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Economics of Female Labor Force Participation: Overcoming Barriers in Pakistan

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Abstract

The active participation of females in the labor force advances gender equality and empowers them to access economic opportunities. The thesis empirically investigates the dynamics of female labor force participation and certain barriers women face in the Pakistan's labor market.

The first study examines the patterns and causes of female labor force participation in Pakistan by constructing a synthetic panel data set spanning three decades of nationally representative labor force surveys (1990-2017). First, the study performs a decomposition analysis to examine the contribution of demographic changes to changes in female labor force participation. Second, the study employs Age-Period-Cohort analysis to explain differences in the female labor force participation across different life stages, years, and birth cohorts. The findings reveal that the shift in age structure contributed to just 0.048 percent of the total 7.46 percent increase in aggregate participation rate from 1990-2017. Cohort effects indicate an increase in labor force participation among cohorts born after the 1950s, particularly among married females and those with the lower levels of education.

The second study investigates the gender and rural-urban (female) digital divide along with analysing the association between digitalization and female labor force participation in Pakistan. Using nationally representative Pakistan Social and Living Standards Measurement Survey (2019-2020), the study employs Oaxaca-Blinder decomposition and instrumental variable approach respectively. The results suggests that institutional and sociocultural norms are the primary factors (0.397 unit of the 0.5 unit gap) explaining the divide in mobile or smartphone ownership between men and women. However, the differences in observable characteristics account (0.152 unit of the 0.205 unit gap) for the digital divide between rural and urban areas among females. Furthermore, employing an instrumental variable approach reveals that mobile or smartphone ownership increases female labor force participation (36.2 % points).

The third study employs a mixed-method approach to analyse the impact of mass transit and ride-hailing services on female labor force participation in Lahore, Pakistan. Using a synthetic control methodology and labor force surveys covering a period of two decades (1999-2020), the study quantify the impact of mass transit and ride-hailing services on female labor force participation. The findings indicate that the introduction of mass transit has results in a modest increase (1 %) in female labor force participation when compared to the synthetic equivalent. However, ride-hailing services do not demonstrate any significant impact. Using primary data collected in Lahore during July-August 2022, the qualitative analysis findings highlights the substantial impact of spatial mismatch on women's mobility choices. Notably, considerations of time-saving and safety concerns emerge as crucial factors influencing women's choices among various transportation modes. Furthermore, the study reveals a lack of gender-sensitive transport planning in Pakistan, as authorities report that transportation infrastructure is primarily geared towards the general population and does not adequately consider the diverse needs of various demographic groups.

Zusammenfassung

Die aktive Beteiligung von Frauen an der Erwerbsbevölkerung fördert die Gleichstellung der Geschlechter und befähigt sie, wirtschaftliche Chancen wahrzunehmen. In dieser Arbeit werden die Dynamik der weiblichen Erwerbsbeteiligung und bestimmte Hindernisse, mit denen Frauen auf dem pakistanischen Arbeitsmarkt konfrontiert sind, empirisch untersucht.

Die erste Studie untersucht die Muster und Ursachen der Erwerbsbeteiligung von Frauen in Pakistan, indem ein synthetischer Paneldatensatz erstellt wird, der drei Jahrzehnte national repräsentativer Arbeitskräfteerhebungen (1990-2017) umfasst. Zunächst führt die Studie eine Dekompositionsanalyse durch, um den Beitrag demografischer Veränderungen zu Veränderungen der Erwerbsbeteiligung von Frauen zu untersuchen. Zweitens setzt die Studie eine Alters-Perioden-Kohorten-Analyse ein, um Unterschiede in der weiblichen Erwerbsbeteiligung über verschiedene Lebensphasen, Jahre und Geburtskohorten hinweg zu erklären. Die Ergebnisse zeigen, dass die Verschiebung der Altersstruktur lediglich 0,048 Prozent des Gesamtanstiegs der aggregierten Erwerbsquote von 7,465 Prozent zwischen 1990 und 2017 ausmachte. Kohorteneffekte deuten auf einen Anstieg der Erwerbsbeteiligung bei den nach den 1950er Jahren geborenen Kohorten hin, insbesondere bei verheirateten Frauen und solchen mit niedrigerem Bildungsniveau.

Die zweite Studie untersucht die digitale Kluft zwischen den Geschlechtern und zwischen Stadt und Land (bei Frauen) und analysiert den Zusammenhang zwischen Digitalisierung und weiblicher Erwerbsbeteiligung in Pakistan. Unter Verwendung des national repräsentativen Pakistan Social and Living Standards Measurement Survey (2019-2020) wendet die Studie die Oaxaca-Blinder-Zerlegung und den Instrumentalvariablenansatz an. Die Ergebnisse deuten darauf hin, dass institutionelle und soziokulturelle Normen die wichtigsten Faktoren sind (0,397 Einheiten des 0,5 Einheiten umfassenden Unterschiedes), die die Kluft zwischen Männern und Frauen beim Besitz von Mobiltelefonen oder Smartphones erklären. Die digitale Kluft zwischen ländlichen und städtischen Gebieten bei den Frauen ist jedoch auf die Unterschiede bei den beobachtbaren Merkmalen zurückzuführen (0,152 Einheiten des Unterschiedes von 0,205 Einheiten). Darüber hinaus zeigt der Einsatz eines Instrumentalvariablenansatzes, dass der Besitz von Mobiltelefonen oder Smartphones die Erwerbsbeteiligung von Frauen erhöht (36,2 Prozentpunkte).

Die dritte Studie verwendet einen Mixed-Methods-Ansatz, um die Auswirkungen von Nahverkehrs- und Ride-Hailing-Diensten auf die Erwerbsbeteiligung von Frauen in Lahore, Pakistan, zu analysieren. Mithilfe einer synthetischen Kontrollmethode und Arbeitskräfteerhebungen, die einen Zeitraum von zwei Jahrzehnten (1999-2020) abdecken, quantifiziert die Studie die Auswirkungen des öffentlichen Nahverkehrs und von Ride-Hailing-Diensten auf die Erwerbsbeteiligung von Frauen. Die Ergebnisse zeigen, dass die Einführung des öffentlichen Nahverkehrs zu einem moderaten Anstieg (1 %) der weiblichen Erwerbsbeteiligung im Vergleich zum synthetischen Äquivalent geführt hat. Ride-Hailing-Dienste zeigen jedoch keine signifikanten Effekt. Auf der Grundlage von Primärdaten, die zwischen Juli und August 2022 in Lahore erhoben wurden, zeigt die qualitative Analyse, dass die räumliche mismatch erhebliche Auswirkungen auf die Mobilitätsentscheidungen von Frauen hat. Vor allem Zeitersparnis und Sicherheitsaspekte erweisen sich als entscheidende Faktoren, die die Wahl der Frauen zwischen verschiedenen Verkehrsmitteln beeinflussen. Darüber hinaus zeigt die Studie einen Mangel an geschlechtersensibler Verkehrsplanung in Pakistan, da die Behörden berichten, dass die Verkehrsinfrastruktur in erster Linie auf die allgemeine Bevölkerung ausgerichtet ist und die unterschiedlichen Bedürfnisse verschiedener demografischer Gruppen nicht angemessen berücksichtigt.

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Contents

Abstract ... iii

Zusammenfassung ... iv

Acknowledgements ... v

List of Tables ... viii

List of Abbreviations ... xi

1 Introduction and motivation ... 1

1.1 Context and framing of research ... 3

1.2 Research objectives ... 8

1.3 Conclusions, policy recommendations and scope for further research ... 9

1.4 Organization of the thesis ... 11

2 Patterns and Causes of Female Labor Force Participation: An Age-Period-Cohort Analysis for Pakistan ... 13

2.1 Introduction ... 13

2.2 Theoretical background and related literature ... 17

2.3 Data and descriptive statistics ... 20

2.4 Empirical methodology ... 24

2.4.1 Decomposition of change in total labor force participation ... 24

2.4.2 Decomposition of age, period, and cohort effects ... 25

2.5 Estimation results ... 27

2.5.1 Decomposition of change in total labor force participation ... 27

2.5.2 Decomposition by age, period, and cohort ... 28

2.5.3 Age effects in female labor force participation rates ... 28

2.5.4 Cohort effects in female labor force participation rates ... 30

2.5.5 Period effects in female labor force participation rates ... 32

2.6 Conclusion and policy recommendations ... 34

3 Narrowing the Gender Digital Divide in Pakistan: Mobile Phone Ownership and Female Labor Force Participation ... 36

3.1 Introduction ... 36

3.2 Context of the study ... 39

3.3 Conceptual framework ... 42

3.4 Data and methods ... 44

3.4.1 Data ... 44

3.4.2 Non- Linear Oaxaca Blinder decomposition ... 45

3.4.3 Instrumental variable approach 46
3.5 Results and discussion 47
3.5.1 Descriptive statistics 47
3.5.2 Non-Linear Oaxaca Blinder decomposition 49
3.5.3 Two-Stage least squares 53
3.5.4 Robustness checks 55
3.5.5 Non-Linear Oaxaca Blinder decomposition for female rural-urban divide 55
3.6 Conclusions, implications and limitations 57
4 Impact of Public Transport and Ride-hailing Services on Female Labor Force Participation in Lahore, Pakistan 59
4.1 Introduction 59
4.2 Context of the project 62
4.2.1 Study area 62
4.2.2 Lahore metro bus system 63
4.2.3 Ride-hailing 64
4.2.4 Conceptual framework and related literature 64
4.3 Research methods and data 66
4.3.1 Quantitative analysis: synthetic control methods 67
4.3.2 Qualitative analysis: thematic analysis 69
4.4 Results and discussion 70
4.4.1 Quantitative section 71
4.4.2 Qualitative section 80
4.5 Conclusion and policy recommendations 86
References 90
Appendix A: appendix to chapter 2 107
Appendix B: appendix to chapter 3 115
Appendix C: appendix to chapter 4 122

List of Tables

Table 1.1 Calculated impact of closing the gender gaps in labor force participation 2

Table 2. 1 Components of labor force participation rate (LFPR) change as percentage of total change 28

Table 3. 1 Summary statistics by gender 48
Table 3. 2 Average marginal effects of the total sample and also the sample disaggregated by male and female 49
Table 3. 3 Decomposition of the gender divide in the ownership of mobile or smartphones . 52
Table 3. 4 Regression results of the effect of mobile phone on female labor force participation 53
Table 3. 5 Decomposition results of mobile phone or smartphone ownership by location 56

Table 4. 1 Female labor force participation predictor means before the metro intervention... 71
Table 4. 2 City weights in the synthetic Lahore (metro intervention) 72
Table 4. 3 Female labor force participation rate predictor means before the intervention (ride-hailing) 77
Table 4. 4 City weights in the synthetic Lahore (ride-hailing intervention)..... 77
Table 4. 5 Summary statistics of Lahore metro users 80
Table 4. 6 Summary statistics of ride-hailing users 81
Table 4. 7 Summary of the analysis of semi-structured interviews based on predetermined and extracted themes..... 82

Table A 1 Summary Statistics (1990-2017)..... 107

Table B 1 No. of Observations (15-64) 117
Table B 2 Construction of control variables used in the study..... 117
Table B 3 Gender digital divide for labor force participation and different digital indicators (aged 15-64)..... 118
Table B 4 Rural-Urban divide for labor force participation and mobile or smartphone ownership and use (15-64)..... 118
Table B 5 Summary statistics of female sample disaggregated by MS ownership 119
Table B 6 Summary statistics rural-urban digital divide for the female sample 119
Table B 7 Association between mobile or smart phone ownership and female labor force participation: Robustness checks (Control function approach and IPWRA)..... 120

Table C 1 Construction of predictors used in the quantitative analysis 122
Table C 2 List of cities along with information on the launch date of different transportation services..... 122
Table C 3 Themes and subthemes (pre-determined) 124

List of Figures

Figure 2. 1 Labor force participation rates (%) of males and females (1990-2020) 15
Figure 2. 2 Female labor force participation by cohort. 22
Figure 2. 3 Labor force participation rates and population shares of females for different age groups and years. 23
Figure 2. 4 Female labor force participation rates and percentage of women by education level and birth year. 24
Figure 2. 5 Age profiles of female labor force participation rates. 29
Figure 2. 6 Cohort profiles of female labor force participation. 31
Figure 2. 7 Year profiles of female labor force participation. 33

Figure 3. 1 Gender Digital Divide in the Ownership and Use of Different Digital Tools (2019-2020). 41

Figure 4. 1 Female labor force participation in Lahore and synthetic Lahore 74
Figure 4. 2 Female labor force participation in Lahore and synthetic Lahore (ride-hailing) 78

Figure A 1 Age effects of urban and rural females. 108
Figure A 2 Age effects of ever married and never married females. 108
Figure A 3 Age effects of females with no formal education and primary level of education. 109
Figure A 4 Age effects of females with secondary and tertiary levels of education. 109
Figure A 5 Cohort effects of urban and rural females. 110
Figure A 6 Cohort effects of ever married and never married females. 110
Figure A 7 Cohort effects of females with no formal education and primary level of education. 111
Figure A 8 Cohort effects of females with secondary and tertiary levels of education 111
Figure A 9 Year effects of urban and rural females. 112
Figure A 10 Year effects of ever married and never married females. 112
Figure A 11 Year effects of females with no formal education and primary education level.. 113
Figure A 12 Year effects of females with secondary and tertiary levels of education. 113
Figure A 13 Population share (1950-2010) and projections (2010-2050) for different age groups. 114
Figure A 14 Annual Growth rate of GDP (1990-2017). 114

