Zagreb International Review of Economics & Business, Vol. 29, No. 1, pp. 115-139, 2026

Faculty of Economics and Business, University of Zagreb and Sciendo. Printed in Croatia.
ISSN 1331-5609; UDC: 33+65
DOI: 10.2478/zireb-2026-0006

Digital Exclusion in Pakistan: A Gendered Analysis

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Abstract: *Advancements in information and communication technology (ICT) have significantly impacted crucial sectors of society, including transport, health, business, education, and communication, in both developed and developing countries. However, internet access has spread unevenly worldwide, resulting in a global digital divide. This study aims to identify the socio-economic and demographic factors contributing to the pervasive digital exclusion of the Pakistani populace. It also explores digital exclusion from a gendered perspective, considering both internet and device exclusion. Results from logistic regression analysis on data from the Pakistan Social and Living Standards Measurement (2019-2020) Survey reveal that education reduces digital exclusion regardless of gender. Employment and increased income also reduce digital exclusion, but these effects are more pronounced among the male population. The study recommends the conduct of digital literacy programs for both males and females and job opportunities for females in the tech sector.*

Keywords: Digital exclusion; gendered digital disparities; Household level data; PSLM

JEL Classification: D10, J16

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Introduction

Information and communication technologies (ICTs) are now integral to contemporary societies, penetrating every aspect of daily life. They have revolutionized the methods of work, communication, consumption, education, entertainment, and access to information and public services. Internet World Stats estimates that between 2000 and 2020, the global number of internet users increased by 1266%. Even though their impact spans all facets of life, access to and utilization of these technologies are unevenly distributed. This is evident from the fact that only 40 percent of people worldwide had internet connectivity in 2020, manifesting pervasive digital exclusion (Shah and Krishnan, 2023; Acilar and Saebo, 2021).

With digital technologies becoming the central ingredient of economic development in the contemporary world, those who are partially or completely excluded are falling further behind. In this context, digital exclusion intersects with other inequalities, particularly gender inequality, exacerbating disparities in labor markets and obstructing financial inclusion for women (Mariscal, 2019). Consequently, women who are digitally excluded may remain deprived of more attractive and lucrative employment opportunities due to a lack of digital literacy, a highly demanded skill in the current digital age. This exclusion may also hinder their ability to find fairly paid jobs, as job search markets are increasingly digital, with many employers preferring to hire through online platforms. Women without access to these platforms risk receiving significantly lower wages than the current market rates for their work. Therefore, the inability to access and use digital technologies is likely to widen the gender pay gap even further.

Similarly, digital exclusion hinders financial inclusion in the contemporary era of revolutionary financial technologies. New financial technologies utilize computer algorithms to analyze customer data from digital transaction records to determine loan eligibility. Digitally excluded women lack this crucial asset, making them appear riskier and less trustworthy to financial capital providers and obstructing them from availing vast opportunities for economic independence and growth.

Initially, digitalization was anticipated to benefit women, particularly in the labor market, as they were thought to face lower risks of being replaced by automated systems (Simonton, 2007; Larson and Viitaoja, 2019; Hanrahan and Evlin, 2017). This expectation stemmed from the nature of their roles, which often demand interpersonal, creative, and social skills (Hanrahan and Evlin, 2017). Furthermore, digitalization was expected to enhance workplace flexibility (Ang et al., 2018), which is vital for women balancing paid work with other responsibilities like caregiving for children, the elderly, and managing household tasks (OECD, 2025). Additionally, digital transformation was projected to boost job opportunities in female-dominated sectors such as education, social services, health, and business services (Ye and Cai, 2024).

Nonetheless, the findings from various studies highlight that the gender digital divide is a pervasive problem that transcends various socio-economic and geographic boundaries. This means that even in countries with high levels of ICT access and strong economic performance, women still face significant barriers to fully participating in the digital world, as depicted by the low level of utilization of the internet among women in Least Developed Countries amounted to a mere 19 percent. Along with higher exclusion, the usage patterns of the internet among men and women are quite distinctive, with a lower likelihood of women having digital technology-related skills and occupations than males, leading to less productive use of digital technology (UNICEF, 2021).

South Asia experiences the largest gender digital divide, with notable disparities in mobile phone ownership and mobile Internet usage. Pakistan, in particular, highlights the severity of this issue, as 54 percent of the population lacks Internet access due to inadequate digital infrastructure and affordability challenges (UNDP, 2024). Though Pakistan's Digital Development Index (DDI) places the country in the 'moderate' digital development category with a cumulative DDI of 0.205 (NHDR, 2024), women's digital exclusion is substantial in Pakistan. In Pakistan, only 26 percent of women have internet access, compared to 47 percent of men. Globally, around 52 percent of women are offline compared to 44 percent of men (ITU, 2020). Women in Pakistan are 48 percent less likely to own a mobile phone than men, whereas in other developing countries, women are 7 percent less likely to own a mobile phone and 18 percent less likely to own a smartphone. Women are 49 percent less likely to use mobile internet compared to men in Pakistan. The gap is even more pronounced for advanced devices like personal computers and laptops (ITU, 2022).

Looking at provincial statistics from Pakistan Standards of Living Measurement Survey (PSLM) 2019-20, Punjab province shows an average score of 5.1 out of 10, and in Punjab, only one district lies in the excellent category for access to IT (information technology) facilities, 30 fall in the poor category, and 5 districts fall in the very poor category. The ICT average score of Sindh province is 4.71. In Sindh, 23 districts fall in the very poor category, and immediate interventions are required for the provision of IT (information technology) services. The total average score of KPK province is 5.09. In KPK, 20 districts lie in the above average category and 12 fall in the below average category. The total score of Baluchistan province is 4.49. In Baluchistan, 15 districts are ranked below average and 13 are above average.

Considering the importance of narrowing of digital divide to achieve high human development and gender equality, this study aims to achieve three objectives: (1) to identify the socio-economic and demographic determinants of digital exclusion among Pakistani population (2) to analyze gender based differences in digital exclusion (3) to examine the digital exclusion in terms of access to internet and ownership and usage of devices. The study endeavors to achieve these objectives using the Pakistan Social and Living Standards Measurement Survey (2019–2020), which includes a section on ICT indicators.

In Pakistan, research on the factors contributing to persistent digital exclusion is still in its early stages. Recent studies by Shair et al. (2023), Amber and Chichaibelu (2023), and Jamil (2021) have made notable contributions, although they examined the issue from the perspective of the digital divide, which inherently considers the factors influencing digital inclusion. While the concept of digital inclusion and exclusion appears highly interconnected, a fundamental difference persists. Digital inclusion research tends to be more proactive, seeking solutions to enhance access and usage, whereas digital exclusion research is often more diagnostic, identifying and understanding the barriers and consequences of being left out of the digital world. We believe our study adds to the literature by identifying these barriers from both gendered and non-gendered perspectives. Additionally, existing research primarily focuses on internet and mobile inclusion, while the inclusion of advanced technologies is largely overlooked. It is crucial to include advanced technologies in the analysis of digital exclusion, as these technologies ensure access to highly productive job opportunities and their exclusion hinders human development both at individual and national levels.

