technology can play a pivotal role in economically empowering women through various channels. For example, in Senegal, when rural women engaged in agriculture were provided phones with Internet access, it helped them obtain information about market prices of inputs for their food processing activities and for the sale of their produce (UN, 2005). ICT adoption has been shown to enable females to start and grow their enterprises (Martin and Wright, 2005), and to have a significant effect on entrepreneurial orientation and opening new ventures among females in India (Chatterjee et al.,2020).

Another digital channel for economic empowerment is digital platforms that have emerged as an attractive opportunity to undertake paid work. The platform economy provides greater flexibility, autonomy and economic independence than the traditional, offline labour markets. Various studies on women's experiences in platform jobs have shown positive impacts on women's income and empowerment.[8] Digital technologies also facilitate remote working and hybrid work opportunities, which have the potential to expand employment opportunities for women beyond purely in-person working models (Joshi et al, 2023).

4. Impact of access to digital technologies on women's labour force participation in India

The use of digital technologies to boost economic outcomes, especially among marginalized groups, has found great appeal in policymaking. Digital technology proves to be a cost-effective tool that policy-makers can utilise to enable the workforce to contribute to the country's economic growth. The cost to the exchequer to implement the second and third categories is significantly different from the first and hence there is a need to test the benefit of the last two categories.

This section explores the direct relationship between mobile access and labour market participation in the Indian context. The idea of access is explored at both the extensive and intensive margin of use to provide policymakers with the appropriate information to advise on policy interventions. For this purpose, mobile use is defined as (a) no use (b) shared use (extensive margin), and (c) exclusive use (intensive margin).

Furthermore, the paper also investigates the impact of broadband availability at the household level and labour market participation. More specifically, the analysis examines whether the internet has an accentuating effect on the impact of mobile phones on labour market participation. Lastly, it is also examined whether this effect is more for women who do not have access to public transportation facilities.

[8] Connected2Work

4.1 Data Source and Methodology

We use the household and individual data from the 78th round of the NSSO MIS Survey, which was conducted between January 2020 and August 2021. The survey covered 276,409 households across all States and Union Territories (UT) of India, enumerating information for 1,163,416 individuals. For our analysis, we consider 358,003 females in the working age group (between ages 15 and 64) distributed across 261,893 households in India.[9]

For our outcome variable, we create a binary variable that categorizes females who are either in the labour force or not in the labour force. The MIS survey provides information on whether a female is in the labour force or not in the labour force. The labour force status of a female is determined in accordance with the usual principal activity status methodology followed by the National Sample Survey Office (NSSO) of India.[10] Our explanatory variable of interest is the female use of a mobile phone. This use can either be no use, shared with a household member, or shared with someone outside the household, or exclusive use.[11] In our case, we use the information on our mobile use variable and divide it into three different ordered categories with each successive category increasing the use of the phone for a female. Hence, category "1" denotes that a female does not use a mobile, category "2" denotes that a female shares her mobile with a household or non-household member, and category "3" denotes that a female has exclusive use of a mobile. We define digital access as the impact of shared use versus no use, while digital inclusion is defined as exclusive use versus shared use. We have also controlled for various individual, household and district characteristics that impact labour outcomes for females in India, such as age, marital status, education, digital literacy, household income, male education, number of children in the household etc.

The distribution of our outcome variables and explanatory variables is given in Appendix A1. In our sample, 22 percent of working age females are in the labour force. Furthermore, with regard to mobile use, 41 percent of women do not use a mobile phone. The detailed methodology used in our study is outlined in Appendix A2.

4.2 Results and Analysis

Our results from the baseline model [Equation (1) in Appendix A2] is presented in Table 1. We study the impact of using a shared mobile phone as compared to no mobile phone, which is

[9] Our sample contains 393,574 females that are present in the working-age group of 15 and 64. We removed the States/UT of Goa, Lakshadweep and Chandigarh containing a total of 2,027 observations due to lack of information in these areas for certain variables in our analysis. We further removed 33,544 observations due to there being no working-age male present (for the highest education of working age male control) in certain households and due to a missing response on the accessibly variable in our model. These exclusions are equivalent to 9.03% of our pre-modified sample

[10] The usual principal activity status is determined by considering the activity in which an individual spent a relatively long time (major time criterion) during the 365-day reference period before the survey date" (National Statistics Office 2019).

[11] The survey collects data on whether an individual used a mobile phone with an active SIM card in the three months preceding the date of the survey (National Statistics Office 2023).

termed the 'Digital Access' effect and the impact of using an exclusive mobile phone as compared to using a shared phone termed the 'Digital Inclusion' effect. The first column of Table 1 presents the Digital Access effect and Digital Inclusion effect across the rural cohort of India. The second column presents these effects for the urban cohort. These results show the isolated impact of the two aforementioned effects on the probability of a female entering the labour force.

We find that having access to a shared mobile phone, as opposed to not having one (i.e., the Digital Access effect), improves the probability of females entering the labour force by 4 percentage points in rural India and 3 percentage points in the urban India. In the urban cohort, this beneficial impact increases by an additional 6 percentage points for females who exclusively use their mobile phones, compared to those who share their mobile phones (the Digital Inclusion effect). Interestingly, the effect of digital inclusion is negligible in rural India. Comparing the estimates across the two cohorts, we find that the Digital Access effect is stronger in the rural cohort, whereas the Digital Inclusion effect is only effective in the urban cohort.[12]

Why does the Digital Access effect matter more in rural India while the Digital Inclusion effect only matters in Urban India? The reasons for these diverging results are related to the mechanisms we discussed earlier in Section 3 of the study. A major reason for this could be the fact there exists a high degree of information asymmetry in the rural cohort (as compared to the urban cohort), thus the information provided to females through even shared access to a mobile phone provides them with a greater marginal utility (in joining the labour force) as compared to their urban counterparts.[13] Similarly, mobility restrictions for females are also higher in rural India as compared to urban India, thereby inhibiting females from joining the labour force, making the marginal utility of having access to a mobile (even sharing one) much higher in rural India.

The channels of skilling and economic opportunities apply more to the intensive margin as one needs increased time with the device to leverage the benefits. In urban India (as compared to rural India), digital inclusion has a significant impact in improving the chances of females to join the labour force, due to three possible reasons.

[12] The difference in the Digital Access Effect between rural and urban cohorts is nearly 2 pp., statistically significant at the one percent level. Similarly, the difference in Digital Inclusion Effect for both these cohorts is nearly -5 pp., statistically significant at the one percent level.