Figure B 1 Labor force participation rate (%) of males and females (1990-2020) 115
Figure B 2 Mobile cellular subscriptions (2005-2020) 115
Figure B 3 Cell towers (sites) all around Pakistan (2016-2020) 116

Figure B 4 Mobile cellular providers in Pakistan 116

Figure C 1 Route of metro bus and feeder routes connecting other areas to metro stations... 125
Figure C 2 Geographic location of ride-hailing users..... 126
Figure C 3 Trends in female labor force participation (Lahore vs the rest of cities in the control group under the metro bus and ride-hailing intervention specification)..... 127
Figure C 4 Female labor force participation rate gaps between Lahore and synthetic Lahore under metro and ride-hailing intervention specifications 128
Figure C 5 Female labor force participation rate gaps in Lahore and placebo gaps in control states (metro analysis)..... 129
Figure C 6 Female labor force participation rate gaps in Lahore and placebo gaps in control states (ride-hailing analysis) 130

List of Abbreviations

APC	Age-Period-Cohort
BRT	Bus Rapid Transit
FLFP	Female Labor Force Participation
GSNI	Gender Social Norms Index
GSMA	Global System for Mobile Communications Association
HIES	Household Integrated Economic Survey
ICT	Information and Communication Technology
ILO	International Labor Organization
ITF	International Transport Worker's Federation
IV	Instrumental Variable
IVR	Interactive Voice Response
IPWRA	Inverse Probability Weighted Regression Adjustment
LFS	Labor Force Survey
LFPR	Labor Force Participation Rate
MENA	Middle Eastern and Northern Africa
MS	Mobile or Smartphone
MF	Mobile phone Franchise
MBS	Metro Bus System
MSPE	Mean Squared Prediction Error
OLS	Ordinary Least Squares
PMTA	Punjab Mass Transit Authority
PM	Participant Metro
PR	Participant Ride-hailing
PUHS	Peshawar Urban Household Survey
WESW	Women Economic and Social Well-being Survey
WVS	World Value Survey
2SLS	Two-Stage Least Squares

CHAPTER 1

1 Introduction and motivation

Sustainable Development Goal 5 advocates for the advancement of gender equality and empowerment of women by emphasizing their increased involvement in areas such as education, employment, healthcare, and their representation in political and economic decision-making processes. Achieving the objectives of Sustainable Development Goals hinges on the equitable participation of both women and men in paid and unpaid work. Women comprise approximately half of the world's population; however, their economic participation remains significantly below their potential. Between 1990 and 2022, the proportion of women participating in the labor force decreased from 50.6 percent to 47.3 percent.[1] However, significant variations in female labor force participation exist across regions. For instance, the Latin American region is experiencing a significant increase in female labor force participation, contrasting with various other regions where participation rates have plateaued. The Middle East exhibits a modest increase, whereas, in South Asia, there is a notable decline in female labor force participation (Klasen, 2019). Furthermore, South Asia's progress toward gender parity stands at 63.4 percent, which is the second-lowest score among the eight regions (Gender Gap Report, 2023).

The gender disparity in labor force participation bears significant implications as it exerts a constraining impact on overall economic growth. Recognizing the importance of closing the gender gap in labor force participation, the leaders of the G20 committed in 2014 to a specific target known as the "25 by 25 target". This target aims to achieve a 25 percent decrease in gender disparity in labor force participation by the year 2025. According to the estimates by the World Employment and Social Outlook: Trends for Women (2017) presented in Table 1.1, if the "25 by 25 target" were achieved on a global scale, it would increase the global GDP by 3.9 percent, equivalent to $5.8 trillion to the world economy.[2] The regions characterized by the most pronounced gender gaps, namely Northern Africa, the Arab States, and South Asia, would experience the most substantial gains from this advancement.

[1] Gender Data Portal: The World Bank. https://genderdata.worldbank.org/indicators/sl-tlf-acti-zs/?view=trend.
[2] World Employment and Social Outlook (WESO) Trends for Women (2017).

Table 1.1 Calculated impact of closing the gender gaps in labor force participation

	2017 projections			25 % gap reduction by 2025	
	Labor force participation (%)			Additional GDP	
	male	female	gap	(%)	$ billions, PPP
World	**76.1**	**49.4**	**26.7**	**3.9**	**5,767**
Northern Africa	74.1	22.9	51.2	9.5	301
Sub-Saharan Africa	76.3	64.6	11.7	2.2	109
Latin America and the Caribbean	78.3	52.7	25.6	4.0	445
Northern America	68.3	56.2	12.1	2.0	452
Arab States	76.4	21.2	55.2	7.1	372
Eastern Asia	76.8	61.3	15.5	2.5	1,013
South-Eastern Asia and the Pacific	81.2	58.8	22.4	3.5	425
South Asia	**79.4**	**28.6**	**50.8**	**9.2**	**1,838**
Northern, Southern, and Western Europe	63.8	51.3	12.5	2.0	406
Eastern Europe	68.1	53.0	15.1	2.6	189
Central and Western Asia	73.5	44.1	29.4	5.7	216

Source *World Employment and Social Outlook: Trends for Women (2017)*

Various studies have identified several key barriers contributing to the low labor force participation of women in developing countries. Jayachandran (2021) indicates that disparities in female labor force participation across countries with similar levels of development can be partly attributed to cultural norms. Conservative norms can restrict females' physical mobility, reducing their job opportunities and available workforce for firms (Field & Vyborny, 2022; Priya Uteng, 2012; Sajjad et al., 2018). In addition, due to deep-rooted socio-cultural beliefs regarding women's role in the society, women exhibit significantly lower rates of information and communication technology (ICT) adoption than men, particularly in developing countries (Antonio & Tuffley, 2014). The availability of Information and communication technology (ICT) greatly influences women's engagement in social and political activities and their economic empowerment (Non et al., 2021; Sife et al., 2010; Shahid & Afreen, 2021; Zheng et al., 2022). Research has shown that expansion of female education has played a crucial role in reducing fertility rates, and consequently, empowering greater female involvement in labor markets (Klasen, 2019; Klasen et al., 2021; Faridi & Rashid, 2014). However, girls are disproportionately affected by factors that hinder access to education for children, such as poverty and parent's low education levels (Saleemi & Kofol, 2022). Women's disproportionate responsibilities for childcare also represent a substantial obstacle to their participation in the labor market (Cassirer & Addati, 2007; Clark et al., 2019; Dang et al.,

2022; Narayanan, 2008). These responsibilities often demand a significant portion of their time and energy, limiting their ability to engage fully in the workforce. Hence, an important concern for policymakers is to address the barriers that women encounter when deciding to join the labor force.

This thesis centers on multiple facets of female labor force participation within a developing country context. Firstly, it aims to investigate the trends and factors influencing female labor force participation over an extended period of three decades. Secondly, it offers empirical insights into the impact of digitalization and transportation on female labor force participation, addressing the unique challenges women encounter in labor markets, such as limited access to technology and constraints on physical mobility outside home.

1.1 Context and framing of research

Pakistan occupies the 142nd position among a total of 146 countries according to the Global Gender Gap Report of 2023. This ranking underscores Pakistan's notably low standing in terms of gender equality performance. Particularly concerning economic participation and opportunities, the country has experienced a decline, moving from the 112th position in 2006 to the 143rd in 2023. Furthermore, the Sustainable Development Report (2023) indicates that in Pakistan, the ratio of female to male labor force participation rate is stagnating at 30.43 percent, with 100 being the benchmark for equality in this indicator. Pakistan exhibits significantly lower female labor force participation rates than what might be anticipated for a country at its stage of development (World Bank Group, 2022). The participation of urban females in the labor force in Pakistan is also notably low, and there has been minimal increase over the past two and half decades (Amir et al., 2018). However, rural female labor force participation doubled from 16 percent to 32.9 percent over the same period, with a notable increase in rural unpaid work (Amir et al., 2018). Therefore, this thesis examines distinct trends in rural and urban female labor force participation and addresses specific barriers influencing the decisions of both rural and urban women to engage in the labor force.

Gender-biased social norms are pervasive on a global scale, with nearly 90 percent of individuals harboring inherent biases against women (Gender Social Norms Index (GSNI), 2023).[3] These biases are prevalent across both men and women, indicating deep-seated integration within society, mirroring widely accepted social norms. Socio-cultural norms that restrict women from entering labor market in developing countries can vary widely based on cultural and regional contexts. And these social norms along with other factors create specific barriers that women encounter when trying to enter the labor force. For instance, gender digital divide in developing world is largely due to entrenched societal views on women's roles (Antonio & Tuffley, 2014; Jiang & Luh, 2017). As highlighted by Kabeer (2012), gender disparities are shaped by unjust systems and customs

[3] The Gender Social Norms Index (GSNI) uses data from the World Value Survey (WVS). It captures biases against four important dimensions - political, educational, economic, and physical integrity – to highlight areas where women and girls face systematic disadvantages and discrimination.

rather than decisions made by individual choices. Furthermore, harassment and violence against women in public places (Aguilar et al., 2021; Borker, 2018; El Feki et al., 2017; Gulland, 2019; Kondylis et al., 2020: Seki & Yamada, 2020) as well as societal norms regulating women's interaction with unrelated men (Bender et al., 2005; Miller et al., 2020; Sajjad et al., 2018) impose limitations on the physical mobility of women outside their homes.

Social norms evolve over time, influenced by various factors such as economic development, technological advancement, government initiatives, and grassroots activism[4]. Claudia Goldin's work (Goldin, 2021; Goldin & Mitchell, 2017) highlight that change in female labor force participation is the result of a complex interplay of factors, and it is a process that unfolds gradually over time. The labor market comprises various generations and cohorts, each of which has encountered distinct circumstances when making life choices.[5] Therefore, the second chapter of the thesis builds on the theory of demographic transition to analyse the trends and factors influencing the participation of females in the labor force in Pakistan using three decades of labor force surveys spanning from 1990-2017. The theory of demographic transition involves shifts in population structure. However, research has consistently regarded the demographic transition as a product of a significant process of social and economic change (Reher, 2011). Thus, these shifts range from periods of high birth and death rates, indicative of lower technological advancement, education, development, and adherence to traditional socio-cultural norms, to periods characterized by low birth and death rates, aligning with improved technology, education levels, economic development along with a shift in socio-cultural norms.

Variations in the social and economic conditions can influence female labor force participation through various channels. First, the shifts in the participation rates are closely linked to substantial differences in the demographic structure of the female population (Lichter & Costanzo, 1987). This entails a shift in the composition, where a higher proportion of females in the working-age population increases the likelihood of their participation in the labor force. Second, reduction in fertility rate can lead to a reallocation of time away from childcare duties, leading to increased levels of female labor force participation (Bloom et al., 1986). Furthermore, as economies progress through various stages of demographic transition, there is a simultaneous evolution in the adherence to social norms. It is recognized that changing behaviors (for instance behaviors related to girl's education), including shifts in social norms, play a pivotal role in motivating women to enter the labor market (Hotchkiss, 2006). The theory of demographic transition helps in explaining the long-term dynamics of female labor force participation and sheds light on the patterns and underlying causes of these shifts. In the second chapter, these dynamics are examined using the life cycle model (Owen, 1989), cohort-based model (Balleer et al., 2014), and the integration of the business cycle's influence when females adjust their labor force participation to capitalize on the opportunities presented by these cycles (Borjas & Van Ours, 2010).

[4] http://cdn-odi-production.s3-website-eu-west-1.amazonaws.com/media/documents/9817.pdf.

[5] https://www.nobelprize.org/uploads/2023/10/popular-economicsciencesprize2023.pdf

Pakistan is slowly converging towards the final phase of demographic transition, marked by the convergence of both low fertility and mortality rates (Goujon et al., 2020). As economies advance along the demographic transition, women's likelihood of engaging in the labor market may rise due to several interrelated factors. Nonetheless, despite declining fertility rates, rising levels of education, technological advancements, infrastructural development, and changing social norms along with economic development, there has been only a slight increase in the participation of females in Pakistan's labor force. To comprehend this scant increase, it is imperative to delve deeper into individual labor supply decisions through the lens of the neoclassical labor supply model, with a focus on specific barriers such as limited access to technology and restriction on physical mobility.

The neoclassical labor supply model seeks to investigate how individuals make decisions regarding their labor supply. The model illustrates how an individual, in pursuit of maximizing utility, allocates their time between the labor market and home. Therefore, choices related to labor supply require balancing the amount of time (theory of allocation of time)[6] dedicated to work (wages) and the time devoted to household activities (reservation wage). The reservation wage represents the lowest wage that an individual needs to consider entering the labor market, and if the market wage falls below this wage, the individual will choose not to engage in work (Borjas & Van Ours, 2010). The reservation wage, often regarded as the marginal utility of non-work, encompasses all factors influencing women's labor supply decisions, excluding the expected market wage (Klasen & Pieters, 2012).

In the third and fourth chapters of this thesis, the neoclassical labor supply model is used to explain women's decisions regarding their labor force participation, focusing on specific barriers they encounter in the labor market. One of these barriers pertains to limited digital access, particularly the lower probability of mobile or smartphone ownership, which acts as an impediment, preventing women from fully leveraging technological advancements (Antonio & Tuffley, 2014; Rajkhowa & Qaim, 2022b; Zheng et al., 2022). The third chapter describes how technology, represented by mobile phone devices, can facilitate women's inclusion in the labor market by directly influencing their reservation wage.