The remainder of the study is organized as follows. Section 2 contains a literature review. In section 3, the methodology for operationalization of the study's objective is stated. Section 4 presents results and discussion, and Section 5 concludes the paper.

Review of Literature

Digital technology serves as a catalyst for improving the education, health, and well-being of individuals, while also fostering growth across agriculture, industrial, services, and social sectors thus ensuring sustainable development (UNDP, 2023). Beyond its role in education and learning, it facilitates civic participation and employment opportunities (Selwyn, 2010). At a broader level, digital inclusion is essential for economic development, educational achievement, labor market engagement, and improved health outcomes, extending even to transport services (Durand et al., 2021).

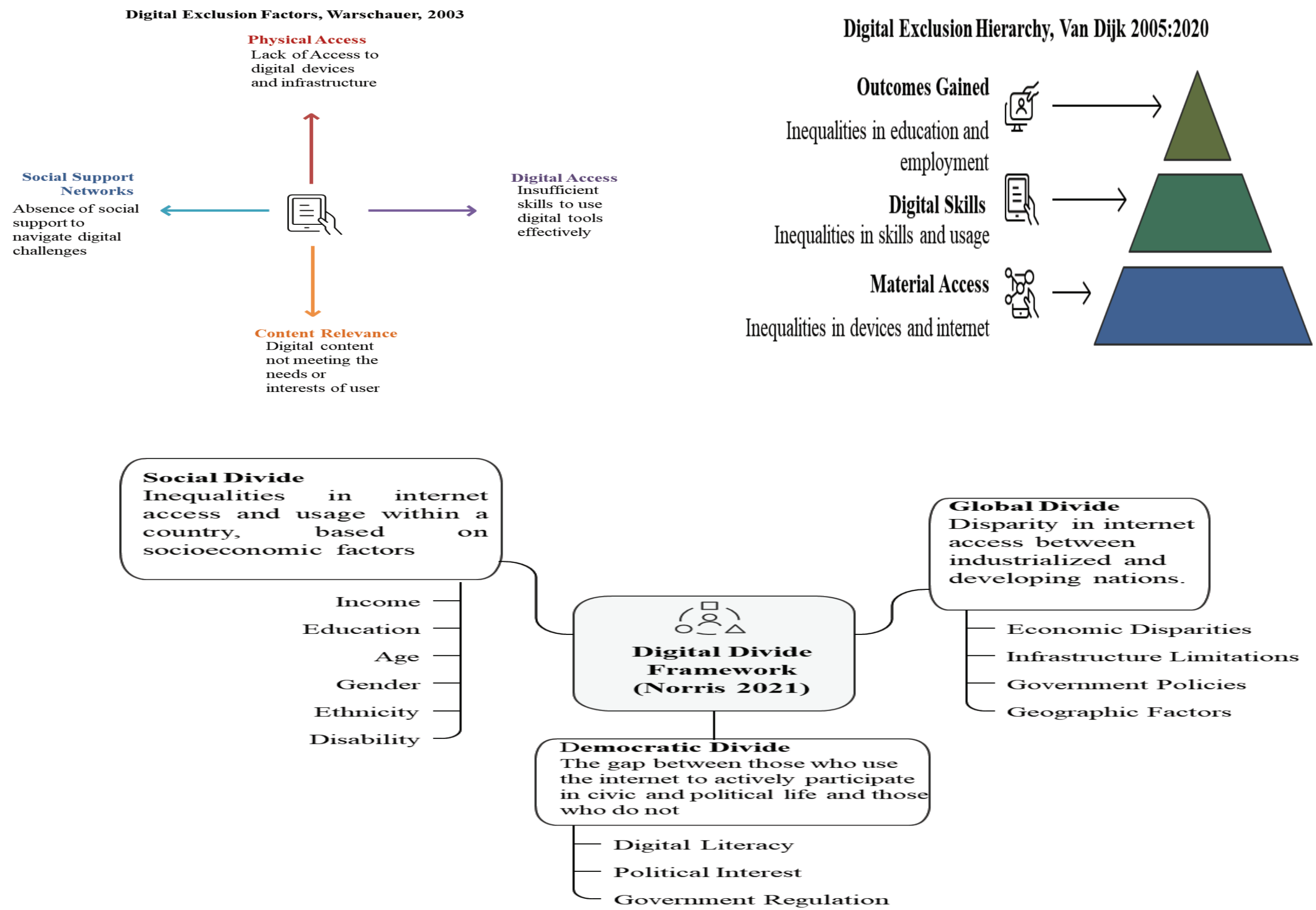
Conversely, digital exclusion is a multifaceted and complex problem with deep social and economic implications, particularly evident in the post-COVID-19 era (Saba et al., 2021). Persistent digital inequalities, specifically in higher education (Selwyn, 2010) and also their negative impact on healthcare delivery (Mee et al., 2025), are a critical concern. Tomczyńska (2017) and Saba et al. (2021) reasoned that digital exclusion contributes to social exclusion, which resultantly reduces the happiness and well-being of the population. Individuals who are digitally excluded often lack the motivation and skills necessary to improve their qualifications (Frączkiewicz-Wronka, 2023) and are less likely to engage in political processes because of limited awareness and civil participation. In other words, digital development is closely tied to economic development (Heidi, 2020).

Theoretical literature utilizes three theoretical frameworks to understand the phenomenon of digital exclusion, namely, the Digital Divide Framework (Norris, 2003), the Stages of Access Model (Van Dijk, 2005), and the Three-Level Digital Divide Perspective. *The Digital Divide Framework* (Norris, 2003) emphasizes that digital exclusion is multifaceted, extending beyond physical infrastructure gaps. It highlights the interplay between physical access, digital access, content relevance, and social support networks. According to Norris, these dimensions are shaped by broader social structures, including income, education, and institutional capacity, that either facilitate or restrict digital inclusion. Complementing this, Van Dijk's (2005) *Stages of Access Model* conceptualizes digital exclusion as a sequential process involving (1) material access (availability of devices and connectivity), (2) skills access (digital literacy and competencies), and (3) usage access (effective utilization of digital tools for economic, educational, and social purposes). Meanwhile, the *Three-Level Digital Divide Approach* differentiates between inequalities in access, capabilities, and outcomes, highlighting that even among those who are digitally connected, disparities persist in how digital resources are used and what benefits they generate. This framework is particularly relevant for developing countries like Pakistan, where the expansion of connectivity has not automatically translated into equitable digital empowerment. These are collectively explained in Figure 1.