[13] The reach of mass media in rural India is far lower than in urban India. For Instance, according to the *India Readership Survey* (IRS) conducted by the Media Research Users Council India in 2019, 30.25% of all rural persons (above age of 12) had read newspapers in the month preceding the date when the IRS was conducted. This share was considerably higher at 51.75% in urban India. Similarly, according the Household Consumption Expenditure Survey (HCES) of India that was conducted by the NSSO in 2022-23, 80.23% of urban households possessed at least one Television compared to only 58.77% of rural households

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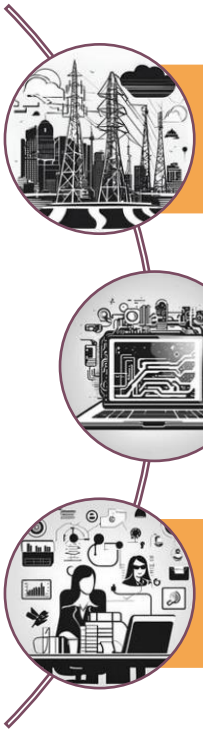


Firstly, urban cohorts of the Indian economy have better availability of telecom infrastructure as compared to the rural cohort. This enables better network coverage and faster internet thereby vastly increasing the benefits that can be accrued from exclusive mobile use.

Secondly, there also exists a disparity between the two cohorts about digital literacy attainment for females. This could be a driving force in improving the labour market outcomes for females who have an exclusive mobile phone compared to sharing one.

Finally, both urban and rural cohorts in India have distinct labour markets compared to each other. In rural India, employment for females is dominated by agriculture while in urban areas there is much higher sectoral diversification with a considerable share of females working in the service sector.

15 16

Therefore, the need for the intensive margin may be less required for rural women.

Table 1: Average Partial Effects of mobile use on FLPR in India

	Prob [*Female Labour Force Participation*]	
	Rural	**Urban**
Digital Access	0.04***	0.03***
	(0.003)	(0.004)
Digital Inclusion	0.007	0.06***
	(0.004)	(0.004)

Robust standard errors in parentheses, * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

However, just looking at the unconditional impact of mobile use (through Digital Access and Digital Inclusion effects) provides an incomplete picture of the other drivers within the digital ecosystem that can impact labour market outcomes for females in India. Thus, we condition our mobile use variable on (a) the impact of availability of internet at home and (b) having

14 https://www.itu.int/en/mediacentre/Pages/pr27-2020-facts-figures-urban-areas-higher-internet-access-than-rural.aspx

15 According to the MIS survey, only 15% of females above the age of 15 had any form digital literacy in rural India as compared to 34% of urban females.

16 According to the Periodic Labor Force Survey (PLFS) of India which was conducted by the NSSO in 2022-23, 76.16% of rural females (above age of 15) are employed in agriculture, 9.77% are in the industry sector and 14.06% are in services. In contrast, within urban India only 11.69% of females are in agriculture, 19.99% are in industry and 68.31% are in the service sector.

any form of digital literacy. Table 2 presents our results for these conditional estimates across both the rural and urban cohorts of India. The Digital Access and Digital Inclusion effect in this table conveys the additional impact of access to internet (at home) and digital literacy on the labour outcomes for females.

Table 2: Average Partial Effects of Mobile Use with Internet availability and digital literacy

		Prob [*Female Labour Force Participation*]	
		Rural	**Urban**
Additional impact of internet at home	**Digital Access**	-0.02***	0.02**
		(0.006)	(0.008)
	Digital Inclusion	-0.003	0.05***
		(0.009)	(0.008)
Additional impact if attained Digital Literacy	**Digital Access**	-0.01	0.02***
		(0.008)	(0.008)
	Digital Inclusion	0.01	0.03***
		(0.010)	(0.007)

Robust standard errors in parentheses, * p < 0.1, ** p < 0.05, *** p < 0.01

We find that with the availability of internet at home, the probability of females in urban India joining the labour force further increases by 2 percentage points and 5 percentage points. for the Digital Access and Digital Inclusion effects respectively. On the contrary, the availability of internet has a negative impact (2 percentage points.) for the Digital Access effect and no impact on the Digital Inclusion effect in rural India. Thus, while the availability of a shared mobile improved female labour force participation by 4 percentage points in rural India, the effect is reduced to 2 percentage points with the introduction of internet. In urban India, the digital access effect increases FLPR from 3 percentage points to 5 percentage points (an additional impact of 2 percentage points), and the digital inclusion effect is enhanced from 6 percentage points to 11 percentage points with the availability of internet (an additional impact of 5 percentage points). The results for rural India are not surprising given that agriculture is a major source of employment in this cohort. Further, poor network coverage in these areas may adversely impact the stability and speed of internet connections at home. The reduced impact of internet availability for women in rural India could also mean that with the availability of internet, the shared access is even lower (i.e. the time spent with the mobile phone reduces as internet becomes available), leading to a reduced overall effect on labour market participation.

Similarly, we also find that having digital literacy only has an additional positive impact in increasing the probability of female labour force participation in urban India. It enhances the Digital Access effect from 2 percentage points to 4 percentage points, and Digital Inclusion

effect from 5 percentage points to 8 percentage points (an additional impact of 3 percentage points). Again, this impact being absent in rural India could be because of the difference in the nature of employment present in both cohorts. For instance, 14 percent of employment for rural females is in the service sector as compared to 68 percent for urban female.[17] This means there a far more avenues for females in urban India to utilise their digital skills and enhance the benefits they accrue from using a mobile phone.

Overall, the results indicate that the digital access effect is significant in enhancing FLPR among rural cohorts, while digital inclusion is significant only in urban cohorts. Furthermore, the availability of broadband and digital literacy of females increases the effect of mobile phone use on labour market participation in urban India. However, this effect is absent in rural India.

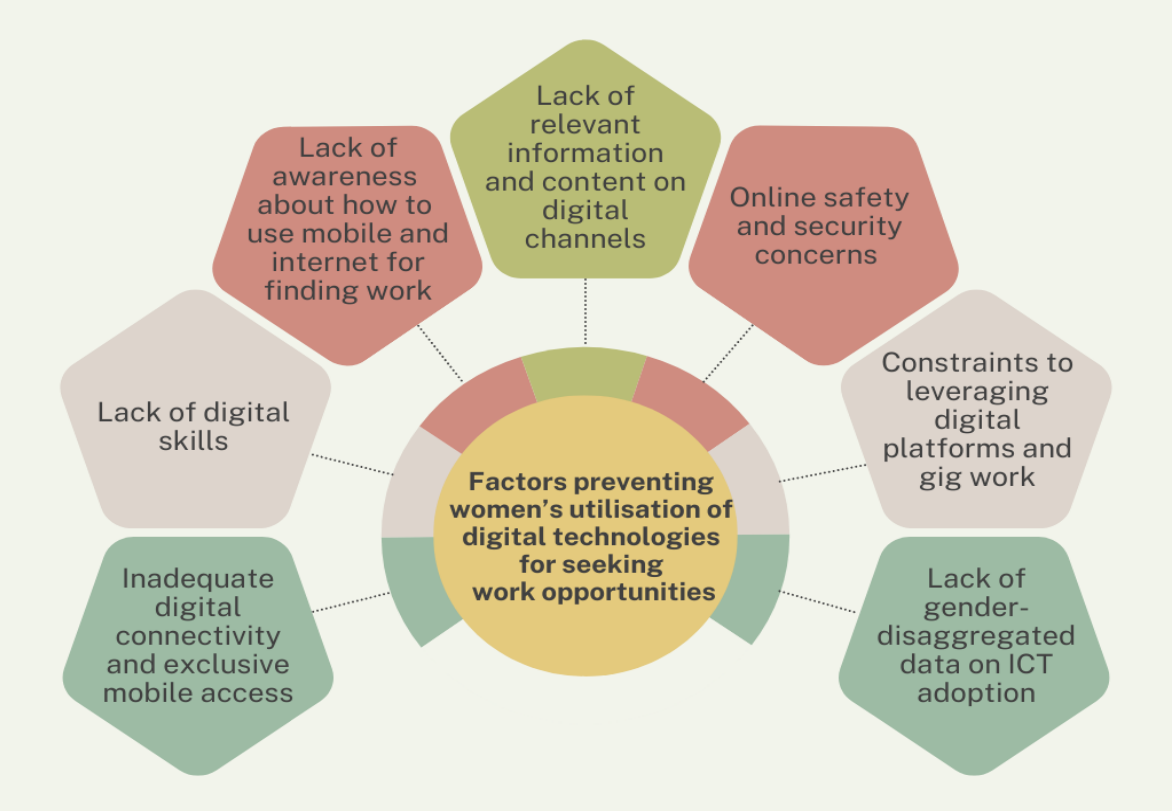
The findings taken together show that women in rural India are mostly using digital technology to access the market and gain information of job opportunities. In this way, digital technology is able to bridge the mobility and network barriers faced by women in rural India. This is the extensive margin of use where the shared benefit is also positive. On the other hand, for urban women, the use is at the intensive margin of skilling and increased opportunities. So exclusive use is beneficial, and the access to internet and digital literacy augments the effect of digital access on labour force participation. Moreover, for rural women, the availability of internet reduces the impact of mobile use on labour force participation as it is probably used for leisure-related activities.