In theory, women can potentially benefit from digitalization in various ways. The accessibility of mobile phones, which enables females to access various services and information, can lower women's reservation wages and contribute to their increased participation in the labor force by facilitating home production (Dettling, 2017). Mobile phones also allow working mothers to maintain predictability and availability while not needing to be physically present, facilitating remote caregiving (Palen & Hughes, 2007). Additionally, the use of mobile phones for job searching can have a direct influence on labor force participation by enhancing people's social skills and enabling the formation of external social networks (Chen, 2007), which, in turn, boosts job search activity (Wanberg et al, 2020). Finally, mobile phones can indirectly enhance female

[6] By Gary Becker (1965)

labor force participation by empowering women to make more decisions within their households and by reducing constraints on their physical mobility (Field & Vyborny, 2022; Rajkhowa & Qaim, 2022b).

Thus, the thesis's third chapter underscores the significance of digitalization in boosting women's participation in the labor force. According to Mobile Gender Gap Report (2023), around 900 million women in low and middle-income countries have yet to access mobile internet, with nearly two-thirds of this demographic residing in South Asia and Sub-Saharan Africa. From 2021 to 2022, the advancement in reducing the gender gap in smartphone ownership has come to a halt; women are still 17 percent less likely than men to possess a smartphone.[7] Among all the countries surveyed,[8] Pakistan exhibits the most significant gap in mobile ownership, with a 35 percent difference. The Mobile Gender Gap Report (2023) highlights some pressing challenges that hinder women's ownership of mobile phones in Pakistan. Among the key barriers are literacy and digital skills, which can prevent women from confidently navigating the digital landscape. Additionally, family approval plays a pivotal role, where societal norms and familial constraints impede women's access to technology. Lastly, affordability emerges as an important hurdle, underscoring the need for equitable access to technology regardless of economic constraints.

The third chapter delves into an empirical analysis of the gender digital divide (in traditional mobile phone or smartphone ownership)[9] and rural-urban digital divide among women. Moreover, employing an instrumental variable approach, the chapter examines the association between mobile and smartphone ownership and female labor force participation in Pakistan. The prevailing body of literature concentrates on examining the gender digital divide and its implications for female labor force participation, with a primary focus on internet use (Galperin & Arcidiacono, 2021; Jiang & Luh, 2017; Viollaz & Winkler, 2021). However, it is imperative to recognize that the need for digitalization differs based on country's development level. Mobile phones, in particular, play a crucial role in enabling cost effective communication and providing access to a wide range of services, including, education, employment, healthcare, market information, and economic resources (Rotondi et al., 2020). Therefore, the chapter addresses a notable gap in literature by examining the impact of traditional mobile phone or smartphone ownership on female labor force participation in a country characterized by most pronounced digital gender divide.

The inclusion of women into the labor market is significantly impeded by limitations on their physical mobility (Field & Vyborny, 2016) beyond domestic confines. This constraint is further exacerbated by the prevalence of sexual harassment and abuse in the transit and workplace settings in developing countries, hindering their ability to participate in the workforce (Jayachandran,

[7] As above

[8] Countries surveyed by Global Systems for Mobile Communication (GSMA).

[9] According to the manual of instructions published by the Pakistan Bureau of Statistics, mobile phone (traditional) refers to a portable telephone subscribing to a public mobile telephone service using cellular technology. However, a smartphone is a multi-purpose mobile computing device distinguished from feature phones by their stronger hardware capabilities and extensive mobile operating systems.

2021). Findings from the household survey conducted in Peshawar (Pakistan) reveal that a significant proportion, approximately one in three women, have encountered sexual harassment in public spaces within the city.[10] Within the specific context of Pakistan, it is noteworthy that women residing in urban areas display lower levels of labor force participation[11] when compared to their rural counterparts. This disparity can be predominantly attributed to the considerable challenges posed by restricted physical mobility (Field & Vyborny, 2016), which constrains their ability to venture beyond the confines of their homes for employment opportunities. Information sourced from the 2019 Pakistan Social and Living Standards Measurements Survey (PSLM) survey and the 2018 Household Integrated Economic Survey (HIES) highlights that a notable proportion of women, over 34%, who are eligible for labor force participation, are not actively seeking employment primarily due to constraints related to working outside their homes.

A lack of inadequate transportation services for women (Priya Uteng, 2012), combined with insufficient attention to their safety and security (Sajjad et al., 2018), reduces their engagement in the labor force (Noor & Iamtrakul., 2023). Transportation infrastructure is pivotal in supporting women's participation in the labor force as it directly influences the affordability of transportation and their physical accessibility to employment (Bastiaanssen et al., 2020; Patacchini & Zenous, 2005; Williams et al., 2019). Additionally, it indirectly contributes to their mobility by enhancing safety features (Martinez et al., 2019), thereby reducing constraints on their movement. According to 2018 Women's Economic and Social Well-being Survey (WESW) of 2018, 34% of women identify the unavailability of transportation services as a significant barrier affecting their ability to join labor force. In Pakistan, societal limitations that discourage women from interacting with unrelated men, along with concerns about harassment, social stigma, and discomfort, serve as barriers to women's mobility and their use of various transportation services (Sajjad et al., 2018). Different modes of transportation can either hinder or facilitate women's freedom of movement, depending on their specific features and the associated social stigma. For instance, women confront multiple obstacles related to safety, harassment, and concerns about their societal image when using public transportation. Conversely, private transportation services offer better safety and accessibility, but they are not affordable compared to public transportation.

The neoclassical labor supply model helps to explain how the provision of different transportation services can have both direct and indirect impacts on the reservation wage and, in turn, influence female labor force participation. Increased transportation expenses lead to increased reservation wages, whereas affordable transportation not only reduces reservation wages but also expands the range of employment opportunities for women (Patacchini & Zenou, 2005). In addition, enhanced accessibility to job opportunities via transportation infrastructure has the potential to shorten the job search process by expanding the range of available options and increasing wage offers for specific jobs, thereby reducing related reservation wages (Bastiaanssen et al., 2020). The indirect

[10] Peshawar Urban Household survey (PUHS) World Bank
[11] LFS (2018-19)

pathways through which transport infrastructure provision lowers the reservation wage by addressing women's safety concerns (Malik et al., 2020; Jayachandran, 2015; Noor & Iamtrakul, 2023) and implementing gender-sensitive transport planning (ITF Global, 2019).

The fourth chapter of the thesis investigates how the provision of public (mass transit) and private (ride-hailing) transportation services in Pakistan affects women's labor force participation and mobility constraints. The chapter makes a substantial contribution through its utilization of a mixed-method approach to examine the aforementioned impact. First, the chapter employs a synthetic control method to investigate the causal impact of mass transit and ride-hailing services on female labor force participation. Using labor force surveys covering over two decades (1999-2020), a synthetic Lahore series is created for comparison with the actual Lahore series. Second, qualitative data from employed women who use metro buses and ride-hailing services in Lahore, as well as from service providers, is used to support results from the empirical analysis. Through thematic analysis, the qualitative research seeks to understand the factors influencing women's transportation mode choices. As argued by Kabeer (2019), the use of mixed-methods helps address specific limitations associated with causal analysis, thereby establishing more robust basis for drawing conclusive insights. To the best of our knowledge, Martinez et al. (2019) are the only researchers who have investigated the causal impact of mass transit on women employment outcomes in Lima. Thus, the study examines an extensive dataset and diverse viewpoints, which collectively facilitate a more profound understanding of the causal impact of transportation services on female labor force participation in Pakistan.

1.2 Research objectives

To address the research gap in the literature concerning female labor force participation, this thesis achieves various research objectives in its distinct chapters:

1. To investigate the contribution of demographic changes to changes in aggregate female labor force participation.
2. To analyse the determinants of the dynamics of female labor force participation by dividing total change into age, period, and cohort components for separate examination.
3. To examine the gender divide in traditional mobile phone or smartphone ownership and identify the contribution of covariates to explaining the divide.
4. To investigate the effect of traditional mobile or smartphones on the participation of the female labor force.
5. To analyze the rural-urban divide in traditional mobile or smartphone ownership of the female sample.
6. To examine the impact of mass transit and ride-hailing services on female labor force participation.
7. To analyze the factors associated with the use of mass transit and ride-hailing services that facilitate or hinder women from participating in the labor force.

The related research questions and hypotheses are elaborated in the respective chapters.

1.3 Conclusions, policy recommendations and scope for further research

This dissertation investigates the dynamics of female labor force participation in Pakistan and offers empirical insights into addressing specific barriers that women encounter in the country's labor market.

In the second chapter, applying age-period-cohort analysis the thesis endeavors to examine the trends and factors influencing female labor force participation in Pakistan spanning a period of three decades. The findings suggest that changes in demographic composition have led to a slight shift in female labor force participation in Pakistan since the 1990s, potentially affecting the country's ability to harness demographic dividend. Regarding age effects, female participation rates exhibit an inverted U-shaped pattern, increasing in early adulthood, remaining steady, and declining approximately after age 50. There is a plateau in participation rates during the early 30s and 40s, coinciding with increased household responsibilities due to marriage and childcare responsibilities. Urban females exhibit a slight M-shaped curve, indicating withdrawal from the labor market for child-rearing. Cohort effects show an ongoing rise in labor force participation for cohorts born after the 1950s, with younger cohorts of married and less-educated females participating more. Furthermore, period effects in female labor force participation are influenced by business cycles, being higher during periods of higher GDP growth and lower during economic downturns.

From a policy perspective, considering that changing demographic composition has only contributed minimally to the shift in female labor force participation in Pakistan since the 1990s, it is evident that strategic planning is essential to fully capitalize on the ongoing demographic dividend. The primary areas to focus involve investing in women's education and family planning, making affordable childcare services available, generating job opportunities in the manufacturing and services sectors, and establishing a work environment that is supportive of maintaining a work-life balance for women. The age-period-cohort (APC) analysis suggests that enhancing female labor force participation in Pakistan entails providing childcare services, particularly for urban women, and improving access to tertiary education in rural areas. Increasing participation of married women from younger cohorts suggests the need for policies promoting gender inclusion in the workforce. Further investigation is needed to examine the transition of individuals or cohorts in and out of the labor market, which can provide a more comprehensive understanding of the dynamics at play.

Third chapter investigates the gender aspect of the mobile phone ownership gap and its implications for women's participation in the workforce within the context of Pakistan, a country with most considerable digital divide. The results of Oaxaca-Blinder decomposition highlight a pronounced gender digital divide in Pakistan, primarily stemming from socio-cultural norms that restrict women from harnessing technological advancements. The constant term of the coefficient

effect underscores that women residing in rural areas constitute the most disadvantaged demographic group, experiencing persistent disparities in mobile phone ownership and utilization. Furthermore, the decomposition analysis of mobile phone ownership gap between rural and urban areas underscores that variations in observable attributes such as income, education, literacy, labor force participation, household size, and household wealth account for nearly all the disparities in mobile phone ownership between rural and urban women. Given the lower levels of female labor force participation in Pakistan, the chapter explores the impact of mobile phone ownership on female labor force engagement through an instrumental variable approach. Consistent with previous research taking into account various digital tools (internet use, mobile phone, smartphone), our findings indicate a positive association between mobile phone ownership and increased participation (36.2%) of females in the labor force.

In terms of policy implications, it is essential to broaden employment opportunities for women in rural areas through digitalization while equipping them with digital resources and enhancing their skills. Offering digital training and upskilling to urban and rural women, especially from low-income households, can both narrow the gender digital gap and boost their economic prospects by increasing their labor force participation. The results unveil that rural women encounter constraints in accessing digital technologies, education, and finances, which hinders their ability to contribute to rural and agricultural development. It is important to implement interventions focused on rural women's access to affordable and reliable mobile networks. Tailored solutions, such as providing agricultural advisory, market price information, weather updates, and input quality details, as well as creating off-farm employment opportunities through interactive voice response (IVR) or short text messages, can empower women to actively participate in rural development.

The conclusions drawn in this chapter have certain limitations. First, the primary variable of interest combines ownership of mobile and smartphone devices, potentially yielding different impact on female labor force participation. Second, due to data limitations, the analysis lack adequate information about the specific purpose for which mobile phones are used, hindering our understanding of the channels through which mobile phones might facilitate female labor force engagement. Third, our conclusions rely on cross-sectional data, restricting our ability to analyse the dynamic association between mobile phone ownership and female labor force participation.

The fourth chapter provides a comprehensive analysis, incorporating both qualitative and quantitative methods, to examine the impact of mass transit and ride-hailing services on female labor force participation in Lahore, Pakistan. Employing the synthetic control method, the findings indicate a modest yet favorable impact (1%) of metro bus transit on female labor force participation in Lahore. However, the introduction of ride-hailing services did not result in a significant increase in female labor force participation. The qualitative (thematic) analysis findings reveal that a significant portion of interviewed women find public transportation options to be cost-effective and within their financial means. In contrast, ride-hailing users indicated that this option is relatively more expensive. Still, they can manage it due to their relatively higher incomes. In terms of accessibility, persistent challenges arise due to inconvenient placement of stations, requiring the

use of alternative transportation modes that can be costly and time-consuming. Travel duration becomes a crucial factor in selecting between various transportation modes. The metro system stands out as a time-efficient option due to its frequent service with a three-minute headway and a dedicated route free of traffic congestion. Regarding safety concerns, users of both public and private transportation services commonly reported never experiencing harassment in either of these mobility choices. The findings also reveal a lack of gender-inclusive transport planning in Pakistan.