A review of existing literature reveals that digital exclusion is a multidimensional phenomenon influenced by various socio-economic, demographic, and contextual factors across countries. Park et al. (2015) examined multiple layers of digital exclusion in rural Australia. The first layer of the digital exclusion is inadequate infrastructure, while the second layer is related to broadband and internet adoption issues, and the third layer of the digital exclusion is lower digital engagement. Like other developed nations, Australia is also moving towards a digitalized society. But in the rural areas, digital exclusion arises due to a lack of infrastructure, education, and density. A study conducted in the United States (Powell et al., 2010) highlighted that low income, limited education, and lack of awareness about advanced technologies hinder digital participation, specifically, among low-income households. Extending this evidence to developing countires, Zia et al. (2009) in their research for Asian countries, namely, Bangladesh, Pakistan, Yemen, and China, identified poverty, high costs, and low digital skills as key barriers to digital inclusion. According to Mumporeze and Prieler (2017) women in rural areas of Rwanda face greater digital exclusion due to poor infrastructure and lack of basic technological skills. Correspondingly, Bala and Singhal (2018) attribute gender gender-based digital divide in India to social norms and financial constraints. A detailed review in this regard is furnished by Acilar and Sæbø (2023).

Parallel investigations in Europe have yielded different insights emphasizing the socioeconomic and regional dimensions of digital exclusion. Robles et al. (2012) and Serrano-Cinca et al. (2018) concluded that income, gender, education, region, and

Figure 1: Theoretical Framework of Digital Exclusion



employment as major determinants of digital exclusion in Spain. On the other hand, Črnič (2013) is of the view that cultural barriers and social inequalities increased digital exclusion in Slovenia. Elena-Bucea et al. (2020) assessed the digital divide between and within 28 EU member countries and found that education is the key determinant of e-service adoption, while social network adoption is affected by individual's age. On the contrary, Picatoste et al. (2022) and Galperin and Arcidiacono (2020), in their separate studies, highlighted employment patterns and labor force participation as the key factors in the gender digital divide for the EU and Latin American countries, respectively.

Some further studies have specifically focused on age-related digital exclusion. Formosa (2013) and Seifert et al. (2018) have shown that older adults in Malta and Switzerland, respectively, are less likely to use digital technologies due to low interest, lack of skills, and anxiety, though those who do engage report improved lifestyles and higher self-esteem and productivity. Gallistl et al. (2020) further demonstrated that older women in rural Austria with poor health and low education face the greatest risk of exclusion. Collectively, these studies underscore that digital exclusion is shaped by intersecting factors, including economic status, education, age, geographic location, and gender.

The digital gender gap is a critical issue since it is believed to increase gender inequalities in health, education, and income (Musizvingoza and Handforth, 2021; Jamil, 2021) with critical implications for sustainable development. While examining the constraints, drivers, and patterns of internet use in females in Nigeria, Adeleke et al. (2021) opined that digital technologies have promoted entrepreneurship, social well-being, and innovation, but the gender digital gap also persists. Here again, females are digitally excluded because of either being in rural areas or due to either high cost, low education, or low level of income. Besides these economic and social disparities, broader cultural and social factors also restrict women's safe and equitable engagement in the digital sphere in developing countries, as shown by Antonio and Tuffley (2014).

Existing empirical research on digital exclusion in Pakistan emphasized its complex and multidimensional nature, determined by socio-economic, demographic, educational, and institutional factors, and especially socio-cultural norms. Several studies (Amber and Chichaibelu, 2023; Shokat et al., 2018; Ahmad et al., 2018; Khalafzai et al., 2011) have investigated the gender dimension of digital exclusion in Pakistan. A few of these have underscored the significance of digital technologies in women's empowerment through better education, labor force participation and social participation. However, gender disparities are persistent, particularly in rural areas. Women's digital participation is hampered by low literacy, unemployment, limited access to digital devices, and restrictive socio-cultural norms. However, Shokat et al. (2018) have confirmed a gradual narrowing of the digital gap among youth and educated women in the AJ&K region.

Besides, a considerable body of literature focuses on the role of digital technologies in Pakistan's education sector. Studies conducted among teachers and students, such as Jan et al. (2020); Ali et al. (2015); Soomro (2020); Sabqat et al. (2019); Khalil (2020), together confirm that access to and effective use of digital tools enhance teaching quality, learning outcomes, and knowledge acquisition. However, digital illiteracy, poor infrastructure, slow internet connectivity and unequal access to digital resources limit the potential benefits of technology-based learning, specifically in rural areas and public sector institutions.

At the national level, digital exclusion is reinforced by structural challenges such as political instability, weak law and order situation, and economic constraints with resultant poor IT infrastructure (Kundi et al., 2008). Additionally, affordability issues, lack of digital skills, language barriers, and regional inequalities are major obstacles to inclusive digitalization (Jan et al., 2020; Khalid et al., 2016; Zia et al., 2009; Ahmad et al., 2018). Moreover, these digital inequalities have broader socio-economic consequences. Shair et al. (2023) and Jamil (2021) are of the view that in Pakistan, widening digital inequalities are causing different social inequalities, which undermine democratic engagement. Recently, Rahman et al. (2021) showed that access and usage of digital technologies improve subjective well-being and economic outcomes; however, disparities do exist based on gender, marital status, and employment status.

Empirical evidence from diverse contexts reveal that structural and socio-economic disparities explain digital inequalities in both developing and developed countries. However, in developing countries, the digital barriers are augmented by inadequate infrastructure, socio-cultural norms and low digital literacy. A critical aspect in this regard is gender based digital divide which further leads to gender inequalities in health, education, income and empowerment. In Pakistan also, there is lack of inclusive digital participation particularly for women and in rural areas owing to literacy gaps, infrastructure deficits, economic constraints and socio-cultural barriers. Despite extensive literature on digital exclusion globally, empirical studies on gender based digital exclusion for Pakistan are limited and fragmented. Most of the existing studies focus on digital divide in education or general disparities in access to digital infrastructure. There is lack of empirical literature on socio-economic determinants of digital exclusion at household level which necessitates the need for a comprehensive study on determinants of digital exclusion in general and gender based analysis in particular for Pakistan.

Methodology and Data

The study aims at analyzing the incidence of digital exclusion in Pakistan and estimate the impact of gender and other determinants on digital exclusion. Digital exclusion is captured through three different dimensions, namely, internet, mobile, and desktop computers/laptops. The regression equation takes the following form:

$$Y_{ij} = \alpha_i + \sum_{k=1}^{r} \beta_k X_{ij} + \varepsilon_{ij}$$

Y_{ij} is the dependent variable with 'jth' type of exclusion (for digital, mobile, desktop computers/laptop, internet)[1], for individual 'i' having age greater than or equal to 10. X is showing independent variables such as gender, age, education (in completed years), marital status, region as rural or urban, income, and employment status. The dependent variable is dummy defined as: Y_{i2}=have you used mobile (1=No), Y_{i3}= have you used desktop (1=No), and Y_{i4}=have you used the internet (1=No). Finally, an index of digital exclusion is also used as a dependent variable based on mobile, internet, and computer (Y_{i1}=ranging from 0 to 3, where 0 indicates no exclusion and 3 indicates exclusion in all three categories). Table 1 describes different variables. The data source is the PSLM Survey for the year 2019-20.