5. Policy Recommendations to leverage technology for improving female labour force participation in India

The theoretical framework (Figure 6) and empirical analysis show that technology can potentially create opportunities to enhance women's labour force participation in India through multiple channels. However, several challenges persist that prevent women from leveraging the benefits of digital technologies for their economic empowerment (Figure 7).

[17] PLFS, 2022-23

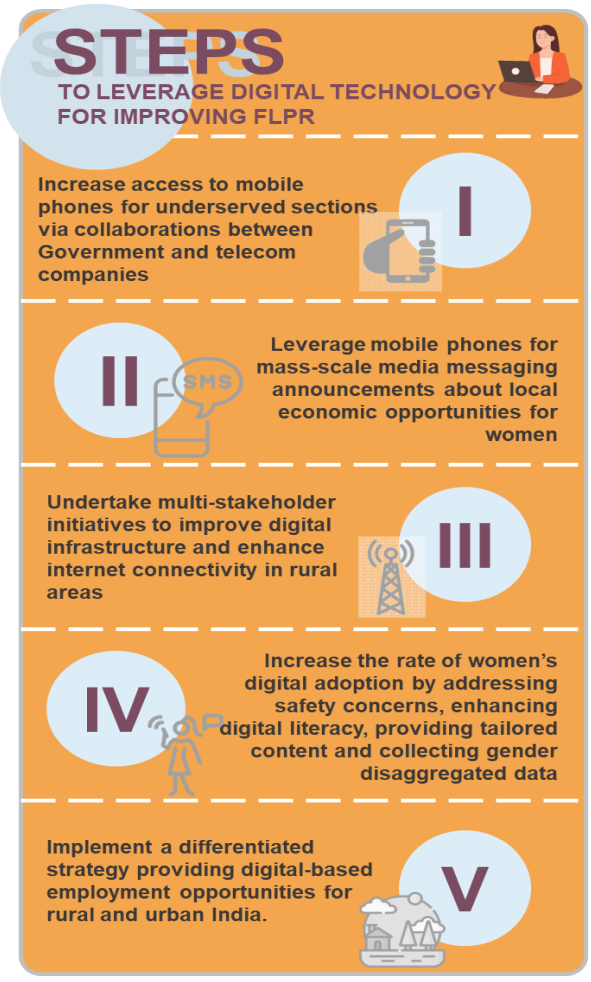
Figure 7: Barriers to Women's Utilisation of Digital Technologies for Economic Opportunities



By enhancing digital connectivity and adopting a multi-faceted approach, India can significantly enhance overall digital inclusion and also enhance women's workforce participation. To enable women to contribute to India's future economic prosperity and reap the benefits, thereof, it is vital to ensure that women not only have equal access to technology but are also able to make the best use of the opportunities it provides.

Meaningful access to digital technologies and the opportunities they create would require large-scale, gender-lens investments, actions, and collaborations between various stakeholders from the ecosystem, including Central, State, and Local governments, private sector players and the non-profit sector. A differentiated approach is needed for urban and rural areas. Following are some recommended steps that can be implemented jointly by ecosystem players to improve female labour force participation by leveraging digital technologies:

Figure 8: Steps to Leverage Digital Technology for Improving FLPR



I. Increase access to mobile phones for underserved sections via collaborations between Government and telecom companies

The first step towards addressing many of women's barriers to digital access is to deepen the penetration of mobile phones, especially in rural areas. For this, State governments could consider tying up with telecom providers to provide subsidized or free-of-cost mobile phones to underserved populations. The Rajasthan Government's systematic interventions since 2008, to provide free mobile phones with free internet to female heads of eligible households (Yourstory, 2018; GSMA, 2022), could be analysed to understand the most effective modes of executing these interventions. Additionally, innovative, multistakeholder campaigns could be designed, similar to the Connect Rwanda campaign (a joint initiative between Rwanda's Ministry of ICT and MTN Rwanda) that aims to collect 1 million smartphones through donations and redistribute them to poor families in rural areas, prioritizing women (GSMA, 2020). Another model could be Nigeria's National Broadband Plan 2020–2025, which outlines a Social Investment Scheme that aims to expand 5 million disadvantaged women's access to smartphones and devices by 2025.[18]

II. Leverage mobile phones for mass-scale media messaging announcements about local economic opportunities for women

Once access to mobile phones is met, the government can initiate large-scale and localised media messaging campaigns via SMSs to provide information about local job opportunities, entrepreneurship subsidies and schemes, and other such opportunities that can incentivize women to participate in the workforce. For instance, mobile phones can act as effective channels of information dissemination and awareness building about the Government's schematic and legislative interventions for women's educational, social, economic, and

[18] (*GSMA,* Policy considerations to accelerate digital inclusion for women in low- and middle-income countries, 2022).

political empowerment. The messages could help women avail services about healthcare, quality education, career and vocational counselling/ training, financial inclusion, entrepreneurship, workplace health and safety, social security, digital literacy etc. Through these mass messages, women in rural India can especially be made aware of income-earning opportunities available around them, from programs like MGNREGA, SHGs and other possibilities of employment and entrepreneurship.