From a policy standpoint, the chapter recommends to enhance the accessibility of public transportation, especially by strategically positioning metro stations and implementing feeder routes in areas with a significant female labor force concentration. Secondly, improving the safety and security of female passengers in public transportation involves increasing the number of female transport personnel, implementing gender-sensitive training, and strengthening the monitoring and reporting system. Furthermore, it is important to promote the involvement of women in decision-making processes related to the planning and design of transport infrastructure. Regarding ride-hailing services, the cahpter suggest implementing following policies to encourage the use of ride-hailing among employed females from low-income households. First, collaborating with ride-hailing companies to provide reduced fares or subsidized rides to females meeting certain criteria, for instance those with low-income or employed in particular sectors. Second, through partnership with employers and organizations to offer ride-hailing benefits to their female staff members. It is also advisable for service providers to foster increased female participation as ride-hailing drivers by forming partnership with women-focused organization. This collaborative effort will facilitate the recruitment of potential female drivers and provide then with essential training and support. Finally, regularly evaluating the effectiveness of both public and private transportation services, including their impact on female labor force participation, and adapting policies and interventions as required, is essential.

There are several challenges related to data availability and analysis that should be explicitly addressed. First, utilization of household data to create city-level aggregates fails to encompass all the predictors essential for assessing female labor force participation at an aggregate level, thus constraining the applicability of the synthetic control method. Second, the introduction of ride-hailing services in numerous metropolitan cities in Pakistan, sharing socioeconomic similarities with Lahore, has led to a poor match between synthetic Lahore and real Lahore. It is also important to mention that, owing to the unavailability of data sets (LFSs) from 2015-2016, the analysis selected 2014 as the intervention year for analyzing the impact of ride-hailing services, in order to align with pre-intervention predictor balance.

1.4 Organization of the thesis

The entire thesis is structured in the following manner. Chapter one provides an introductory overview in which the thesis introduces the study, presents the underlying motivation and context,

and concludes with policy recommendations. In the second chapter, research objectives one and two are addressed. The chapter analyses the patterns and causes of female labor force participation in Pakistan over the last three decades by constructing a synthetic panel of nationally representative labor force surveys from 1990 to 2017. The chapter employs an age-period cohort model to investigate variations in female labor force participation, studying how labor market behavior has evolved across different time periods and generations.

The third, fourth, and fifth research objectives are explored in the third chapter. The chapter employs the nationally representative PSLM survey (2019-2020) to examine the gender digital divide and asses the association between digitalization (ownership of mobile or smartphone) and female labor force participation. This investigation utilizes Oaxaca-Blinder decomposition and instrumental variable approach. Research objectives six and seven are achieved in the fourth chapter. The chapter adopts a mixed-method approach to estimate how mass transit and ride-hailing services affect female labor force participation in Lahore, Pakistan. The quantitative section employs the synthetic control method, involving the construction of a synthetic Lahore dataset for comparison. Furthermore, the qualitative analysis seeks insights from female commuters utilizing these services. The analysis draws on Labor Force Surveys spanning from 1999 to 2020 and primary data gathered through semi-structured interviews conducted in July and August 2022.

CHAPTER 2

2 Patterns and Causes of Female Labor Force Participation: An Age-Period-Cohort Analysis for Pakistan[12]

Abstract

Female participation rates in Pakistan's labor force are well below regional averages despite approximately 9 percent growth in the past three decades. To probe the underlying causes of the dynamics of female labor force participation in Pakistan, we use a synthetic panel constructed from nationally representative labor force surveys (1990-2017). The results indicate that the rising population share of working-age women does not account for changes in aggregate labor force participation rates. The age-period-cohort analysis demonstrates that for cohorts born since the 1900s, urban females' age effects follow a slight M-shaped curve, representing the child-raising phase during which females reduce labor force participation. The cohort effects signal an increase in the labor force participation of cohorts born after the 1950s. This is particularly the case for married females and females with less education that traditionally have weaker attachments to the labor markets due to social norms. Therefore, understanding and identifying the factors that can have an effect on the inhibiting role of social norms is central to devising policies to foster female labor force participation.

Keywords Demographic, female labor force, synthetic panel, age–period–cohort, Pakistan
JEL Classification J16, J21, J22

2.1 Introduction

Women constitute almost 50 percent of the world population, yet overall female contributions to economic activity are far below their potential. Despite remarkable growth over recent decades, females remain underrepresented in the labor force. The percentage of women participating in the labor force declined from 50.9 percent in 1990 to 47.7 percent in 2019.[13] However, substantial differences exist concerning female participation in the labor force across regions. Mincer (1985) finds considerable differences in female labor force participation across 12 industrialized countries over 20 years. Nevertheless, these countries have experienced a common trend of rising female

[12] **Amber, H**., & Chichaibelu, B. B. (2023). Patterns and Causes of Female Labor Force Participation: An Age–Period–Cohort Analysis for Pakistan. Population Research and Policy Review, *42*(2), 20. https://doi.org/10.1007/s11113-023-09751-9.

[13] Catalyst (2021) *Women in the Workforce – Global: Quick Take.* https://www.catalyst.org/research/women-in-the-workforce-global/.

labor force participation over the past few decades. For developing countries, Klasen (2019) finds heterogeneous trends in female labor force participation rates, moderate upturns in the Middle East, and an increase in Latin America, whereas female labor force participation has declined in South Asia.

South Asia presents a gloomy picture of the second lowest women's employment participation rates after the Middle East and North Africa (Kapsos et al., 2014). Moreover, the participation of women in economic activity is the lowest for females in the age group between 15 and 29. Between 1990 and 2020, Pakistan, Bangladesh, and Afghanistan each witnessed increasing female labor force participation. However, for India and Sri Lanka, female labor force participation has declined since 1990. Among South Asian countries, female labor force participation in Pakistan is well below the regional average, despite growing by approximately 9 percent over the past three decades (Figure 2.1). According to ILO estimates of labor force participation in Pakistan, the percentage of females in the labor force went from 13.95 in 1990 to 21.67 in 2019.[14] Although the change has been steady, female labor force participation reached a minimum of 12.51 per cent in 1995 and a maximum of 23.86 per cent in 2015.

Females' participation in the labor force constitutes a decision that is dynamic in nature because women enter into and exit from the labor force at different points in their lives (Sarkar et al., 2019). For instance, Gutierrez-Domenech (2005) examines the employment transition of women following the advent of motherhood in five European countries, observing a high transition from employment to unemployment for both Germany and Spain. The author also identifies changes in working hours after motherhood, which demonstrate the transition from full-time to part-time employment.

[14] https://data.worldbank.org/indicator/SL.TLF.CACT.FE.ZS?locations=PK.

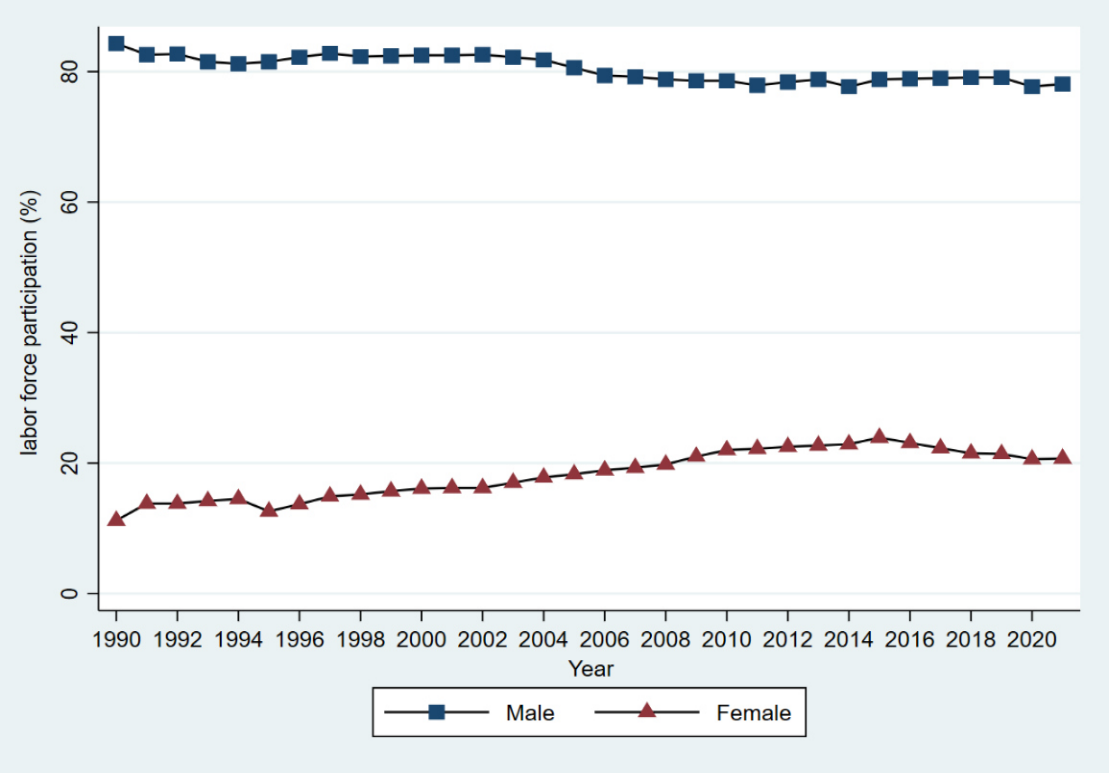

Figure 2. 1 Labor force participation rates (%) of males and females (1990-2020)
Source *World data bank (ILO modelled estimates)*

Age-period-cohort analysis presents a needed analytical tool for the analysis of female labor force participation by considering changing labor market behavior over time and across generations (Paweenawat & McNown, 2018). Previous research on labor force participation using cohort-based models offers comprehensive explanations of these changes across cohorts (Balleer et al., 2014; Beaudry and Lemieux, 1999; Fitzenberger et al., 2004; Fakuda, 2006; Grigoli et al., 2021; Joshil et al., 1996; Lassassi & Tansel, 2020; Lee, 2014; Nientker & Alessie, 2019; Paweenawat & McNown, 2018; Tunali et al., 2021). For instance, younger cohorts enter the labor market with lower fertility rates and higher educational attainment than older cohorts do, and hence, they are more likely to participate. Tunali et al. (2021) examine labor force participation of Turkish women with a synthetic cohort analysis, noting that later cohorts participate more in the labor force. Similarly, in terms of advanced economies, the entry of new cohorts has improved aggregate participation rates, indicating the progression of social norms and preferences (Grigoli et al., 2021).

Thus far, there is a dearth of literature examining the dynamics of female labor force participation in Pakistan by applying cohort analysis. Research on employment has largely been performed using cross-sectional data sets from labor force and Pakistan Social and Living Standards Measurement surveys (Arif et al., 2002; Azid et al., 2010; Ejaz, 2011; Fafchamps et al., 1999; Ferdoos, 2005; Khaliq et al., 2017). Arif et al., (2002) are the only ones to investigate labor market

dynamics using panel data from the Pakistan Socio-Economic Survey (PSES), demonstrating that women's transitions from unemployment to employment are slow in Pakistan. Age and marital status of females are also found to have a negative influence on the transition from employment to unemployment. Moreover, females with below-college-level education are more likely to lose their jobs than those with college educations are. Another panel study conducted by Fafchamps et al. (1999) presented an analysis of human capital, labor productivity, and labor allocation in rural Pakistan. One of the main findings is the absence of evidence supporting the effect of education and nutrition on female labor productivity and labor market allocation.

An important contributing factor that accounts for the changes in labor force participation in the end is the change in demographic distribution. It has been observed that changes in the female populations' demographic structure account for changes in overall participation rates (Lichter & Costanzo, 1987). Pakistan's population statistics indicate a gradual increase of females in the total population, from 46.4 percent in 1960 to 48.5 percent in 2019.[15] However, the contribution of this growth in female population to economic participation is under-researched. This study fills this gap by examining the patterns of female labor force participation in Pakistan over the past three decades,[16] applying an age-period-cohort (APC) analysis. It also contributes toward understanding the long-recognized puzzle of the potential contributions to slow growth in female labor force participation.

The present study aims to achieve two objectives, (1) to investigate the contribution of demographic changes to changes in aggregate female labor force participation and (2) to analyze the determinants of the dynamics of female labor force participation by dividing total change into age, period, and cohort components for separate examination. To this end, the study uses annual labor force surveys (1990–2017) to construct a synthetic panel data set to support the analysis of the dynamics of female participation in Pakistan's labor force. The use of a synthetic panel allows the study of the dynamic behavior of a population group that would not be possible with a single cross-sectional data set (Duval Hernández & Orraca Romano, 2009). The study separates changes in aggregate female labor force participation into changes attributable to population share and those attributable to labor force participation within each age group category in order to identify the influence of demographic fluctuations. The age–period–cohort model aims to explain the following: (1) differences in labor force participation over the lifetime; (2) variations in labor force participation due to differences over the years, when women are exposed to different events simultaneously; and (3) differences in labor force participation due to differences in the year of birth. The analysis also separately examines location and education level. Additionally, we perform analysis for marital status and results are presented in the appendix. Location is divided into rural and urban domains. Marital status is divided into two categories of ever-married (including married, divorced, and widowed females) and never married. Furthermore, the

[15] https://data.worldbank.org/indicator/SP.POP.TOTL.FE.ZS?locations=PK

[16] There has not been much variation in the labor force participation of men over the past three decades. It hovers around 80 percent. This is the reason for which the study primarily focuses on female labor force participation.

subdivisions of education include no formal education, primary education, secondary education and tertiary education.