Because of the dichotomous nature of the dependent variable (use of mobile, desktop, and computer), the logistic regression technique is used. While the variable of the index of digital exclusion encompasses all, mobile, laptop, and internet, it is ordered in nature. Therefore, the ordered logistic regression technique is utilized for the analysis.

Descriptive statistics of independent and dependent variables of the model are presented in Tables 2 and 3. According to Table 2, the total number of observations is 613,046, out of which 31.2% of the respondents have not used a mobile phone. Similarly, 94.3% of the respondents have not used a computer/laptop, and only 5.7% of the respondents are digitally included in this category. As far as internet exclusion is concerned, 86.8% of the respondents are digitally excluded from the internet. Among the total sample, 51.4% of the respondents are male and 48.6% are female. As far as marital status is concerned, 43.4% are married and 56.6% are unmarried respondents. Region is also an independent variable, which reveals that 29.3% respondents are from rural areas and 70.7% respondents are from urban areas. The location variable includes four provinces such as KPK, Punjab, Sindh, and Baluchistan. A major portion of the respondents are from Punjab, which is nearly 48.8%. KPK province contributes 21.2% of the respondents. There are 20.3% respondents from Sindh province, and Baluchistan province is contributing 9.7% of the sample.

Table 1: Description of Variables

Variable	Variable Definition
Y_{i1}	Ordered variable of Digital exclusion (0 to 3, where 0 indicates use of all three, mobile, computer, and internet, and 3 indicates use of none of the three)
Y_{i2}	Have you used mobile (0=Yes, 1=No)
Y_{i3}	Have you used a desktop computer/laptop (0=Yes, 1=No)
Y_{i4}	Have you used the internet (0=Yes, 1=No)
Age	In years
Education	Completed years of schooling
D_1 (dummy for gender)	Dummy variable, 1=Male, 0=Female
D_2 (dummy for region)	Dummy variable, 1=Urban, 0=Rural
D_3 (dummy for marital status)	Dummy variable, 1=Married, 0=Unmarried
D_4 (dummy for employment status)	Dummy variable, 1=employed, 0=unemployed
D_5 (dummy for Punjab)	Dummy variable, 1=Punjab, 0=otherwise
D_6 (dummy for Sindh)	Dummy variable, 1=Sindh, 0=otherwise
D_7 (dummy for KPK)	Dummy variable, 1=KPK, 0=otherwise
Income (in rupees)	Total from all sources

Table 2 reports descriptive statistics of some of the independent variables. For the variable 'age' mean value is approximately 24, while the minimum age of a respondent is 11 and the maximum age is 99. For the variable education, the mean value is 4, whereas the maximum education is 21, and the minimum education is zero. The variable household per capita income is measured by aggregating household income from all sources and dividing it by the number of household members. Household per capita income is measured in thousands. According to Table 3, the mean value of household income is 84.2 thousand, whereas the minimum income is 0, and the maximum income is 10,600 thousand.

Table 2: Frequency Distribution of Dependent and Independent variables

Y_1 (Digital)		
Category	Frequency	Percentage
0	30,897	5.0
1	86,223	14.1
2	419,745	68.5
3	76,181	12.4
Total	613,046	100
Y_2 (mobile)		
Inclusion	530,884	86.6
Exclusion	82,162	13.4
Total	613,046	100
Y_3 (computer/laptop)		
Inclusion	46,463	7.6

Exclusion	566,583	92.4
Total	613,046	100
Y_4 (internet)		
Inclusion	107,535	17.5
Exclusion	505,511	82.5
Total	613,046	100
D_1		
Male	311,654	50.8
Female	301,392	49.2
Total	613,046	100
D_2		
Rural	423,100	69.02
Urban	189,946	30.98
Total	613,046	100
D_3		
Married	380,341	62.04
Unmarried	232,705	37.96
Total	613,046	100
D_4		
Working	233,161	38.0
Not working	379,885	62.0
Total	613,046	
Province		
Punjab	307,325	50.1
Sindh	123,296	20.1
KPK	125,373	20.5
Baluchistan	57,052	9.3
Total	613,046	100

Table 3: Descriptive Statistics

Variables	Observation	Mean	Standard Deviation	Min	Max
Age (in years)	613,046	32.2	16.4	11	99
Education (in years)	613,046	3.5	4.8	0	21
Household per capita income (in 000 rupees)	613,046	84.2	144.2	0	10,600

Results and Discussions

Baseline Model

For causal analysis of determinants of digital exclusion, an ordered logistic model is estimated. Table 4 presents empirical results for digital exclusion. To begin with gender comparisons, Table 4 reveals that the incidence of digital exclusion is higher for females than males, and the coefficient is significant at 1% level of significance. Empirical results confirm a gender based digital divide in Pakistan. The log-odds of digital exclusion is lower for male individuals by 0.339, and marginal effects show that the probability of digital exclusion is lower for male individuals by 0.021. Musizvingoza and Handforth (2021) argued that in Pakistan, there is a gender based digital divide owing to the lack of digital skills of women. In developing countries like Pakistan, women use digital devices less frequently as compared to men due to cultural bias, gender disparities, limited free time, financial constraints, and gender inequalities (Antonio and Tuffley, 2014). Mushtaque et al., (2022) are of the view that in Pakistan, men are better users of digital technology compared to women. Given the gender-based difference in results, the equation is separately estimated for the male and the female samples, too.

Results for the variable of age and age square show a U-shaped relation between age and digital exclusion. Results show that a one-year increase in individual age reduces the log-odds of digital exclusion by 0.163 and the likelihood of digital exclusion by 0.01. The coefficient is significant at the one percent level of significance. Seifert (2020) is of the view that young people use digital technology more frequently because they can learn advanced digital skills promptly, and the digital use intensity increases with age. Similarly, people at an older age (above 80 years) are usually digitally excluded due to a lack of adaptability to advanced technology (Zhou et al., 2020). Therefore, age effects correspond to medium-related skills, usage diversity, and content-related skills (Van Deursen et al., 2015). Results further show that the impact is higher for females as compared to males. One additional year of age of a male individual decreases digital exclusion by 0.132, while the coefficient size is 0.174 for females.