III. Undertake multi-stakeholder initiatives to improve digital infrastructure and enhance internet connectivity in rural areas

The next step after enhancing smartphone access should be to provide "*meaningful digital connectivity*" to all parts of the country, based on higher minimum thresholds of internet access, i.e. 4G-like speed, an unlimited broadband connection, and daily usage of the internet.[19] It is especially urgent to deepen the internet and digital penetration in rural areas, which still face poor, slow, and unstable network coverage.

In addition to mobile internet, innovative mechanisms to provide low-cost, on-the-go internet can be designed. The Prime Minister Wi-Fi Access Network Interface (PM-WANI) is one such scheme, whereby through 200,000 plus public hotspots, the government has provided low-cost internet to the underserved urban poor and rural households.; and increased employment for small and micro-entrepreneurs.[20] This initiative needs complementary effort from the private sector players and more public-private partnerships (PPPs), such as the Edison Alliance21 and Broadband Equity Access and Deployment (BEAD) Program can scale up such innovative and more affordable internet services to the vast Indian population.[22]

IV. Increase the rate of women's digital adoption by addressing safety concerns, enhancing digital literacy, providing tailored content and collecting gender-disaggregated date

While India has introduced affordable and low-cost smartphones with inbuilt internet plans, the rate of adoption by women is much lower. Innovative solutions are urgently required to help overcome various social and economic barriers that prevent women from fully participating in the digital economy. Measures are especially needed to move women from shared to exclusive use of mobile phones and increase their usage of the internet. Following are some suggested steps to enable this –

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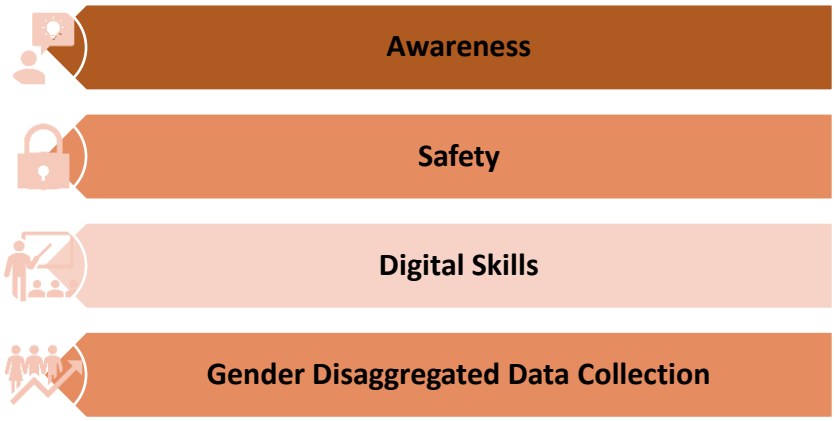
19 Global Digital Inclusion
20 PM-WANI
21 *https://www.edisonalliance.org/home*
22 BEAD Program

Figure 9: Focus Areas for Increasing Women's Digital Adoption



i. Generate awareness about the usefulness of the mobile and internet using tailored content **-** Past research has shown that women are less likely than men to see how mobile services can be useful, which often prevents them from adopting and using mobile phones (GSMA, 2020). Our empirical analysis also showed that digital literacy does not enhance the impact of mobile phone use on labour force participation in rural India, indicating that perhaps women don't understand the usage. The benefits of mobiles must, therefore, be promoted via channels that women already use and trust, such as local radio stations and ASHA Workers. Rural libraries, like those set up in Karnataka's gram panchayats, can also be used as spaces to educate women about the possibilities of utilizing digital technologies.

Evidence also shows that a lack of relevant and relatable content on the internet often makes women feel "*what they find online is not worth their while*.[23] Therefore, mobile internet adoption by women can be enhanced by creating relatable and relevant, local language content that is easily accessible for them. It would also be useful to embed educational content within entertainment content.

Additionally, phone manufacturers and digital application developers can enhance the usability of digital services for women by integrating tools like voice search, chatbots, and video tutorials in local languages to explain the features, onboarding process, and troubleshooting mechanisms.

ii. Address digital safety concerns **-** Research has shown that safety and security concerns are a key reason for low digital adoption and usage, with women being more likely than men to report these concerns. To enable women to reap the full benefits of the internet, it is important to ensure that they are not deterred from using it, and when they do, they feel confident they can keep themselves safe. Therefore, mobile manufacturers, internet companies and the government must take these safety and security concerns seriously (GSMA, 2024). Mobile phones must have in-built safety features and include safety-related applications and services (like emergency alerts or call-blocking services). Companies also need to make it easy and safe for customers to report online abuse and collaborate with

[23] *WWF Foundation*

relevant government agencies. For instance, Singapore's Protection from Harassment Act recognizes online GBV and publishes guidelines on recourse mechanisms for victims of online harassment. The Philippines' Safe Spaces Act has recognised and defined gender-based online sexual harassment, appointed government bodies that are responsible for implementing this law on cybercrime, and defined penalties for breaking the law (GSMA, 2020).

iii. Undertake innovative multi-stakeholder initiatives for imparting practical digital skills to women - "*Not knowing how to use the Internet*" continues to be a significant barrier for women's digital inclusion, and women are 1.6 times more likely than men to cite 'lack of skills' as a barrier to their internet use24. In India, digital literacy is very low for both men and women, with only 22% of all men and 21% of all women above the age of 15 having some form of digital literacy. The gender gap in digital literacy increases as the complexity of the skill increases since the gender gap for basic digital literacy skills is 6.7%, 7.4% for intermediate skills and 9.8% for advanced skills. This gap gets further widened in the rural cohorts of the Indian economy.[25] Therefore, developing digital capabilities in women is a critical requirement for increasing their earning and employment prospects.

Imparting digital literacy to all children at the school level would leverage the high enrolment of girls in primary and secondary education. India's New Education Policy (2020) has emphasized the importance of digital literacy and encourages the development of digital content and resources. To implement this, the Government can take inspiration from Estonia's "Tiger Leap" program, which connected all the country's schools to the internet and implemented digital literacy programs where children learn the basics of programming.[26] In India, an inspirational initiative is by Pratham Infotech Foundation (an NGO in the education sector) that has been instrumental in bridging the digital divide and fostering ICT adoption among schools in India.

Large-scale digital literacy programs are needed to enable adult women with basic as well as high level of digital skills. The Pradhan Mantri Gramin Digital Saksharta Abhiyan (PMGDISHA), which runs digital literacy campaigns for one member of households in rural areas, imparts basic literacy skills to users and has certified nearly 20 million women as digitally literate.[27] Given that more than 50 percent of beneficiaries are women, add-on content could address women's needs and challenges relating to online safety and utilizing digital resources to seek income opportunities. Interested beneficiaries should also be provided the option for getting trained in higher levels of employment-generating digital skills using the same infrastructure.