The results demonstrate that the rising population share of working-age females does not account for changes in aggregate labor force participation rates between 1990 and 2017. It reveals that Pakistan has not taken advantage of its demographic dividend.[17] For the cohorts born since the 1900s, the age effects follow an inverted U-shaped curve. However, urban females' age effects reveal a slight M-shaped curve, representing a child-raising phase during which labor force participation is reduced. The cohort effects of labor force participation plateaued around the 1990s and began to decline more recently. Therefore, the declining labor force participation of recent cohorts is limiting the gains Pakistan could reap from its demographic dividend.

The remainder of this paper is organized into five sections. "Theoretical background and related literature" provides an overview of related theories and literature. In "Data and descriptive statistics", we describe the construction of synthetic panel and map out the general trends using the constructed data set to provide clarity regarding the rationale behind this research. "Empirical methodology" presents a description of the techniques used to analyze the data into distinct subdivisions of analyses. The first part explains the methodology applied to disentangle aggregate labor force participation into compositional and participation components. The second part explains the APC methodology and the two methods that were used to subdivide APC effects. "Estimation results" discusses the results and interpretations. This section is divided into two subsections. The first subsection provides the results of the decomposition analysis of the overall change in female labor force participation. Furthermore, the second subsection presents the results of age effects, cohort effects, and period effects respectively. "Conclusion and policy recommendations" section concludes the paper with pertinent policy recommendations.

2.2 Theoretical background and related literature

The topic of labor supply dynamics is one of the most researched domains in the economics and social science literature. Below, we will explore two specific strands of the literature to describe the objectives of this study.

First, the theory of demographic transition refers to variations in population structure, from high birth and death rates indicating low technological advancement, education levels, and development, to low birth and death rates accompanying improved technology, education levels, and economic development. Demography is correlated with female labor force participation through its link to fertility rates (Abraham et al., 2017). Many researchers (Aaronson et al., 2006; Fuchs, 2008; Guettabi, 2019; Hotchkiss, 2009) have examined the contribution of demographic

[17]The term *demographic dividend* refers to a stage in demographic transition wherein an increased working-age population has the potential to serve as an economic benefit (Durr-e-Nayab 2006).

shifts to aggregate labor force participation. Changes in the demographic structure of female populations account for substantial differences in overall participation rates (Litchter & Costanzo, 1987). For example, Smith (1977) reports that, for the U.S. economy, changes in the demographic structure of females in the labor force between 1971 and 1975 accounted for 28 percent of the increase in participation. The decline in fertility during demographic transition also serves to increase female labor force as women with fewer children are more likely to participate in the labor force (Sullivan, 2019). Such demographic shifts facilitate improvement in labor force participation through two effects. First, the composition effect refers to the changes in overall participation attributable to the change in each age category's population share. Lee (2014) finds that composition effects from education, marriage, and child rearing account for 7, 11, and −2 percent changes in female labor force participation in the U.S., respectively. Second, the behavioral effect relates to a population's characteristics or behaviors that translate into the labor market inclusion of women. For example, characteristics that inhibited female labor force participation, including the number of children, marriage, and low levels of education, have declined over the years. However, changing behaviors (e.g., social norms) are recognized as more influential in pulling women into the labor force (Hotchkiss, 2006). In general, demographic transition changes aggregate labor force participation through changing each age category's population share, which might translate into increased participation. Thus, the following hypothesis is proposed:

H_1: Changes in population share account for substantial changes in aggregate female labor force participation.

Testing this hypothesis by tracing change in population composition is relevant, as changes due to demographic structure might misleadingly be interpreted as part of behavioral change. Observed variations in female labor force participation may result from a change in population behavior over the years; for instance, changing social norms with regard to girls' education might translate into higher female labor force participation.

The second strand of the literature follows an analysis of three sources of change in labor force participation rates, i.e., age, cohort, and period,[18] and requires labor supply models that reflect different periods over which these considerations can be observed. The first source relates to life cycle models that differ from static labor supply models,[19] considering the allocation of time

[18] Participation at a given age; participation in the given birth cohort; and participation due to the influence of institutional changes.

[19] The neo-classical model of labor–leisure choice is typically used to analyze individuals' life supply behavior (Borjas, 2010). According to this model, individuals decide how much time they will spend working by mapping out competing utility gains from work and leisure. The simple model of labor supply has been elaborated in many different ways. For example, work and leisure decisions made over the life cycle result in a predictable path, and labor supply decisions are often made within households, rather than by individuals alone (Johnston 2005).

between work and leisure over individual lifetimes (Owen, 1989). Labor force participation over a lifetime has been shown to follow an inverted U-shaped curve, wherein younger cohorts are more likely to participate in the labor force than earlier ones are (Abrahamsen, 2015; Duval Hernández & Orraca Romano, 2009; Goldin & Mitchell, 2017; Lee, 2014). Tunali et al. (2021) reveal an M-shaped curve in rural areas and for low-educated females in urban areas. Evidence from Turkey also demonstrates that participation rates of rural women are higher than those of urban women and that rural women remain in the labor force longer than their urban counterparts. However, a study of five selected Middle Eastern and Northern African (MENA) countries describes the same participation rates for rural and urban females (Lassassi & Tansel, 2020). Thus, we can propose the following hypothesis:

H_2: Female labor force participation over the life cycle depends on the timing of education, children, and retirement.

Cohort-based models capture unobserved sources of shifts in labor force participation between various generations (Balleer et al., 2014). Cohort effects can explain differences in labor force participation over the life cycle that can be attributed to the choices made earlier in life, e.g., education, marriage, and fertility. For example, women from later cohorts are more likely to participate in the labor force and exit from the labor market less often when they have their first child than women from older cohorts are (Nientker & Alessie, 2019). Further, participation rates of ever-married females in Egypt are increasing across the cohort, whereas they are decreasing for never-married females (Lassassi & Tansel, 2020). In general, changes in social norms and policy interventions affect individuals' choices of participation in the labor market. Hence, we formulate our third hypothesis as follows:

H_3: Higher educational attainment, decreased fertility rates, and changed social norms allow younger cohorts to participate more in the labor force.

The third source describes the behavior of workers who adjust their labor participation to take advantage of economic opportunities brought about by business cycles (Borjas & Van Ours, 2010). The relationship between business cycles and labor force participation can be explained with the help of two effects. The discouraged worker effect occurs when during an economic downturn, many workers find it difficult to find work; hence, they give up. In contrast, the added worker effect arises during a recession, when secondary workers join the labor force when the main breadwinner becomes unemployed; hence, the labor force participation of secondary workers exhibits a counter-cyclical trend. Women's participation in the labor force is considered a coping strategy during recessions. Başlevent & Onaran (2003) find that women's labor force participation follows a counter-cyclical trend; hence, the added worker effect dominates the discouraged worker effect. However, Benati (2001) and Gregg (1994) identify the discouraged worker effects for the U.S. and the U.K., respectively. Thus, we propose our fourth hypothesis as follows:

H_4: Female labor force participation follows a pro-cyclical behavior.

All hypotheses presented are tested for aggregate female labor force participation over the past three decades as well as labor force participation disaggregated by education level, location, and marital status.

2.3 Data and descriptive statistics

The study uses annual rounds of labor force surveys (LFSs) taken over 27 years (1990–2017) obtained from the Pakistan Bureau of Statistics.[20]We do not have all the datasets from 1990 to 2017. Labor force survey was not conducted for the years 2011, 2015 and 2016. Additionally, data sets were not available for the years 1995, 1998, 2000, 2002 and 2004. The Pakistan Bureau of Statistics launched a LFS for the first time in 1963, and LFSs have since undergone suitable improvements in questionnaire design and methodology. The questionnaire was improved in 1990 to include additional economic activities. LFSs provide data on the sociodemographic attributes of the total population, including age, gender, marital status, level of education, and current employment. The LFS also collects data on different elements of the labor force, such as the number of persons employed, unemployed, underemployed, or out of the labor force. LFSs are the primary source of labor force statistics of the population of Pakistan. Because of the dearth of longitudinal data sets for Pakistan that track individuals' labor force participation over their life course, cross-sectional data provides a good source to trace people who share some common features, e.g., a birth year. LFSs are the only independent cross-sectional surveys to have been conducted in Pakistan on a regular basis since 1963 and are most suitable for conducting our APC analysis.[21] We use labor force surveys until 2017. According to the annual report of LFS (2017-2018), the enumeration of the sampled households took place between July 2017 and June 2018.

This study constructs a synthetic panel from repeated cross sections of LFSs to identify cohorts and follow them over time, wherein cohorts are defined by date of birth. The birth year is computed as a survey year subtracting age. A synthetic panel constructed from repeated cross-sectional data sets has an advantage over panel data in that it does not incur the problem of attrition and that it is less susceptible to measurement error (Deaton, 1997). Although the synthetic panel has the shortcoming of the inability to follow the same individuals over time, it is more useful than short-lived panel data as it covers a sufficiently lengthy time (Duval Hernández & Orraca Romano, 2009).

In this study, labor force participation for each cohort is calculated as the sum of employed and unemployed individuals divided by active and inactive individuals in each age category and each

[20] The questionnaires and methodology of the LFSs can be accessed at https://www.pbs.gov.pk/content/labor-force-statistics.

[21] Other cross-sectional surveys, the PSLM (2004–2015) and the Demographic Household Survey (1990–2017) are not conducted annually.

year.[22] Employed females include the females 15 years and above who (1) work(ed) for pay, profit, or family gain, during the reference period, for at least 1 hour any day, and (2) had a job or enterprise, even if, for some reason, they did not work in the reference period. The reference period for the above mentioned questions is one week. Unemployed females comprise females 15 years and above who are (1) not working; (2) looking for work during the reference period; and (3) available for work during the reference period. The study calculated labor force participation rates for all females aged 15 and above as well as by education level, marital status, and location. To structure a measure of education level that is same over all the surveys, the study divides education levels into four categories: (1) no formal education; (2) primary education: grades 1–8; (3) secondary education: grades 9–12; and (4) tertiary education: above 12 grades or years. The study divides marital status into two categories: (1) ever-married (which includes married, widowed, and divorced) and (2) never-married. To account for the effects of fertility changes over the years, married females' labor force participation effects are observed. Location classification delineates between urban and rural.

For the sake of amenability, the study tracks female labor force participation rates for various age groups: 15–19, 25–29, 30–34, 35–39, 40–44, 45–49, 50–54, 55–59, 60–64, 65–69, 70–74, 75–79, 80–84, and 85 and above. Summary statistics for each age group are presented in Table A1,[23] reporting the participation rate and sample size. Labor force participation rates follow an inverted U pattern, wherein women participate less at an early age but increase their participation with age and begin to decline after retirement age. In addition, participation rates for different categories of marital status, location, and education are also presented.

Figure 2.2 presents the labor force participation rates for various cohorts over their life cycle. The pattern suggests that labor force participation in later cohorts is higher than that in earlier cohorts for the same age group. For example, for the age group 45–49, the highest participation is from the 1970 cohort, followed by 1965, 1960, and older cohorts. The Figure 2.2 clearly shows that females participate more in the labor force in their late 30s and early 40s, confirming the existence of a U-shaped path in the supply of labor over their life cycle.

[22] The labor force participation rates are calculated for females aged 15 years and above, while labor force participation rates reported by the Pakistan Bureau of Statistics are calculated for females aged 10 years and above.

[23] See Appendix

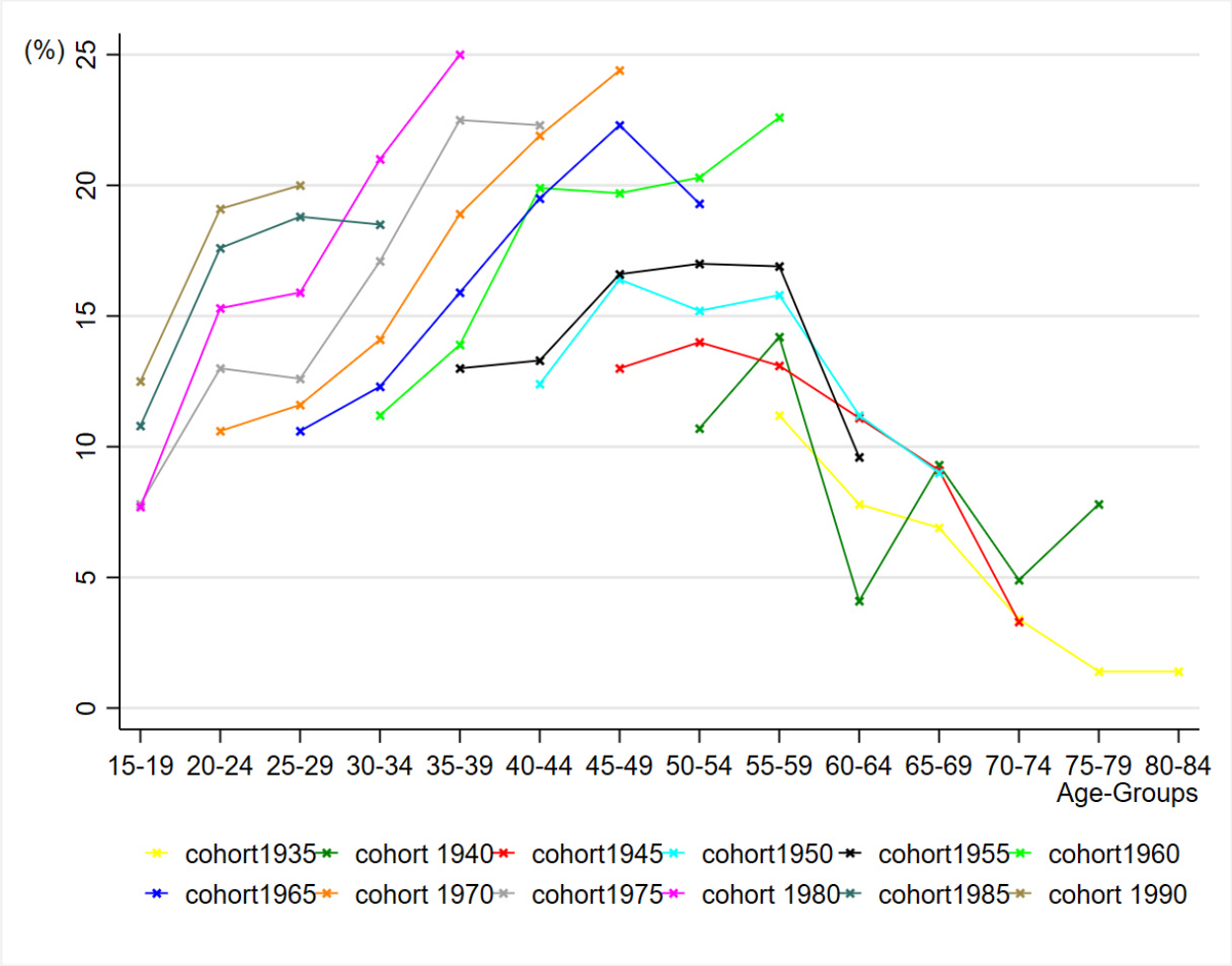

Figure 2. 2 Female labor force participation by cohort.
Source *Authors' own calculations from labor force surveys.*