Table 4: Determinants of Digital Exclusion

	Full sample		Male Sample		Female Sample	
Variables	Coefficient	Marginal effects	Coefficient	Marginal effects	Coefficient	Marginal effects
Age	-0.163*** (-130.30)	-0.0101*** (112.8)	-0.132*** (-75.8)	-0.006*** (-66.5)	-0.174*** (-95.4)	-0.014*** (-88.5)
Age^2	0.002*** (131.1)	0.0001*** (-113.3)	0.002*** (78.4)	0.0001*** (68.9)	0.002*** (93.0)	0.0002*** (86.6)
Education	-0.215*** (-274.6)	-0.0134*** (157.26)	-0.223*** (-215.6)	-0.0106*** (-152.3)	-0.22*** (-180.0)	-0.018*** (-177.1)
Hhpci	-0.486*** (-121.1)	-0.030*** (102.7)	**-0.521*** (-91.8)**	-0.025*** (-83.0)	**-0.417*** (-71.9)**	-0.034*** (-70.2)
D_1 (gender)	-0.339*** (-40.0)	-0.021*** (38.6)	-	-	-	-
D_2 (region)	**-0.369*** (-52.2)**	-0.022*** (46.8)	-0.449*** (-47.6)	-0.02*** (-49.3)	-0.293*** (-27.2)	-0.023*** (-28.4)

Variables	Full sample		Male Sample		Female Sample	
	Coefficient	Marginal effects	Coefficient	Marginal effects	Coefficient	Marginal effects
D_3 (marital status)	-0.065*** (-6.4)	-0.004*** (6.3)	-0.291*** (-21.2)	-0.014*** (-21.3)	0.263*** (16.5)	0.022*** (15.7)
D_4 (employment status)	-0.076*** (-9.3)	-0.005*** (9.3)	-0.266*** (-23.5)	-0.013*** (-22.04)	-0.176*** (-14.5)	-0.014*** (-15.3)
D_5 (Punjab)	-0.105*** (-9.2)	-0.006*** (8.90)	-0.164*** (-10.5)	-0.007*** (-11.01)	-0.034*** (-2.01)	-0.003** (-2.03)
D_6 (Sindh)	-0.095*** (-9.3)	-0.006*** (9.3)	-0.076*** (-5.6)	-0.004*** (-5.6)	-0.128*** (-8.1)	-0.01*** (-8.08)
D_7 (KPK)	-0.026** (-2.2)	-0.002** (2.2)	-0.029* (-1.87)	-0.001* (-1.89)	-0.014 (-0.8)	-0.001 (-0.83)
No. of obs.	598,338		304,398		293,940	
Pseudo R^2	0.1946***		0.1922***		0.1880***	
Note: ***, ** and * represents 1%, 5% & 10% level of significant. z-statistics are reported in parentheses.						

The next variable is education, and as per expectations, the coefficient is negative and significant, implying that 1 additional year of education reduces the log-odds of digital exclusion by 0.215. Marginal effects indicate that one additional year of an individual's education reduces the probability of digital exclusion by 0.0134. The coefficient is significant at the one percent level of significance. Higher education levels of individuals boost their digital skills (Shair et al., 2023). Shahzad (2024) also indicated that digital exclusion increases in a country having education inequalities. Many other studies have confirmed a positive relationship between digital inclusion and an individual's education level (Van Deursen and Helsper, 2017; Van Deursen & Van Dijk, 2015; Serrano et al., 2018). Results in Table 4 also show that one additional year increase in education for male individuals reduces the log-odds of digital exclusion by 0.223, while for females, this coefficient is also 0.22.

Household's per capita income is taken as an indicator of the financial status of an individual to determine the accessibility to these digital devices. According to the results in Table 4, a unit increase in household per capita income decreases the log-odds of digital exclusion by 0.486. The marginal effect shows that a 1 unit increase in per capita income of household decreases the probability of digital exclusion by 0.03. Different studies have confirmed the existence of digital exclusion in low-income households (Powell et al., 2010; Shair et al., 2023). The coefficient size for the male sample is 0.521 compared to 0.417 for the female sample.

Regional comparisons for digital exclusion on the basis of rural-urban categorizations are gauged through the dummy (D_2) whose significant and negative coefficient in Table 4 shows that the log-odd ratio of digital exclusion in urban households is 0.369 less than in rural households, and the marginal effects reveal that the probability of digital exclusion is lower for urban households by 0.022. Thus, there not only exists gender based digital divide but also regional dispersion in Pakistan. Urban households have better access to advanced technology and quality network coverage than rural households due to advanced digital infrastructure and higher purchasing power (Ahmad et al., 2018; Zia et al., 2009). Further, the Table shows that the log-odds of digital exclusion in male individuals of urban households is 0.449 less than that in rural households, and for females, the coefficient size is 0.293. Alternatively, the probability of digital exclusion in male individuals of urban households is 0.02 less than in male individuals of rural households, while for female individuals, the likelihood of digital exclusion in urban households is 0.023 less than that of rural households.

The result of D_3 in Table 4 further explains that the log-odds of digital exclusion in married individuals is 0.065 less than in unmarried individuals. The probability of digital exclusion in married individuals is lower by 0.004 as compared to unmarried individuals. However, the log-odds of digital exclusion in male married individuals is 0.291 less than in male unmarried individuals, while for the female sample, the result is opposite. Log-odds of digital exclusion are higher in unmarried females by 0.263 as compared to the married ones. The study by Duplaga (2017) showed that married people use digital devices more frequently as compared to unmarried people.

D_4 (1=employed, 0=unemployed) in Table 4 shows the relationship between employment status and digital exclusion, indicating that the log-odds of digital exclusion in employed individuals is 0.076 less than in unemployed individuals. Campose et al. (2017) also confirmed that access to digital devices is higher among employed individuals as compared to the unemployed ones. Results of gender-based regressions show that the coefficient value for the male sample is 0.266, while for the females it is 0.176. Employment status has a larger impact on digital exclusion for males as compared to females. This might be due to the reason that employment opportunities availed to females require digital skills only marginally.

Results for provincial comparisons show that the log-odds of digital exclusion is highest in Baluchistan. As compared to Baluchistan, the log-odds of digital exclusion in Punjab is lower by 0.105, while in Sindh it is lower by 0.095. Log-odds of digital exclusion is lower in KPK by 0.026 relative to Baluchistan. As far as marginal effects for these provincial dummies are concerned, the probability of digital exclusion is lower for individuals in Punjab and Sindh by 0.006 each compared to Balochistan. However, this coefficient is 0.002 for KPK. It is worth noting that the coefficient size of the dummy for Punjab is higher for males as compared to female individuals in Table 4, while it is opposite for Sindh, in which the coefficient for the female sample is much higher than that of males.

After presenting the results for digital exclusion, Tables 5, 6, and 7 present results for determinants of mobile exclusion, computer exclusion, and internet exclusion, respectively.