Further, the reach of digital literacy campaigns can be scaled up by deploying models such as the Train the Trainer model. For instance, the Rwanda Digital Ambassador Programme (R-DAP) trained 5,000 young Digital Ambassadors to serve as digital skill trainers to 5 million

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[24] https://www.ohchr.org/sites/default/files/Documents/Issues/Women/WRGS/GenderDigital/WWW_Foundation.pdf

[25] ICRIER-EPWD Blog

[26] *https://courier.unesco.org/en/articles/global-lessons-estonias-tech-savvy-government*

[27] *PMGDISHA*

Rwandans, 75% of whom reported greater motivation and confidence in using digital technology (GSMA, 2020). Similarly, India's Internet Saathi initiative by Google and Tata Trusts, empowers women in rural areas as trainers for their communities, and has trained 60,000 saathis and 20 million women who now use the internet for upskilling and starting businesses.[28]

NGO initiatives can also be effective in promoting digital literacy. For example, FreeDem provides a platform for girls and women from marginalized backgrounds to learn digital literacy and explore the practical functionalities of smartphones. Once girls complete the course, they receive a stipend to utilize their skills to produce media content and voice their concerns.[29]

iv. Improve gender-disaggregated data in ICT adoption **-** In India, there is no extensive data to indicate the reasons for the lack of access and use of technological infrastructure by women. To provide evidence-based solutions for filling digital gender gaps, there is an urgent need to provide better gender-disaggregated data on the adoption and skill levels of ICT infrastructure in India. Currently, the MIS survey is the only nationally representative survey that provides this data. However, only one round of this survey was conducted in 2020-21. While the MIS survey provides data on the degree of use, it does not detail the reasons for shared or no use of mobile phones by women.

The government should include gender-disaggregated data collection on the ICT adoption and skills in their national census that will enable policymakers to undertake necessary interventions in particular states and districts of India. In particular, there is a need to collect sex-disaggregated data on indicators that look beyond just access, to understand meaningful use of the internet and specific constraints of women (like lack of digital skills, and technology-facilitated risks. India could take inspiration from other countries that have undertaken initiatives for collecting gender-disaggregated data. Mozambique includes sex-disaggregated ICT data in their national census, Zambia's three-yearly national ICT has included a gender component based on the USAID Gender ICT Survey Toolkit, and the Philippines's Women in ICT Development Index (WIDI) Survey especially aims to understand how ICTs are used to expand women's social, economic and livelihood opportunities (GSMA, 2022). The government and service providers could also look at the possibilities of harnessing non-traditional, 'big data' sources to fill existing data gaps to understand access and usage patterns of different age and gender groups access and use digital technology.[30]

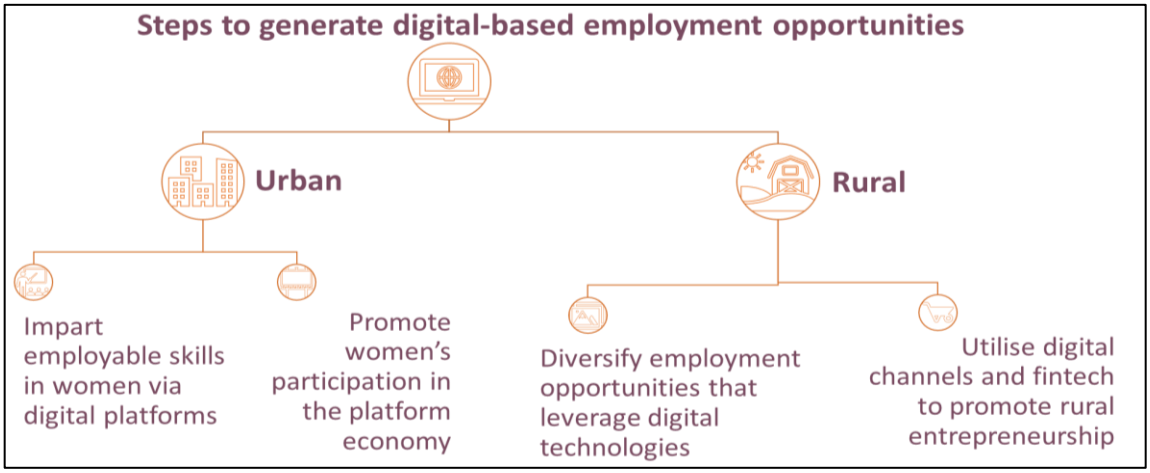
V. Implement a differentiated strategy providing digital-based employment opportunities for rural and urban India.

Once women have been equipped with digital infrastructure and the requisite digital literacy skills, proactive and dedicated measures are needed to provide them with opportunities to

[28] Tata Trusts
[29] *CNBC TV-18*
[30] *SDG UN*

upskill, find jobs and build businesses that utilise digital technologies. Following are some ways by which this can be enabled –

Figure 10: Measures for creating digital-based employment opportunities for women in rural and urban India



i. Impart employable skills in women via digital platforms **-** In 2022-23, only 18.6% of women aged 18-59 had ever received vocational training compared to 36.1% of men.[31] Digital skilling platforms are an effective mode of delivery for skilling and capacity-building initiatives and a greater number of women must be made aware of and enabled to leverage these to garner income-generating skills. For instance, The Pradhan Mantri Kaushal Vikas Yojana (PMKVY) is the Government's flagship scheme that leverages telecommunication infrastructure and provides short-term vocational training courses via empanelled private sector trainers. The National Skill Development Corporation (NSDC)'c e-Skill India portal, in collaboration with Microsoft, was set up to skill more than 1 lakh underserved women in India covering topics such as digital literacy, enhancing employability, nano entrepreneurship, and communication skills. Such Public-Private Partnerships for skilling and capacity building of women must be scaled up and marketed to all target groups. Additionally, better engagement of the private sector to expand apprenticeship programs will ensure that young people acquire the relevant technological skills and expertise to thrive in today's competitive job market.

ii. Promote urban women's participation in the platform economy **-** The number of gig workers in India is expected to increase from 77 lakh in 2021 to 2.35 crore by 203032, but women face several constraints to leveraging digital platforms, including unregulated working hours, physical harassment and sexual violence as such platforms do not have adequate forms of protection.[33] Introduction of legislative mechanisms that provide a safety net for gig workers can enable women to enter the labour force as gig workers, similar to the Rajasthan Platform-Based Gig Workers Registration and Welfare Act in 2023. Similarly, women's usage of online job platforms is much lower than men, indicating a need for job search platforms to

[31] PLFS, 2022-23

[32] https://www.niti.gov.in/sites/default/files/2022-06/Policy_Brief_India%27s_Booming_Gig_and_Platform_Economy_27062022.pdf

[33] Why Women In India Are Less Likely To Find Jobs

take steps to attract more women to onboard onto their platforms. Job search platforms specifically for women can also be promoted.

iii. Diversify employment opportunities in rural areas that leverage digital technologies *- To* enable a greater positive impact on the employability of rural women through mobile internet and digital literacy, it is essential to provide opportunities to utilize their digital skills. For example, SEWA Bharat enables women workers to benefit from technological innovations by creating new job roles such as digital data collection and photography. They also facilitate linking women service providers to consumers through digital platforms, exploring non-traditional work such as homestays, public transport, and other gig work. Creating similar opportunities for women in rural areas can enhance their employability and improve their economic prospects through mobile internet and digital literacy.