Changes in the population's age structure are considered a vital source of change in labor force participation.[24] Pakistan is undergoing the most important demographic development in recent decades as its working-age population is increasing alongside a decline in the dependency ratio (Durr-e-Nayab, 2006). As shown in the left-hand-side panel in Figure 2.3, the female population share between the ages of 20 and 60 increased sharply between 1990 and 2017, whereas the share of the female population between 0 and 15 years of age has decreased. Moreover, the Population Council projects that the working-age population's share will continue to rise until 2050.[25] This might influence females' aggregate participation rate as they constitute 48.54 percent of the total population.[26] As a typical life cycle pattern of labor force participation in the right-hand-side panel shows an increase in labor force participation from the working-age population.

[24] See Aaronson et al. (2006), Grigoli et al. (2021), and Hotchkiss (2009).
[25] See Figure A13 in the Appendix.
[26] https://data.worldbank.org/indicator/SP.POP.TOTL.FE.ZS?locations=PK

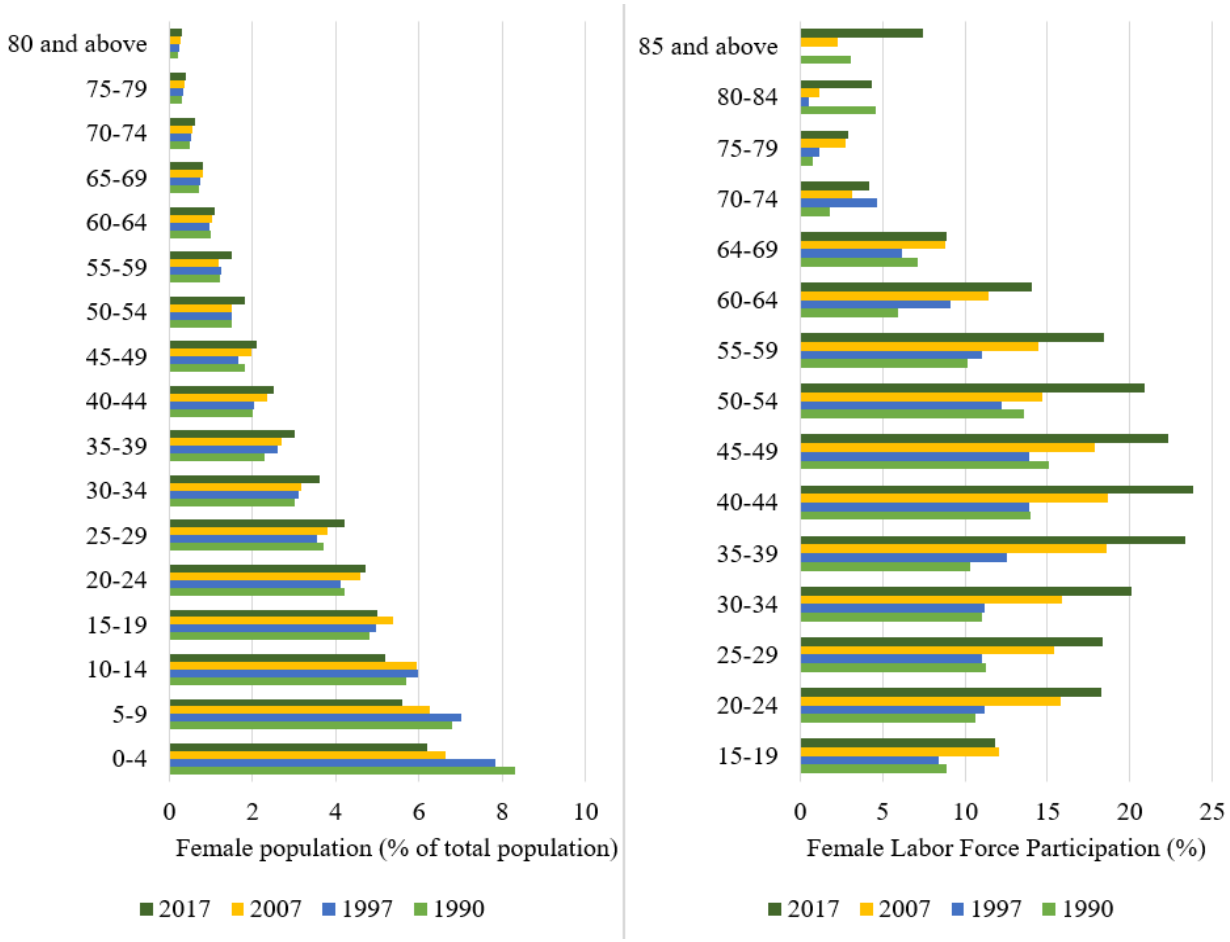

Figure 2. 3 Labor force participation rates and population shares of females for different age groups and years.

Source *World Bank data and authors' own calculations from labor force surveys*.

The increased female labor force participation observed over the past three decades could be attributed to the rise in female education levels. As reported by many researchers, an increase in female education level is accompanied by an increase in female labor force participation (Dao et al., 2021; Duval Hernández & Orraca Romano, 2009; Goldin & Mitchell, 2017; Klasen & Pieters, 2012; Lee, 2014). The left-hand-side panel in Figure 2.4 demonstrates this positive relationship between education and labor force participation. Moreover, the percentage of women in primary, secondary, and tertiary education has risen across birth cohorts. In comparison, the percentage of women with no formal education has steadily decreased across birth cohorts. Females with no education are participating more in the labor force than are females with primary and secondary education across all birth cohorts although their share in the population is steadily decreasing. Women with primary and secondary education reside more in the urban areas which comes with

certain constraints that hinder their labor force participation. For instance, restriction on the physical mobility outside the home is an important determinant of low female labor force participation in urban Pakistan (Field and Vyborny 2016). Klasen & Pieters (2012) have shown, in the case of India, that labor force participation of less educated women is determined by economic push factors, whereas the participation of females with high levels of education is determined by economic pull factors.

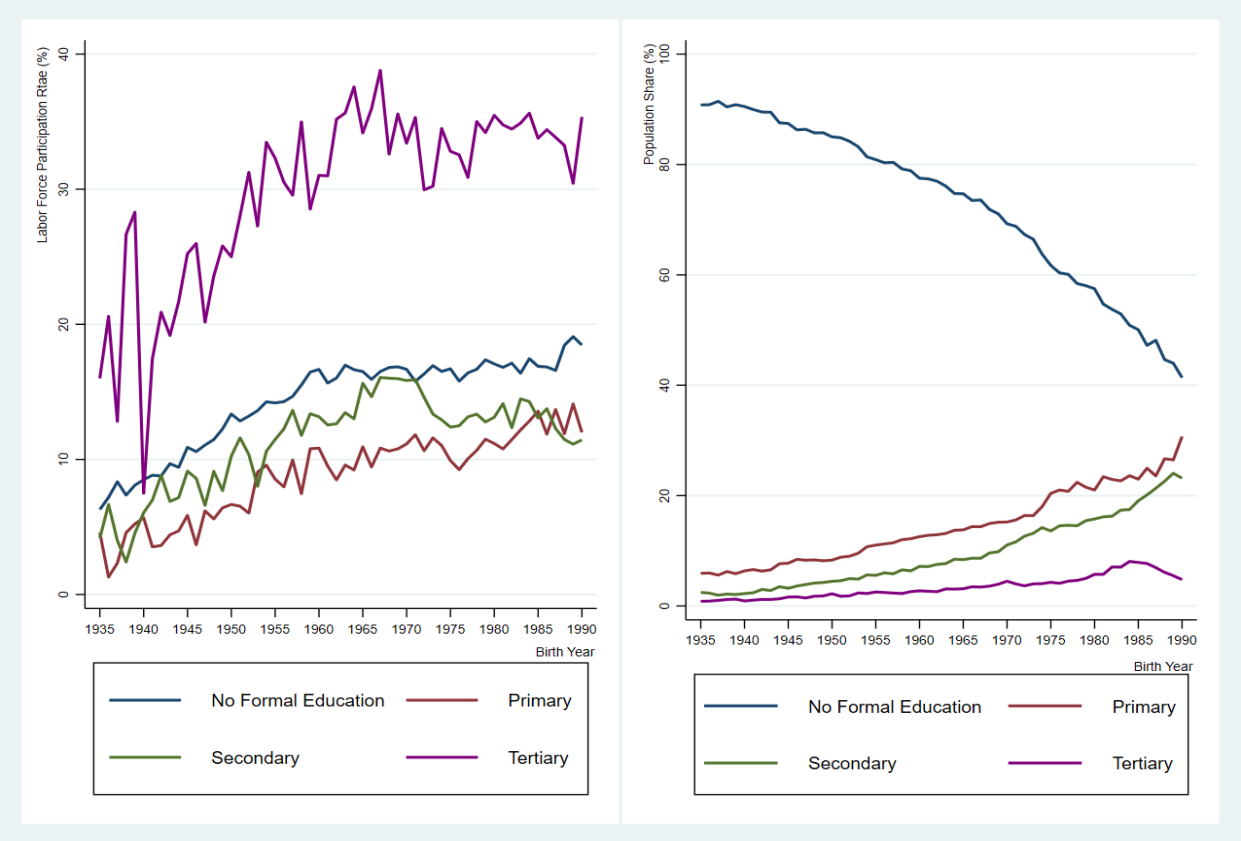

Figure 2. 4 Female labor force participation rates and percentage of women by education level and birth year.

Source *Authors' own calculations from labor force surveys.*

2.4 Empirical methodology

2.4.1 Decomposition of change in total labor force participation

To probe how demographic changes have contributed to the changes in labor force participation since 1990, the study performs a decomposition analysis of the overall change in female labor supply. The method decomposes observed changes in aggregate labor force participation into

different components,[27] which should not be considered causal components because other factors could also be attributed to these changes (Fuchs, 2008). An analysis of causal influence is beyond the scope of this study.

Formally, aggregate female labor force participation can be written as the sum of labor force participation for each age group and its respective population share in the year t:

$$Lfpr_t = \sum_i (P_t^i * lfpr_t^i) \quad (1)$$

where i denotes age group and t is the year. P_t^i is the share of the population of age group i in the year t, and $lfpr_t^i$ is labor force participation rate of age group i in the year t. A decomposition analysis can be performed by disaggregating total female labor force participation between a year (t) and a base year (t = 0) into three components:

$$Lfpr_t - Lfpr_0 = \sum_i \{[lfpr_0^i(P_t^i - P_0^i)] + [P_0^i(lfpr_t^i - lfpr_0^i)] + [(lfpr_t^i - lfpr_0^i) * (P_t^i - P_0^i)]\} \quad (2)$$

Equation (2) decomposes changes in labor force participation between two periods into changes due to population share and changes attributable to labor force participation within each age group category. The third part is the interaction effect that shows simultaneous changes attributable to the first two components.

2.4.2 Decomposition of age, period, and cohort effects

APC models are widely used to analyze the behavior of individuals or populations over time. The APC model divides age, period, and cohort effects for a particular outcome of interest. The age effect corresponds to the influence of aging, whereas period and cohort effects correspond to the influence of the survey year and the subject's date of birth. Frost (1939) employed this approach to perform a descriptive analysis in his classic study of tuberculosis. Ever since, it has become a popular tool in data analysis and is commonly used in various fields, including sociology, epidemiology, demography, economics, and business. In economics, APC models are used to examine labor market behavior, saving, and consumption patterns over time. Age effects explain the differences associated with different subjects within a population at different life stages related to schooling, work, marriage, fertility, etc. Period effects relate to changes in certain years wherein all subjects within a population are exposed to specific events simultaneously, e.g., recessions, pandemics, epidemics, wars, environmental changes, and policy interventions. In contrast, cohort effects refer to variations across subjects with shared life experiences, such as birth year and graduation.

The APC model for labor force participation can be expressed as follows:

$$lfp_{iapc} = \alpha + \beta_a A_{ap} + \gamma_p P_p + \delta_c C_c + \varepsilon_{iapc} \quad (3)$$

[27] See Aaronson et al. (2006), Grigoli et al. (2021), and Hotchkiss (2009).