Table 5: Determinants of Mobile Exclusion

	Full sample		Male Sample		Female Sample	
Variables	Coefficient	Marginal effects	Coefficient	Marginal effects	Coefficient	Marginal effects
Age	-0.183*** (-113.21)	-0.013*** (-106.43)	-0.129*** (-55.34)	-0.006*** (-52.12)	-0.210*** (-94.69)	-0.019*** (-92.32)
Age²	0.002*** (115.13)	0.0001*** (108.09)	0.001*** (53.99)	0.0001*** (50.74)	0.002*** (94.49)	0.0002*** (92.14)
Education	-0.132*** (-108.14)	-0.009*** (-112.87)	-0.170*** (-94.53)	-0.008*** (-100.00)	-0.107*** (-64.78)	-0.010*** (-66.49)
Hhpci	-0.244*** (-43.96)	-0.017*** (-43.52)	-0.217*** (-25.45)	-0.011*** (-25.16)	-0.233*** (-31.50)	-0.022*** (-31.46)
D_1	-0.220*** (-20.52)	-0.016*** (-20.41)	-	-	-	-
D_2	-0.103*** (-9.85)	-0.007*** (-10.00)	-0.122*** (-7.75)	-0.006*** (-7.88)	-0.111*** (-7.73)	-0.010*** (-7.85)
D_3	0.637*** (38.37)	0.049*** (35.94)	0.281*** (10.23)	0.015*** (10.05)	**0.626***** (29.28)	0.065*** (26.85)
D_4	**-0.638***** (-48.98)	-0.043*** (-52.95)	**-1.296***** (-69.42)	-0.082*** (-58.57)	-0.099*** (-4.75)	-0.009*** (-4.90)
D_5 (Punjab)	0.033*** (2.12)	0.0024*** (2.11)	0.083*** (3.50)	0.004*** (3.43)	-0.024** (-1.12)	-0.002*** (-1.13)
D_6 (Sindh)	-0.108*** (-7.27)	-0.008*** (-7.25)	-0.05*** (-2.27)	-0.0026*** (-2.27)	-0.227*** (-10.89)	-0.021*** (-10.83)
D_7 (KPK)	0.125*** (7.41)	0.0092*** (7.17)	0.149*** (5.89)	0.008*** (5.65)	0.078*** (3.38)	0.007*** (93.32)
Pseudo R^2	0.1996***		0.2184***		0.1885***	
Note: ***, ** and * represents 1%, 5% & 10% level of significant.						

Table 6: Determinants of Computer Exclusion

	Full sample		Male Sample		Female Sample	
Variables	Coefficient	Marginal effects	Coefficient	Marginal effects	Coefficient	Marginal effects
Age	-0.037*** (-12.88)	-0.007*** (-11.87)	-0.077*** (-17.48)	-0.002*** (-15.23)	-0.015*** (-3.12)	-.0002*** (-3.05)
Age²	.0005*** (15.55)	0.000*** (14.15)	0.001*** (21.11)	0.000*** (17.93)	0.000*** (2.88)	2.42*** (2.83)
Education	-0.330*** (-127.16)	-0.006*** (-102.98)	-0.336*** (-90.23)	-0.009*** (-101.79)	-0.309*** (-84.46)	-0.004*** (-60.35)
Hhpci	-0.407*** (-52.60)	-0.008*** (-41.18)	-0.471*** (-45.82)	-0.012*** (-35.69)	-0.360*** (-28.62)	-0.005*** (-24.14)
D_1	-0.508*** (-34.73)	-0.009*** (-30.07)	-	-	-	-
D_2	-0.409*** (-35.07)	-0.008*** (-29.17)	-0.473*** (-31.22)	-0.013*** (-25.93)	-0.343*** (-18.06)	-0.005*** (-15.48)
D_3	-0.382*** (-21.52)	-0.008*** (-18.70)	0.015*** (0.59)	0.0004*** (0.59)	-0.593*** (-21.93)	-0.009*** (-16.79)

	Full sample		Male Sample		Female Sample	
Variables	Coefficient	Marginal effects	Coefficient	Marginal effects	Coefficient	Marginal effects
D_4	0.483*** (30.74)	0.009*** (25.74)	0.056 (44.22)	0.033*** (27.00)	-0.483*** (-21.45)	-0.008*** (-17.45)
D_5 (Punjab)	**-0.699***** (-24.53)	-0.016*** (-19.67)	**-0.780***** (-23.29)	-0.026*** (-18.30)	**-0.508***** (-8.63)	-0.008*** (-7.46)
D_6 (Sindh)	-0.532*** (-19.70)	-0.010*** (-19.07)	-0.578*** (-18.18)	-0.015*** (-17.61)	-0.438*** (-7.84)	-0.006*** (-7.74)
D_7 (KPK)	-0.133*** (-4.63)	-0.002*** (-4.46)	-0.228*** (-6.69)	-0.006*** (-6.28)	0.038** (0.65)	0.0005** (0.66)
Pseudo R^2	0.3226***		0.3175***		0.3313***	
Note: ***, ** and * represents 1%, 5% & 10% level of significant.						

Table 7: Determinants of Internet Exclusion

	Full sample		Male Sample		Female Sample	
Variables	Coefficient	Marginal effects	Coefficient	Marginal effects	Coefficient	Marginal effects
Age	-0.086*** (-40.22)	-0.007*** (-41.06)	-0.103*** (-35.60)	-0.013*** (-36.59)	-0.027*** (-8.40)	-0.001*** (-8.42)
Age^2	0.001*** (48.09)	0.0001*** (49.89)	0.002 *** (42.84)	0.0001*** (44.81)	0.0004*** (10.85)	0.000*** (10.91)
Education	-0.221*** (-219.4)	-0.018*** (-200.98)	-0.227*** (-163.75)	-0.027*** (-167.67)	-0.224*** (-141.6)	-0.012*** (-113.66)
Hhpci	**-0.721***** (-114.7)	-0.060*** (-113.85)	**-0.701***** (-87.99)	-0.085*** (-88.45)	**-0.723***** (-69.66)	-0.039*** (-70.59)
D_1	-0.606*** (-56.81)	-0.051*** (-57.55)	-	-	-	-
D_2	-0.577*** (-66.57)	-0.052*** (-59.91)	-0.618*** (-55.67)	-0.081*** (-50.98)	-0.509*** (-36.09)	-0.030*** (-32.44)
D_3	-0.055*** (-3.96)	-0.005*** (-3.94)	-0.213*** (-11.48)	-0.026*** (-11.35)	0.258*** (11.72)	0.014*** (12.11)
D_4	-0.053*** (-4.59)	-0.004*** (-4.56)	-0.155*** (-9.82)	-0.018*** (-9.94)	0.053*** (2.44)	0.003*** (2.48)
D_5 (Punjab)	-0.077*** (-4.19)	-0.006*** (-4.11)	-0.142*** (-6.63)	-0.017*** (-6.43)	0.069** (1.90)	0.004** (1.94)
D_6 (Sindh)	-0.061*** (-3.75)	-0.005*** (-3.76)	-0.036*** (-1.89)	-0.004** (-1.89)	-0.129*** (-4.01)	-0.007*** (-4.02)
D_7 (KPK)	-0.153*** (-8.52)	-0.013*** (-8.22)	-0.088*** (-4.10)	-0.011*** (-4.03)	-0.274*** (-8.01)	-0.016*** (-7.46)
Pseudo R^2	0.2988***		0.2801***		0.2943***	
Note: ***, ** and * represents 1%, 5% & 10% level of significant.						