iv. Utilise digital channels to promote rural entrepreneurship **-** Another avenue where digitisation can be used for the economic empowerment of rural women is the enhancement of entrepreneurial opportunities. For one, women entrepreneurs organised as SHGs can leverage digital platforms and e-commerce sites to expand their markets and customer base. The Ministry of Rural Development (MoRD) has already signed a Memorandums of Understanding (MoUs) with e-commerce players like Reliance Retail's JioMart and Amazon to help enhance the outreach of the products of SHGs.[34] E-commerce platform Meesho has also collaborated with state governments and SHGs to identify women sellers from poor economic backgrounds in rural areas and handholds them to onboard onto e-commerce.[35]

The other channel that can be leveraged is Micro, Small, and Medium Enterprises (MSME's), which are the second largest source of employment for women in India after agriculture and almost 50 percent of MSME's are in rural India. A large proportion of the businesses are beginning to leverage digital technologies for their businesses. The share of e-commerce integrated MSME's have increased from less than 1 percent in 2011-12 to almost 7 percent in 2022-23. More than 57% of the total business on Government E-Marketplace (GeM) comes from MSMEs but women entrepreneur's share is just about 6%, indicating a wide scope for enhancing women's participation in digital commerce.[36]

Lastly, fintech platforms have played a significant role in boosting women entrepreneurship, especially through alternative routes of credit. For instance, peer-to-peer platforms enable women entrepreneurs to access credit by individual investors, thereby reducing the dependency on banks and other formal financial institutions. As an example, firms such as *Dvara SmartGold* offer micro savings and investment products to rural women, enabling them to invest in gold and build their savings. These innovative solutions vastly improve the gender gap in SME financing in India. Furthermore, in order to bridge the credit gap faced by MSMEs, India is actively seeking to leverage its DPI through the Account Aggregator (AA) network (Kapoor, 2024). The AA framework is a financial sharing platform that democratises credit and has particularly been beneficial for women entrepreneurs.

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[34] Press India Bureau
[35] Meesho
[36] Economic Times

While it would take a combined effort of multiple stakeholders to provide an enabling ecosystem, the onus of implementing these policy prescriptions largely lies with the central government, state government, local government, NGO's and the private sector. Among these, the central, state, and local governments have the maximum reach and ability to create the needed policy impact. However, effective public-private partnerships that foster collaborations with the private sector are key to scaling up these initiatives. Table 3 provides the summary of the policy recommendations mapped to key stakeholders that can provide the maximum impact for the respective policy measures.

Table 3: Policy Recommendations mapped to Stakeholders with Primary Responsibility for Implementation

Recommendations	Central Govt	State Govt	Local Govt	NGOs	Private Sector
Increase access to mobile phones for underserved sections via collaborations between Government and telecom companies	○	○			○
Leverage mobile phones for mass-scale media messaging announcements about economic opportunities that can be availed by using mobile phones	○	○	○	○	○
Undertake multi-stakeholder initiatives to improve digital infrastructure and enhance internet connectivity in rural areas	○	○	○	○	○
Increase the rate of women's digital adoption by addressing safety concerns, enhancing digital literacy, providing tailored content and collecting gender-disaggregated data	○	○		○	○
Implement a differentiated strategy providing digital-based employment opportunities for rural and urban India.	○	○			○

In conclusion, it is important to take note that technology alone cannot overcome long-standing barriers and gender norms. It will be important to ensure that the pre-existing gender gaps are not translated into digital gender gaps, by ensuring gender mainstreaming of technological solutions and the policy ecosystem. It should also be noted that while technology creates new job opportunities, it has the potential to displace jobs too. Occupational segregation by gender is a leading factor for potential job displacement due to automation and technological changes. A recent study found that both women and men are at equal risk of losing jobs due to technological changes, but for women, mitigating job displacement would require addressing mobility, technological savviness, and skilling – which are all currently lagging for women as compared to men (Mckinsey Global Institute).[37]

[37] Will automation improve work for women - or make it worse? | McKinsey

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Appendix

Appendix A1: Descriptive Statistics

Table A1 describes the descriptive statistics of the model used in Section 4 and includes all the explanatory variables used in our analysis.

Table A1: Descriptive Statistics of the Regression Models

Variable	Mean	Std. Dev.	Min	Max
FLPR	0.22	0.42	0	1
Mobile Use				
Does Not Use	0.41	0.49	0	1
Shared Use	0.37	0.48	0	1
Exclusive Use	0.22	0.41	0	1
Household access to Internet				
No	0.53	0.50	0	1
Yes	0.47	0.50	0	1
Sector (Location)				
Rural	0.70	0.46	0	1
Urban	0.30	0.46	0	1
Age	35.03	13.26	15	64
Marital Status				
Never Married	0.20	0.40	0	1
Currently Married	0.74	0.44	0	1
Widowed	0.05	0.23	0	1
Divorced	0.00	0.07	0	1
Highest Education Level				
Less than Basic	0.35	0.48	0	1
Basic	0.43	0.50	0	1
Intermediate	0.12	0.32	0	1
Advanced	0.10	0.30	0	1
Has Digital Literacy				
No	0.79	0.41	0	1
Yes	0.21	0.41	0	1
Highest Education Level of Working Age Male in HH				
Less than Basic	0.13	0.34	0	1
Basic	0.48	0.50	0	1
Intermediate	0.19	0.40	0	1
Advanced	0.20	0.40	0	1

Atleast one male is a salaried worker in HH				
No	0.76	0.43	0	1
Yes	0.24	0.43	0	1
Log of Monthly HH Consumption	9.19	0.53	7	13
Land Holding of HH (in hectare)				
less than 0.005	0.06	0.23	0	1
0.005 - 0.02	0.12	0.33	0	1
0.02 - 0.21	0.34	0.47	0	1
0.21 - 0.41	0.05	0.22	0	1
0.41 - 1.01	0.12	0.32	0	1
1.01 - 2.01	0.12	0.33	0	1
greater than 2.01	0.19	0.39	0	1
House Type				
Kutcha	0.04	0.18	0	1
Semi-Pucca	0.11	0.31	0	1
Pucca	0.86	0.35	0	1
HH has atleast one AC/Cooler				
No	0.80	0.40	0	1
Yes	0.20	0.40	0	1
No. of children in HH below 4	0.41	0.73	0	6
No. of elderly in HH above 65	0.24	0.52	0	5
Religion and Social Group of HH				
Non-SCST Hindu	0.56	0.50	0	1
SCST Hindu	0.27	0.45	0	1
Islam	0.11	0.32	0	1
Others	0.05	0.22	0	1
Relation of female to HH head				
HH Head	0.04	0.20	0	1
Wife	0.53	0.50	0	1
Daughter in Law	0.17	0.37	0	1
Unmarried Daughter	0.18	0.38	0	1
Other	0.08	0.27	0	1
HH has access to roads in rural India or public transport in urban India				
No	0.06	0.24	0	1
Yes	0.94	0.24	0	1
Observations	3,58,003			

Appendix A2: Methodology

We can only observe whether the surveyed female is within the labor force or not, hence our dependent variable is a function of a latent variable Y^*_{ihd} . This variable denotes the net benefit that a surveyed female "i" in household "h" in district "d" receives from entering the labour force. If the net benefit received is positive i.e., $Y^*_{ihd} > 0$, then the female chooses to be in the labour force and vice versa. Thus, for our outcome variable, we create a binary variable by delineating the working age females observed into two categories: In the Labour Force and Not in the Labour Force. The labor force status of a female is determined in accordance to the usual principal activity status methodology followed by the National Sample Survey Office (NSSO) of India[38].