The above equation[28] shows labor force participation by individual i, at age a, belonging to cohort c in period p. A, P, and C represent dummies for age, period, and cohort, respectively. Moreover, a = 1… n; p = 1… n; and c = 1… (p − a). Hence, c = p − a. A_{ap} is equal to 1 if individual i is aged a at the end of year p. C_c is equal to 1 if individual i was born in year c, and P_p is equal to 1 if labor force participation is recorded in year p. Lfp is a dummy variable that equals 1 if individual i at age a born in year c participates in labor force in year p.

2.4.2.1 Identification problem

APC models suffer from a well-known conundrum of identification with reference to the perfect collinearity among age, period, and cohort effects: survey year (period) = year of birth (cohort) + age. The identification problem makes it impossible to observe independent variations among these variables, consequently making it difficult for standard regression models to separate them (Browning et al., 2012). The literature on the APC methodology offers many possible solutions and identification strategies (Browning et al., 2012; Deaton & Paxson, 1994; Hanoch & Honig, 1985; Yang & Land, 2008).

One of the simplest ways to manage the identification problem is to set age, period, or cohort effects equal to 0. This can be applied to each variable in three different equations, and the models can be estimated by using ordinary least squares (OLS). This solution seems impractical because if removing one variable causes two effects to change dramatically, then the removed variable might be important for the total effect (Abrahamsen, 2015).

Another way to address the APC identification problem is using proxy variables to capture the effect of explanatory variables. For instance, a proxy variable can be used for the period that is not correlated with age and cohort. Euwals et al. (2011) use unemployment rate as a proxy variable for period effects. However, the reliability of results depends on the choice of proxy variable and the proxy (Abrahamsen, 2015) explains not all the potential variations in explanatory variables.

The Deaton–Paxson normalization approach to address the identification problem was first popularized by Hanoch & Honig (1985) and further elaborated by Deaton & Paxson (1994). It requires applying an extra parametric restriction so that the APC model is just identified. This involves detrending so that period effect dummies are orthogonal to a trend and sum to 0. This method is more plausible when there are sufficient years for trend and cycle to be separated (Browning et al., 2012). Despite applying an arbitrary restriction, this method is most widely used by researchers to employ APC models (Abrahamsen, 2015; Browning et al., 2012; Epstein, 2018; Nientker & Alessie, 2019; Tunali et al., 2021).

The maximum entropy approach of Browning et al. (2012) is the most recent method of addressing the identification problem introduced in the APC literature. It offers an approach that can formalize

[28] We estimate the model for averaged version, i.e., $lfp_{apc} = \sum_{i=1}^{n_{apc}} lfp_{iapc}$.

uncertainty in the model. Instead of providing one unique solution, this method estimates the *most likely* solution. The main idea is to reparametrize the APC model's coefficient vector in terms of a probability distribution over the set of possible solutions, from which to choose the probability distribution that has the maximum entropy allowed by the data.[29] Browning et al. (2012) note that this approach is best employed in cases wherein the set of possible solutions is enclosed. In economics literature, wherein the application of the APC model is imperative, the outcome variable is naturally bounded, making it plausible to use the maximum entropy approach.

This study applies both the Deaton–Paxson normalization and maximum entropy approaches[30] to test the robustness of our results.[31] These two methods were chosen over others for the following reasons: (1) sufficient years of LFSs almost cover three decades; and (2) the predicted variable, labor force participation rate, is enclosed.

2.5 Estimation results

2.5.1 Decomposition of change in total labor force participation

Table 2.1 presents the contributions of the demographic and participation components in total labor force participation. We perform a decomposition analysis over various periods, and selection of time is arbitrary. As shown in the last row of Table 2.1, the overall change in age structure only accounted for 0.048 percent of the 7.465 percent increase in aggregate participation rate between 1990 and 2017. The results clearly demonstrate that demographic changes do not explain the increase in participation rates between different periods. Therefore, we cannot accept the first hypothesis and infer that changes in aggregate labor force participation are driven by changes in labor supply behavior within different demographic categories. The second row of the table indicates that an increase in participation rate mainly occurred during 1997–2007. This period was marked by high economic growth under the authoritarian rule of General Musharraf.[32] However, the rapid growth in this period is attributed to the aid provided by the United States' government and Washington's financial institutions (Zaidi, 2008). The important steps that might have helped increase women's economic participation include the foundation of the Higher Education Commission in 2002, the establishment of the Ministry of Women's Development as an independent ministry in 2004, and the approval of the Women's Protection Bill[33] in 2006.

[29] For a more detailed description of the maximum entropy method, see Browning et al. (2012).
[30] Yang et al. (2004) propose an intrinsic estimator approach to manage the APC identification problem. This approach elicits primarily the same results as the other approaches and is not discussed in detail.
[31] The results of APC model estimates are close to OLS estimates as we categorize age in fourteen categorize which somehow solve this identification problem.
[32] After a successful military takeover in 1999, General Musharraf became the 10th president of Pakistan (2001–2008).
[33] The bill initiated the legal punishment of rape and adultery in Pakistan.

Table 2. 1 Components of labor force participation rate (LFPR) change as percentage of total change

	Demographic (%)	Participation (%)	Interaction (%)	Total change in aggregate LFPR (%)
1990–1997	0.016	0.169	0.004	0.190
1997–2007	0.025	4.144	0.013	4.188
2007–2017	0.008	3.009	0.068	3.086
1990–2017	0.048	7.343	0.072	7.465

Source *Authors' own calculations from labor force surveys.*

2.5.2 Decomposition by age, period, and cohort

This section explains the results of the decomposition of female labor force participation rate (LFPR) by age, period, and cohort, following the Deaton–Paxson normalization and maximum entropy approaches (Browning et al., 2012; Deaton & Paxson, 1994). The purpose of applying two approaches is to address the identification problem and ensure the robustness of our results. The analysis is also performed separately for location, marital status, and education level. The analysis is conducted for females aged 15 and above and by subdividing age into the 15 previously introduced categories. The oldest birth cohort that can be tracked are the females born in 1891, and the youngest are those born in 2002. All figures in this section provide age, period, and cohort effects of predicted participation rates along with 95 percent confidence intervals.

2.5.3 Age effects in female labor force participation rates

Figure 2.5 below presents the age effects of the LFPR of females aged 15 and above. Labor market activity depends on several demand and supply factors, along with different institutional settings that may result in very distinct age effects (Fitzenberger et al., 2004). Both panels reveal an inverted U-shaped curve for female labor force participation in Pakistan, supporting our second hypothesis. Participation rates increase in early adulthood, remain constant, and begin to decline after the 50s. This might be a result of the joint family system institution of multigenerational cohabitation in Pakistan, wherein child raising and employment are compatible. The results are consistent with other studies' labor force participation age effects (Abrahamsen, 2015; Browning et al., 2012; Lassassi & Tansel, 2020).

When we decompose participation rates separately for urban and rural areas,[34] we observe that urban females' age effects display a slight M-shaped curve. This dip represents the child-raising

[34] The age effects of female labor force participation with subcategories of location, marital status, and education level are provided in the Appendix. Ever-married females' age profiles follow the inverted U-shaped curve. In comparison labor force participation age profiles of never-married females show more fluctuations.

age of females, during which labor force participation is reduced. Grigoli et al. (2021) also find an M-shaped curve without a rural-urban divide for advanced economies. They observe that females from the United States join the labor force earlier than in Europe. However, they drop out at a higher rate in the late 20s and early 30s. Furthermore, a slight M-shaped curve for Egyptian urban women shows the existence of a temporary exit faced by women for childbearing purposes (Lassassi & Tansel, 2020). In some developed countries, married women with children are more likely to work part-time, rather than quitting completely for home responsibilities (Ferriman et al., 2009).

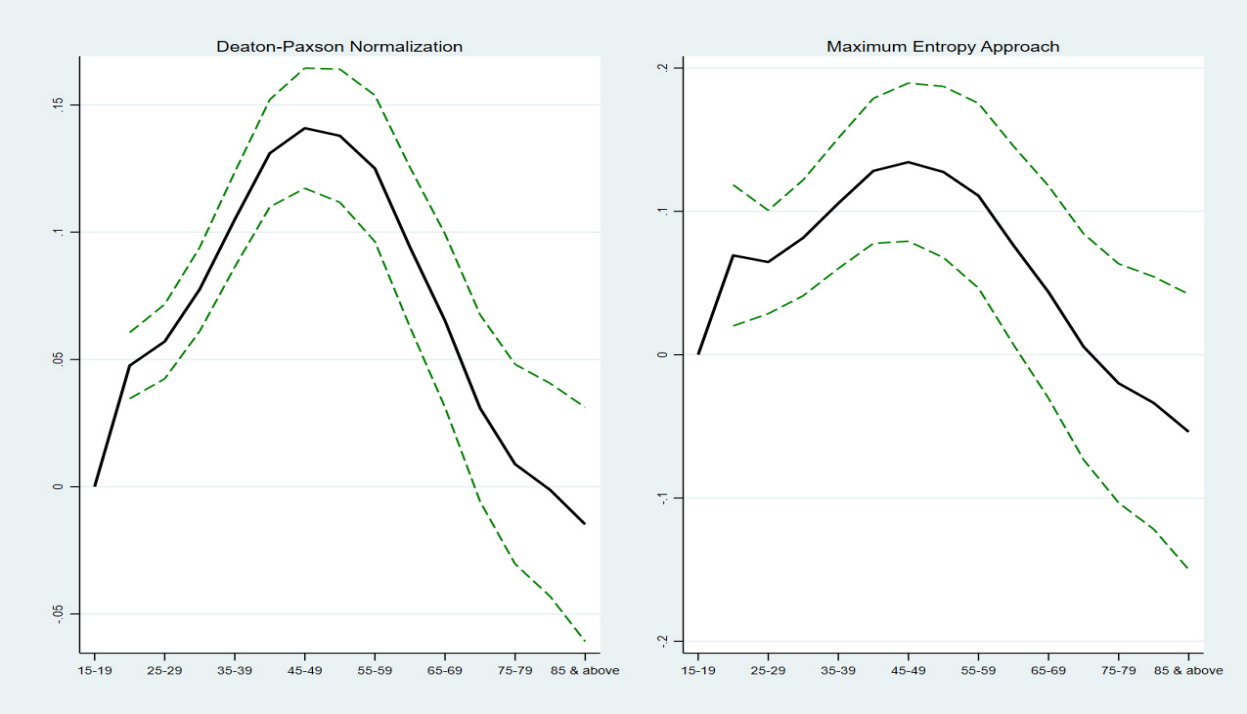

Figure 2. 5 Age profiles of female labor force participation rates.
Source *Authors' own calculations. The black line represents predicted participation rates, and the green lines are 95 percent confidence intervals.*

For rural females, there is an inverted U-shaped curve. A closer look at the age effects of rural and urban females reveals, for almost all the age groups, that LFPRs are higher in rural areas. The same difference of a rural–urban divide has been observed in Turkey (Tunali et al., 2021). The reason might be rural females' increased involvement in unpaid work (Amir et al., 2018). In addition, the possibility of combining home production and employment is greater in rural areas because workplace and home are in close proximity (Bloom et al., 1986). We also notice that the age effects in rural areas peak late. Considering the median age at marriage for rural females is lower than urban females' median age at marriage and larger household size, young rural women participate

in the labor force with the double burden of home production (with infants) and labor market work. The later peak reflects that when kids reach a certain age, managing home production and labor work is easier because they can help perform different tasks at home and on the farms.

On different subdivisions of education level, the study reports age effects of females with no formal education, primary education, secondary education, and tertiary education. LFPR age effects for females with no formal education follow a standard U-shaped curve, and their participation begins to decrease after age 50. In comparison, the age profile of females with tertiary education is not exactly U-shaped. The distinct feature is that their exit from the labor market is not very steep after age 50 as they appear to choose to participate even after retirement age. The age profile of females with primary and secondary education level follows the same pattern, but participation rates are lower than those of females with no formal education. Females from rural areas have been observed to participate more in the labor force. Many females in rural areas have no formal education, which might be relevant to their higher participation than that of females with primary and secondary education. We can also infer that educated females (with primary, secondary, and tertiary levels) remain in the labor force longer than females with no formal education do. The two methods' results are quite consistent, other than those for education level estimates, which indicate the robustness of our estimates.

2.5.4 Cohort effects in female labor force participation rates

Figure 2.6 presents the differences between participation rates among females from different cohorts. The figure reveals that cohort effects increase for women born after 1950, plateau around 1990, and have started to decline more recently, thus partially supporting our third hypothesis. Evidence from some advanced economies reflects the same cohort profile patterns (Grigoli et al., 2021). The effects are estimated to be larger with Deaton–Paxson normalization than those with the maximum entropy approach. These differences might reflect changing social norms, education levels, and individual preferences across generations. The decline after 1990 implies that new cohorts are limiting the gain that the economy can achieve from increasing female labor force participation. However, we report these results cautiously as we observe later cohorts for a short period of time. To understand the cohort effects across generations, we further decompose cohort effects in labor force participation conditional on location, marital status, and educational attainment. We observe a dip in the cohort effects for the females born in the 1940s and 1950s. The reason relates to the central historical event in the 20th century South Asia i.e. British India gained independence from Britain. Therefore, the eras of 1940s and 1950s are viewed as years of economic instability for Pakistan due to the absence of economic infrastructure, financial resources

and industrial base (Anjum & Sagro 2017). The dip for these cohorts are justified in the sense that they were born during the unfortunate times of economic turmoil.