Results in Tables 5, 6, and 7 are consistent with those in Table 4, with few exceptions. According to Table 5, mobile exclusion in married individuals is 0.637 higher than in unmarried individuals, while this was opposite for digital exclusion. According to Rice and Hagen (2010), unmarried individuals have fewer claims on their time, leaving them more time for leisure and use of mobile phones. Similarly, coefficients of dummies for Punjab and KPK are positive, indicating that these two provinces have higher mobile exclusion than Balochistan. As far as results for computer exclusion are concerned, one variation from the results of digital exclusion is the result for $D_{4,}$ which is positive and significant. This result implies that the log-odds of computer exclusion is 0.483 higher for working individuals than for non-working. It might seem counterintuitive at first, but it can nonetheless be interpreted in light of Pakistan's labor market structure, where a significant share of employment is concentrated in informal, low-skilled, or non-office-based sectors such as agriculture, retail trade, and manual services. Workers in these occupations typically rely on mobile phones rather than computers for communication and productivity. Conversely, computer use remains limited to white-collar or office-based employment, which represents a relatively small share of the workforce. On the other hand, a major segment of the population consists of young people who are using technology for both educational and entertainment purposes.

The provincial comparison reveals significant gendered disparities in digital exclusion across Pakistan. For mobile exclusion, males in Punjab are more excluded than those in Balochistan, while females in Punjab are relatively less excluded, indicating that women in Punjab benefit from better mobile access compared to their counterparts in Balochistan. In Sindh, both males and females experience lower mobile exclusion than in Balochistan, reflecting stronger digital infrastructure and connectivity. Conversely, in KPK, both genders face higher levels of mobile exclusion, suggesting regional and infrastructural disadvantages.

For computer exclusion, females in KPK are more excluded than females in Balochistan, highlighting persistent gender gaps in digital literacy and access in the province. However, for all other provinces, both males and females are less computer-excluded than in Balochistan. In the case of internet exclusion, females remain more excluded in Punjab, Sindh, and KPK compared to females in Balochistan, while males across all three provinces are less excluded. This pattern suggests that although overall internet access is better outside Balochistan, the gender divide remains pronounced, with women in all provinces facing greater barriers to digital inclusion.

Robustness Analysis

Robustness Analysis by Changing Estimation Technique: IV Regression

To ensure that baseline results are not biased due to potential endogeneity between explanatory variables, particularly per capita household income and education, this study employs an instrumental variable ordered logit (IV-Ologit) model on the variable of digital exclusion. As a preliminary step, the Durbin and Wu Hausman tests are conducted to ascertain the existence of endogeneity, and the results are presented in Table 8.

Table 8: Results of IV-Ologit

	Full sample		Male Sample		Female Sample	
Variables	Durbin Test (H_0: No Endogeneity)	Wu-Hausman Test (H_0: No Endogeneity)	Durbin Wu Test (H_0: No Endogeneity)	Hausman Test (H_0: No Endogeneity)	Durbin Wu Test (H_0: No Endogeneity)	Hausman Test (H_0: No Endogeneity)
Hhpci (chi-sqaure)	398987***	201322***	205452***	145678***	345213***	324590**
Education (chi-square)	162946***	412702 ***	23976***	234590***	127689***	143098***
	Odd-ratio	**Marginal effects**	**Odd-ratio**	**Marginal effects**	**Odd-ratio**	**Marginal effects**
Age	-0.087*** (-144.46)	-0.003*** (-65.46)	-0.10*** (-98.01)	-0.007*** (-72.20)	-0.091*** (-104.62)	0.024*** (-34.53)
Age^2	0.001*** (-149.55)	0.0001*** (-113.3)	0.001*** (88.4)	0.001*** (74.38)	0.001*** (104.36)	0.0002*** (86.6)
Education	-0.114*** (-290.83)	-0.004*** (-79.41)	-0.120*** (-222.9)	-0.012*** (-145.81)	-0.114*** (-190.74)	-0.018*** (-177.1)
Hhpci	**-0.264***** (-129.68)	-0.010*** (-65.96)	**-0.280***** (-98.0)	-0.028*** (-83.35)	**-0.23***** (-78.02)	-0.034*** (-70.2)
D_1 (gender)	-0.188*** (-45.77)	-0.01*** (-38.47)	-	-	-	-
D_2 (region)	-0.204*** (-55.1)	-0.01*** (45.8)	-0.247*** (-48.8)	-0.024*** (-47.3)	-0.169*** (-30.54)	-0.023*** (-28.4)
D_3 (marital status)	-0.01*** (-1.70)	-0.0003* (-1.69)	-0.146*** (-18.23)	-0.014*** (-18.11)	0.160*** (19.72)	0.022*** (15.7)
D_4 (employment status)	-0.049*** (-11.2)	-0.002*** (-11.24)	-0.165*** (-26.60)	-0.016*** (-26.39)	-0.10*** (-11.5)	-0.014*** (-15.3)
D_5 (Punjab)	-0.054*** (-8.65)	-0.002*** (8.58)	-0.10*** (-9.45)	-0.008*** (-9.43)	-0.022*** (-2.35)	-0.003** (-2.03)
D_6 (Sindh)	-0.044*** (-7.72)	-0.002*** (-7.66)	-0.033*** (-4.34)	-0.003*** (-4.33)	-0.065*** (-7.41)	-0.01*** (-8.08)
D_7 (KPK)	-0.004 (-0.69)	-0.0001 (-0.69)	-0.01 (-0.87)	-0.001 (-0.87)	0.001 (0.87)	-0.001 (-0.83)
No. of obs.	598,338		304,398		293,940	
Pseudo R^2	0.1907***		0.1922***		0.1849***	
Note: ***, ** and * represents 1%, 5% & 10% level of significant.						

The results for the endogeneity diagnostics test revealed the rejection of the null hypothesis of exogeneity of regressors for both per capita income of household and education of the individual. The results from the Hansen test confirm the validity of instruments. The results for the full sample and sample disaggregated by gender obtained from IV-Ologit are consistent with the results of the baseline model presented in Table 4. Results highlighted income to be the most important factor for digital exclusion, followed by region, for all regressions.

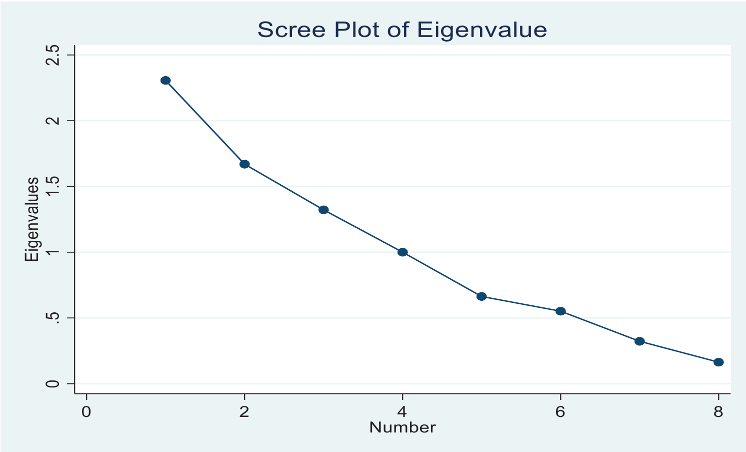
Robustness Analysis by changing the Digital Exclusion Variable: Digital Exclusion Index through Principal Component Analysis (PCA)

To ensure the robustness of results further, the study computes the alternative specification of the dependent variable. The study constructs the index of digital exclusion (DE) using principal component analysis (PCA). To construct the DE Index, PCA is applied to 6 observed variables representing different dimensions of individual digital exclusion: voluntary exclusion of use of mobile (DE1), involuntary exclusion of use of mobile (DE2), voluntary exclusion of use of more sophisticated gadgets (DE3), involuntary exclusion of use of more sophisticated gadgets (DE4), voluntary exclusion of use of internet (DE5) and involuntary exclusion of use of internet (DE6). The variables were first standardized to ensure comparability. PCA was conducted to reduce dimensionality and extract uncorrelated linear combinations (principal components) of the variables. The general form of the *i*-th principal component is given as follows

$$PC_i = \alpha_{i1} DE_1 + \alpha_{i2} DE_2 + \cdots + \alpha_{i6} DE_6$$

where α_{ij} denotes the loading of the variable j on the component i. Components with eigenvalues greater than one were retained, based on the Kaiser criterion. In this study, four such components were selected. The scree-plot of factor loading is presented in Figure 2.