Thus, we define the binary variable Y_{ihd} as:

$$Y_{ihd} = \begin{cases} 1 \text{ if } Y^*_{ihd} > 0 \\ 0 \text{ if } Y^*_{ihd} \leq 0 \end{cases}$$

where Y_{ihd} take the value 1 if the observed female is within the labour force. It takes the value 0 if the observed female is not within the labour force.

Our explanatory variable of interest is the female use of a mobile phone. This use can either be exclusive, shared with a household member, or shared with someone outside the household.39 We can also observe the females that do not use a mobile phone. The underlying distribution that determines the use of a mobile by a female is also unobserved and can be described by a latent variable M^*_{ihd}. Suppose female "i" in household "h" in district "d" is sorted into "k" observable categories regarding their use of a mobile, with each category being denoted by "j," such that j = 1, 2 ,.., k. If the k different categories have a natural ordering, then we can create an ordered categorical variable.

In our case, we use the information on our mobile use variable and divide it into three different ordered categories with each successive category increasing the use of a mobile for a female. Hence, category "1" denotes that a female does not use a mobile, category "2" denotes that a female shares her mobile with a household or non-household member, and category "3" denotes that a female has exclusive use of a mobile. Thus, we can observe the ordered categorical variable M_{ihd} 40 but not the latent variable M^*_{ihd} .

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[38] The usual principal activity status is determined by considering the activity in which an individual spent a relatively long time (major time criterion) during the 365-day reference period before the survey date" (National Statistics Office 2019).

[39] The survey collects data on whether an individual used a mobile phone with an active SIM card in the three months preceding the date of the survey (National Statistics Office 2023).

[40] We define M_{ihd} as $M_{ihd} = \begin{cases} 1 & if \ a_0 < M^*_{ihd} \leq a_1 \\ 2 & if \ a_1 < M^*_{ihd} \leq a_2 \\ 3 & if \ a_2 < M^*_{ihd} < a_3 \end{cases}$, where $a_1 \ and \ a_2$ are unobserved cut-offs dividing the use of a mobile; $a_0 \equiv -\infty$ and $a_3 \equiv \infty$.

Our choice problem is described by the latent variable model:

$$Y^*_{ihd} = X_{ihd}\alpha + S_d\beta + M_{ihd}\theta + S_d M_{ihd}\gamma + \varepsilon_{ihd,} \qquad (1)$$

where $Y_{ihd} = 1$ if $Y^*_{ihd} > 0$ and $Y_{ihd} = 0$ otherwise. ε_{ihd} is a random error.

where $\phi[]$ is the evaluation of the standard normal cumulative distribution function.

Equation (1) presents our baseline specification. Following the literature on the determinants of the labour outcomes for females in India, the vector X_{ihd} includes various individual, household and district characteristics that impact our outcome variable. At the individual level we control for the age (both linearly and non-linearly), marital status, highest level of education[41], and an indicator for the digital literacy attainment[42] of a female.

Previous literature on India's labour market has also emphasized the role of household income, wealth, and male education in explaining the female choice to participate in the labour force as well as on the type of employment they obtain (Klasen and Pieters 2015; Sarkar, Sahoo, and Klasen 2019). We account for such factors in our analysis by including the log of monthly household consumption, the landholding of the household, the house type of the females i.e., kutcha, semi-pucca, and pucca, whether the household has at least one air conditioner/air cooler , the security of household income via a dummy variable for having at least one male household member with salaried employment (Klasen and Pieters 2015), and the control for the highest education attainment of a working-age male in the household. We also include other household-level controls such as the number of children in the household below the age of four and the number of elderly individuals in the household (those over the age of 64). We also include dummies to control for the position of the female within the household (an indicator for the cultural constraints at the intra-household level). These dummies include whether the female is the head of her household, the wife of the household head, the daughter-in-law of the household head, the unmarried daughter of the household head, and others. We further control for the caste and religion of a household to account for culturally or religiously imposed constraints on women. These constraints are expected to be strongest among upper-caste Hindus and Muslims (Klasen and Pieters 2015; Chen and Drèze 1992; Das and Desai 2003). Finally, at the household level, we also create a dummy variable that accounts for whether a household resides within 2 km of an all-weather road in rural India or within 0.5 km of a public transport facility in urban India.

Furthermore, to control for the difference in urbanization of the local area, we include an indicator S_{ds} to control for the location (urban or rural) of a female. Thus, S_{ds} takes the value 1 if a female belongs to rural India and 2 if she belongs urban areas. Given that access to

[41] We categorize the highest education level attained by a female according to the ISCED-11 classification.

[42] The MIS survey includes 9 different questions on the levels of digital literacy attained by an individual. We create a binary variable which takes the value 1 if the female surveyed has any level of digital literacy and 0 otherwise.

digital infrastructure depends significantly on the creation of necessary infrastructure in an area, we interact the location indicator with the mobile use variable. This will allow us to the isolate the impact of mobile phone use on our outcome variable in rural and urban India. In addition to these controls, we also include the district fixed effects to control for the inter-regional differences within India.

We can estimate Equation (1) by using a standard Probit model. In such a case, females would choose to be in the labor force if the expected net benefits were positive, and thus the probability that a female chooses this outcome is:

$$\text{Prob}[Y_{ihd} = 1\ ] = \text{Prob}[X_{ihd}\alpha + S_d\beta + M_{ihd}\theta + S_d M_{ihd}\gamma + \ \varepsilon_{ihd} > 0]$$

$$= \phi[X_{ihd}\alpha + S_d\beta + M_{ihd}\theta + S_d M_{ihd}\gamma],$$

where $\phi[]$ is the evaluation of the standard normal cumulative distribution function.