Figure 2: Scree Plot of PCA for Digital Exclusion Index



Each component was weighted by its proportion of variance explained. The composite DE Index was constructed as the weighted sum of the retained components as follows.

$$DE\ index = w_1PC_1 + w_2PC_2 + w_3PC_3 + w_4PC_4$$

Where

$$w_j = \frac{Variance\ Explained\ by\ PC_j}{\sum Variance\ Explained\ by\ retained\ PCs}$$

To enhance interpretability and comparability, the DE Index was normalized to lie between 0 and 1 using min-max normalization

$$Normalized\ Index = \frac{DE\ Index - \min(DE\ Index)}{\max(DE\ Index) - \min(DE\ Index)}$$

This ensured that higher values indicate greater levels of digital exclusion. The Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy was 0.78, indicating that the sample was appropriate for PCA. Bartlett's Test of Sphericity was highly significant ($\chi 2$=384.26 with p<0.001), confirming that the correlation matrix was not an identity matrix and thus suitable for factor extraction.

The normalized DE index is then taken as the dependent variable, and the results are reported in Table 9. Table 9 reports robust standard errors corrected for heteroscedasticity. The results of the model are consistent with the baseline model, ensuring that results are robust over alternative specifications of the dependent variable. The most important variable for determining the extent of digital exclusion is again household per capita income, followed by region.

Table 9: Results with Digital Exclusion Index

	Full sample		Male Sample		Female Sample	
	Coefficient	S.E	Coefficient	S.E	Coefficient	S.E
Age	-0.10***	-0.01	-0.89***	-0.010	-1.00***	0.001
Age^2	0.01***	0.001	0.01***	0.0001	0.001***	0.00001
Education	-1.22***	-0.004	-0.120***	-0.012	-1.182***	-0.0001
Hhpci	**-2.69*****	-0.020	**-3.00*****	-0.003	**-2.19*****	-0.034
D_1 (gender)	1.78***	-0.05	-	-	-	-
D_2 (region)	-2.35***	-0.44	-2.88***	-0.060	-1.91***	-0.006
D_3 (marital status)	-0.35***	-0.065	-1.72***	-0.080	1.26***	0.001
D_4 (employment status)	-0.48***	-0.005	-1.39***	-0.07	-1.32***	-0.001
D_5 (Punjab)	-0.032***	-0.007	-0.10***	-0.009	-0.08***	-0.0009
D_6 (Sindh)	-0.017***	-0.001	-0.13***	-0.009	-0.19***	-0.01
D_7 (KPK)	-0.009*	-0.0071	-0.10	-0.10	0.003	-0.01
No. of obs.	598,338		304,398		293,940	
R^2	0.30***		0.29***		0.249***	
Note: ***, ** and * represents 1%, 5% & 10% level of significant.						

Conclusions

In our research, we have analyzed the household-level data to assess the impact of individual and household characteristics on digital exclusion. In 2010, 90% of individuals were not using digital technology, and this figure reduced in 2020 to 75%, but still a higher percentage of population are digitally excluded in Pakistan because the country has a higher cost of internet, weak connectivity, high taxes on broadband, low literacy rate and low smart phone penetration. Digital exclusion is more prevalent and persistent among females. The study examined determinants of digital exclusion with particular focus on gender dimension. Moreover, along with internet exclusion, device exclusion is also examined, given the conjecture that different types of exclusion hinder people from excelling in different capacities. This study has used PSLM (2019-20) data, comprised of 613,046 individuals covering all four provinces. Estimation is based on the Maximum Likelihood Technique for logistic regression.

The results revealed that age, education, geographical region, employment, and income are conducive factors to reduce both internet and device exclusion among the overall and gendered segregated population. Digital exclusion is less in males, and the gender digital divide can be bridged significantly through education and employment. Though household income tends to reduce digital exclusion for both males and females, nonetheless, household income tends to reduce all types of digital exclusion of males more than females and may trigger a wider digital gender gap.

Digital exclusion is a multifaceted phenomenon. To address this issue, several policies at different levels are necessary. In Pakistan, the government authorities and policymakers need to upgrade digital infrastructure and educate the people about the benefits of using advanced digital services. The government of Pakistan has, over time, improved the digital infrastructure and improved levels of accessibility and affordability of digital devices. The government needs to introduce advanced broadband services all over the country (especially in rural areas) and reduce internet taxes and tariffs. To reduce digital exclusion in Pakistan, basic skills and digital literacy among people must be promoted. The government must implement cybercrime laws to reduce digital risks. Women have less access to digital services due to societal conservatism and religious reasons. Therefore, the government must introduce broadband services to women. Lack of education and language barriers have also increased digital exclusion in rural areas of Pakistan. Therefore, the government of Pakistan must make policies to address these issues.

The findings of the research offer critical insights, but several limitations should be acknowledged. First, the analysis is based on cross-sectional PSLM data, which offers limited insights for the dynamic relationship among variables. Consequently, the role of changing infrastructure, digital literacy programs, and evolving household behavior cannot be captured. Second, while the study focuses on digital exclusion from a gendered lens, the available data measure access rather than actual digital engagement or capability, thus offering little insight on effective digital participation. Future research could therefore benefit by incorporating longitudinal data to capture temporal changes and contextual influences on digital inclusion.

Declarations/acknowledgement

Funding

This research did not receive any funding.

Conflicts of interest/Competing interests

There is no conflict of interest/Competing interests

Availability of data and material

Data Source is explicitly cited in the paper and data is openly available for download at https://www.pbs.gov.pk/pslm-3/.

Code Availability

The study has used STATA default commands to regress the models.

Authors' Contributions

Saira Tufail: Idea conception, Data Analysis, final writeup, supervision and validation
Sawarna Shahzadi: Idea conception and Initial draft
Faiza Azhar Khan: Idea refinement, data collection and initial estimation, supervision
Tahir Mukhtar: Editing and revision, final writeup, validation

NOTES

[1] According to the PSLM survey 2019-20, ICT has three indicators, i.e., households with a laptop, computer, and tablet, households with internet, and households with a mobile phone.

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