Using the Probit Model, we can also estimate average partial effects on the outcome variable of using "j" category of mobile phone as compared to "j-1" category of mobile phone conditioned on the location of the female. Hence, the impact of using a shared mobile phone (j= 2) as compared to no mobile phone ($j = 1$) is termed the 'Digital Access' effect and the impact of using an exclusive mobile phone ($j = 3$) as compared to using a shared phone is termed the 'Digital Inclusion' effect. These effects are estimated in the following manner43:

Digital Access Effect = $\text{Prob}\ [Y_{ihd} = 1 \mid S_d = \text{q}\ , M_{ihd} = 2\ ] - \text{Prob}\ [Y_{ihd} = 1 \mid S_d = \text{q}\ , M_{ihd} = 1\ ]$, for q = 1,2

Digital Inclusion Effect = $\text{Prob}\ [Y_{ihd} = 1 \mid S_d = \text{q}\ , M_{ihd} = 3\ ] - \text{Prob}\ [Y_{ihd} = 1 \mid S_d = \text{q}\ , M_{ihd} = 2\ ]$, for q = 1,2

Additionally, in our analysis we also estimate the impact of Internet with mobile phone. The MIS survey does record the access of household to broadband44 but does not collect this information individually. So, we can only observe the category of mobile use by female and whether her household (any household member) has access to the Internet. This creates six scenarios that can be observed for each female. Thus, we make the strong assumption that if

[43] The general effect for a mobile use category 'j' as compared to the mobile use category 'j-1' will be estimated as $\text{Prob}\ [Y_{ihd} = 1 \mid S_d = \text{q}\ , M_{ihd} = \text{j}\ ] - \text{Prob}\ [Y_{ihd} = 1 \mid S_d = \text{q}\ , M_{ihd} = \text{j} - 1\ ]$, for q = 1,2. For q =1 i.e. rural location, the effect would estimate $\phi\left[X_{ihd}\alpha + \theta_j\right] - \ \phi\left[X_{ihd}\alpha + \ \theta_{(j-1)}\right]$. The same effect for q =2 i.e., urban location will estimate $\phi\left[X_{ihd}\alpha + \beta + \theta_j + \gamma\right]$ - $\phi\left[X_{ihd}\alpha + \beta + \theta_{(j-1)}\right]$.

[44] In the MIS survey, broadband is defined as "technologies that deliver advertised download speeds of at least 256 kbit/s. The main types of broadband services are: i) Fixed (wired) broadband network, such as DSL, cable modem, high speed leased lines, fibre to- the-home/building, powerline and other fixed (wired) broadband; ii) Terrestrial fixed (wireless) broadband network, such as WiMAX, fixed CDMA; iii) Satellite broadband network (via a satellite connection); iv) Mobile broadband network (at least 3G, e.g., UMTS) via a handset and v) Mobile broadband network (at least 3G, e.g. UMTS) via a card (e.g. integrated SIM card in a computer) or USB modem". If any household member has access to the technologies mentioned above, the survey records that household as having access to broadband.

the female resides in a household where any member has access to internet, she can access it as well. We model this by introducing a new binary variable which indicates whether the household (where the female resides) has access to Internet or not and interact this variable with our mobile use explanatory variable.

Our choice problem is described by the following latent variable model:

$Y^*_{ihd} = X_{ihd}\alpha + S_d\beta + M_{ihd}\theta + I_{hd}\partial + S_d M_{ihd}\gamma + S_d I_{hd}\vartheta + I_{hd}M_{ihd}\tau + S_d M_{ihd} I_{hd}\emptyset + \omega_{ihd}$, (2)

where $Y_{ihd} = 1$ if $Y^*_{ihd} > 0$ and $Y_{ihd} = 0$ otherwise. I_{hd} is the binary variable indicating household access to internet. $\omega_{ihd,}$ is a random error.

We can estimate Equation (2) using a Probit Model as explained before[45]. The Average Partial Effects on the outcome variable for a female residing in household with Internet (given her mobile use category) is[46]:

Digital Access Effect = $\{\text{Prob}\,[Y_{ihd} = 1 \mid S_d = \text{q}\,, M_{ihd} = 2\,, I_{hd} = 1\,] - \text{Prob}\,[Y_{ihd} = 1 \mid S_d = \text{q}\,, M_{ihd} = 2, I_{hd} = 0\,]\}$ - $\{\text{Prob}\,[Y_{ihd} = 1 \mid S_d = \text{q}\,, M_{ihd} = 1\,, I_{hd} = 1\,] - \text{Prob}\,[Y_{ihd} = 1 \mid S_d = \text{q}\,, M_{ihd} = 1, I_{hd} = 0\,]\}$, for q = 1,2

Digital Inclusion Effect =$\{\text{Prob}\,[Y_{ihd} = 1 \mid S_d = \text{q}\,, M_{ihd} = 3\,, I_{hd} = 1\,] - \text{Prob}\,[Y_{ihd} = 1 \mid S_d = \text{q}\,, M_{ihd} = 3, I_{hd} = 0\,]\}$ - $\{\text{Prob}\,[Y_{ihd} = 1 \mid S_d = \text{q}\,, M_{ihd} = 2\,, I_{hd} = 1\,] - \text{Prob}\,[Y_{ihd} = 1 \mid S_d = \text{q}\,, M_{ihd} = 2, I_{hd} = 0\,]\}$, for q = 1,2

Similarly, we present another interaction in our estimates for the baseline model [equation (1)]. This interaction conditions the mobile use categories on the female's digital literacy attainment. The binary variable indicating digital literacy attainment is explained before. In this case as well, we estimate the 'Digital Access' and 'Digital Inclusion' as we did for the Internet access variable.

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[45] $\text{Prob}[Y_{ihd} = 1\,] = \text{Prob}[X_{ihd}\alpha + S_d\beta + M_{ihd}\theta + I_{hd}\partial + S_d M_{ihd}\gamma + S_d I_{hd}\vartheta + I_{hd}M_{ihd}\tau + S_d M_{ihd} I_{hd}\emptyset + \omega_{ihd} > 0]$
$= \phi[X_{ihd}\alpha + S_d\beta + M_{ihd}\theta + I_{hd}\partial + S_d M_{ihd}\gamma + S_d I_{hd}\vartheta + I_{hd}M_{ihd}\tau + S_d M_{ihd} I_{hd}\emptyset]$

[46] The general effect of Internet access at home for a mobile use category 'j' as compared to the mobile use category 'j-1' will be estimated as $\{Prob\,[Y_{ihd} = 1 \mid S_d = q\,, M_{ihd} = j\,, I_{hd} = 1\,] - Prob\,[Y_{ihd} = 1 \mid S_d = q\,, M_{ihd} = j\,, I_{hd} = 0\,]\} - \{Prob\,[Y_{ihd} = 1 \mid S_d = q\,, M_{ihd} = j-1\,, I_{hd} = 1\,] - Prob\,[Y_{ihd} = 1 \mid S_d = q\,, M_{ihd} = j-1, I_{hd} = 0\,]\}, for\ q = 1,2$. For q =1 i.e., rural location, the effect would estimate $\{\phi[X_{ihd}\alpha + \theta_j + \partial + \tau] - \phi[X_{ihd}\alpha + \theta_j]\} - \{\phi[X_{ihd}\alpha + \theta_{(j-1)} + \partial\,] - \phi[X_{ihd}\alpha + \theta_{(j-1)}\,]\}$. For q = 2 i.e., urban location, the effect would estimate $\{\phi[X_{ihd}\alpha + \beta + \theta_j + \partial + \gamma + \vartheta + \tau + \emptyset] - \phi[X_{ihd}\alpha + \beta + \theta_j + \gamma]\} - \{\phi[X_{ihd}\alpha + \beta + \theta_{(j-1)} + \partial + \vartheta\,] - \phi[X_{ihd}\alpha + \beta + \theta_{(j-1)}]\}$.

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