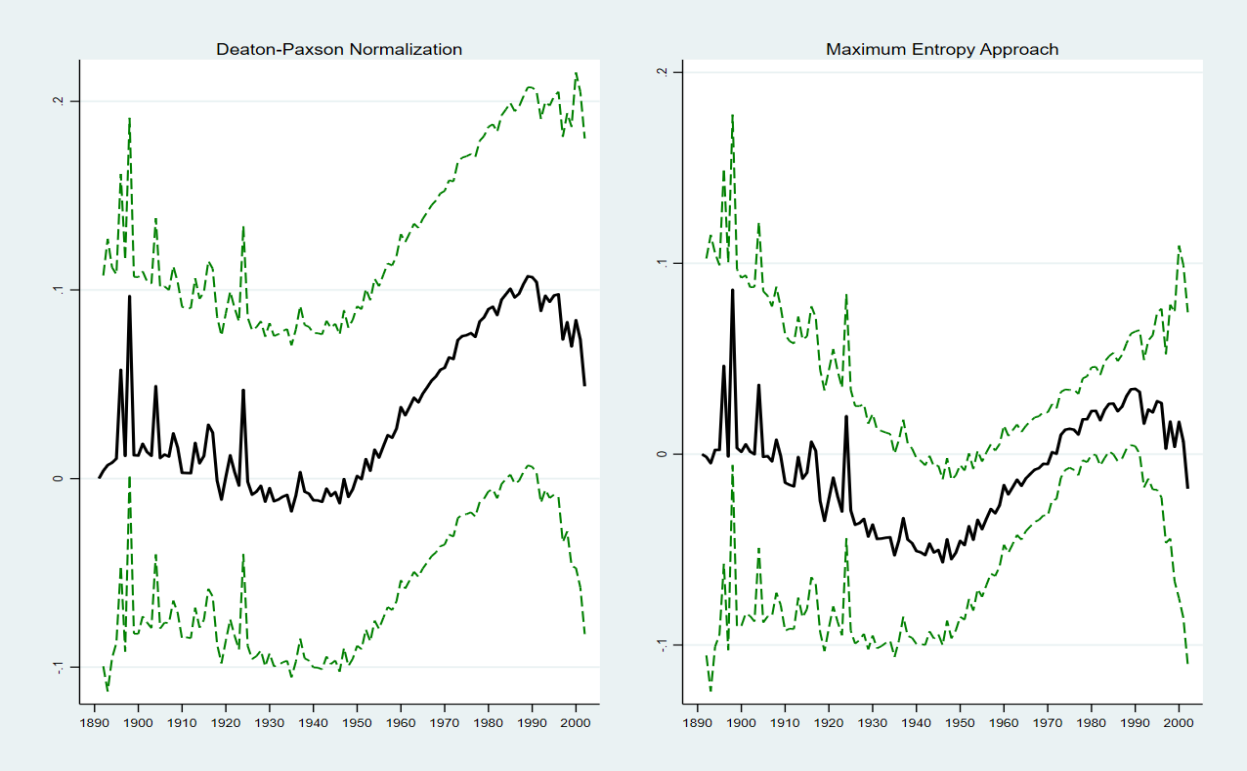

Figure 2. 6 Cohort profiles of female labor force participation.
Source *Authors' own calculations. The black line represents predicted participation rates, and the green lines are 95 percent confidence intervals.*

Cohort effects with a rural–urban divide follow almost the same pattern for rural areas. In the rural areas, the participation rates hover around 0 until the 1950s and then follow the same pattern under the Deaton–Paxson approach, whereas with the maximum entropy approach, after remaining stable for over two decades, the participation rates take negative values and start to increase after the 1950s.

Considering educational attainment reveals a rise in labor force participation from cohorts with no formal education and born after the 1950s. We observe this increase in both urban and rural areas. In urban areas, it might be because of the growth of the industrial sector, which provide employment opportunities to uneducated females, especially in the textile sector, where approximately 30 percent of the workers are women.[35] However, the rise in the labor force participation of rural females with no formal education is closely linked with poverty in Pakistan. Pakistan faced high poverty in the late 1980s due to the adherence to structural adjustment

[35] https://gender-works.giz.de/competitions2020/pakistan-inspiring-change-women-in-action-in-the-textile-garment-industry-of-punjab/

programs to deal with the current account deficit. It has been observed that Pakistani women from poor rural households disproportionately bear the burden of poverty because of lesser ownership of land and productive assets, lower educational attainment, social norms favoring men, and primarily unpaid farm jobs (Akram, 2016). There is a small increase in labor force participation among females with primary education although their share in population increases over time. Labor force participation for females with secondary education show different results with different methods. With Deaton–Paxson normalization, the cohort profile begins decreasing after the 1930s; however, with the maximum entropy approach, it remains constant and hovers around 0. It is not possible to reach a precise conclusion about cohort effects, given the different results with the two methods. Nevertheless, Fig. 4, along with cohort effects of females with secondary education, demonstrate that participation rates are declining for the cohorts born after the 1970s. For females with tertiary education, the results of estimated cohort effects are inconsistent under different methods, making it difficult to draw conclusions. Women with high educational attainment have been observed to participate more in the labor force (Amir et al., 2018). However, the Asian Development Bank (ADB) reports that only 25 percent of Pakistani women with a university degree participate in the labor force (Tanka, 2016).

2.5.5 Period effects in female labor force participation rates

In this section, we present period[36] effects in the participation rates covering almost three decades. Figure 2.7 shows the year effects of aggregate female labor force participation from 1990 to 2017. The year effects reveal how participation rates behave over almost three decades. Female LFPRs are pro-cyclic, displaying a positive relationship between female labor force participation and the annual GDP growth rate, confirming our fourth hypotheses. This is higher for the years in which GDP growth rate is high and lower for the years in which it is low.[37] For instance, annual GDP growth rate is less than 5 percent between 1993 and 2002, which translates into lower female labor force participation. A sharp dip in participation is observed for 2012, which might be the repercussion of low annual growth rate in preceding years (less than 3 percent from 2008 to 2011). Concerning the global financial crisis, Haq et al., (2014) find that GDP growth declined by 8.8 percent, whereas there was an increase in unemployment by 6 percent during 2007–2011.

[36] *Period* and *year* are used interchangeably.
[37] See Figure A14 in Appendix.

Figure 2. 7 Year profiles of female labor force participation.
Source *Authors' own calculations. The black line represents predicted participation rates, and the green lines are 95 percent confidence intervals.*

Considering the rural–urban divide, the year effects of labor force participation rates for rural females follow the similar pattern, i.e., pro-cyclicality. The main difference is that the estimated participation rates are higher for rural females than they are for urban females under both approaches. Turning to the year effects of ever-married females, one can observe the pro-cyclical behavior in year effects.

The period effects with no formal education follow a similar trend as aggregate labor force participation. However, females' labor force participation with a primary level of education presents an increasing trend over the years, with no sharp decline around 2012. The estimates of labor force participation with secondary and tertiary education show different results under different approaches. Deaton–Paxson normalization shows a slightly increasing trend in labor force participation for females with secondary and tertiary education. However, the estimates under the maximum entropy approach are negative, with no clear trend.

2.6 Conclusion and policy recommendations

In this study, we analyze the patterns and causes of female labor force participation in Pakistan over three decades. To probe how demographic changes have contributed to the changes in labor force participation since 1990, the study employed a decomposition analysis of overall change in female labor supply. This study has also performed APC analysis to decompose the total change in female labor force participation into three components using two different methods to solve the identification problem.[38] In general, female labor market behavior in Pakistan shows that women's participation in the labor force is driven by necessity rather than intent. High participation of females observed for rural areas with no formal education confirms this notion. Saqib & Arif (2012) identify monetary poverty an important factor compelling females to work for long hours and at the lowest wage-rate to make both ends meet. In view of our first hypothesis that demographic changes explains a substantial increase in female labor force participation, the results demonstrate that changing demographic composition account for a slight change in female labor force participation since the 1990s. If this trend continues, it is highly unlikely for Pakistan to reap the benefits of demographic dividend.

Second, the results of our APC decomposition uncover some interesting insights. The results support our second hypothesis regarding age effects which relates labor force participation of females to the timing of education, children and retirement. We have observed the following patterns. First, female labor force participation follows an inverted U-shaped curve. Participation rates increase in early adulthood, remain constant, and start declining at around age 50. Participation rates remain constant between the ages of early 30s to late 40s, which is a period marked by increasing household responsibilities because of marriage and child-rearing. Second, urban females' age effects show a slight M-shaped curve demonstrating a withdrawal from the labor market to take care of children. Age effects of rural females show that they remain in the labor force longer than urban females do. Third, the analysis of age effects with different education levels reveals that females with no formal education participate more in the labor force than females with primary and secondary education do; however, females with a high level of education remain in the labor force longer.

Regarding the cohort effects, we observe a continuous increase in labor force participation rates of cohorts born after the 1950s. The evidence supports our third hypothesis which establishes a link between labor force participation with changing social norms, increasing education levels, and decreasing fertility rates. Considering marital status and educational attainment, younger cohorts of married females and females with less education are participating more in the labor force. This suggests that females with traditionally weaker attachments to the labor market are participating more in the labor force. Finally, the period effects of female labor force participation

[38] Deaton–Paxson normalization and maximum entropy approach

behave pro-cyclically, they are higher for the years when the GDP growth rate is higher and lower for the years when it is lower.

The findings of this study have several policy implications. First, given that changing demographic composition explains a very small change in female labor force participation in Pakistan since the 1990s, it is clear that ingenious planning is required to maximize the gains from an ongoing demographic dividend. The key areas of focus include investment in female education and family planning, provision of affordable childcare facilities, generation of employment opportunities in the manufacturing and services sector (Durr-e-Nayab, 2006; Navaneetham & Dharmalingam, 2012) and creating a family-friendly work environment for females to maintain work–life balance.[39]

Second, the APC analysis results indicate that what is required to improve female labor force participation in Pakistan is the provision of childcare services, especially for urban women, as well as the improvement of access to tertiary education, particularly in rural areas where education levels are low. Increased participation of married females from younger cohorts implies the designing of policies that can persuade more progressive gender attitudes towards the inclusion of females in the labor force. Additionally, identifying causal links between social norms and female labor force participation require further examination.

[39] More than 50 percent of women in each LFS (1990–2017) are inactive because of housekeeping.

CHAPTER 3

3 Narrowing the Gender Digital Divide in Pakistan: Mobile Phone Ownership and Female Labor Force Participation[40]

Abstract

The unprecedented growth in access to mobile phones and smartphones has opened up new possibilities in the way people live and work. However, women in developing countries are unable to take advantage of this growth due to certain factors and socio-cultural norms that give rise to the gender digital divide. In this study, using the nationally representative Pakistan Social and Living Standards Measurement Survey (2019-2020), we investigate the gender and rural-urban (female) digital divide in a country with one of the most considerable digital divides. Furthermore, we employ an instrumental variable approach to study the effect of mobile or smartphone ownership on female labor force participation. The results indicate that institutional and sociocultural norms explain most of the ownership gap of mobile or smartphones between men and women. The instrumental variable approach demonstrates that mobile or smartphone ownership increases the participation of women in the labor force. We also find that the differences between observable characteristics, especially literacy and education, explain the rural-urban digital divide among females. Considering the importance of mobile or smartphone ownership in facilitating women's labor supply decisions, providing women with digital tools and upskilling them has wider implications for their economic well-being.

Keywords Gender digital divide, female labor force, rural-urban divide, decomposition, instrumental variable, mobile or smartphone
JEL Classification J16, J21, J71

3.1 Introduction

In the second half of the twentieth century, the world has witnessed a convergence in the economic status of men and women (Ponthieux & Meurs, 2015). However, the gender gap in economic participation and opportunities continues to widen; it is estimated to take 151 years to close this gap (World Economic Forum, 2022). Developing countries have specific characteristics and sociocultural norms that lead to significant gender gaps in employment, education, health, and autonomy (Jayachandran, 2014). These gaps are more pronounced in the labor markets. Legal

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restrictions to undertake economic activities, e.g., opening a bank account, women's right to inheritance, and maternity leave, are associated with larger gender gaps in labor force participation in developing countries (Gonzales et al., 2015). On average, women in developing countries are more likely to be unemployed, have fewer employment opportunities and are more likely to work in the informal sector (Antonio & Tuffley, 2014). Additionally, most women work as contributing family workers, constituting 82 percent of all females in informal employment (Bonnet et al., 2019).

The gender inequality in the physical world is also apparent in the digital world. Globally, around 52% of women are offline compared to 44% of men (International Telecommunication Union, 2020). However, the gender digital divide is more pronounced in the developing world, where women are 7 percent less likely to own a mobile phone and 18% less likely to own a smartphone (Global System for Mobile Communication, 2022). Computer access is also low in developing countries, where 54% of households in urban areas have access, while access in rural areas is only 17%. There are noticeable regional differences in the gender digital divide. South Asia is the region with the highest gender digital divide, with the widest gaps in mobile phone ownership and mobile internet use.

Considering the pace of the fourth industrial revolution, the digital gender divide has been determined as a critical challenge to achieving gender equality (Kuroda et al., 2019). The impact of digitalisation on gender equality, income, and employment has attracted considerable research interest (Alozie & Akpan-Obong, 2017; Bayes, 2001; Dettling, 2017; Hilbert, 2011; Ma et al., 2020; Ma et al., 2022; Rotondi et al., 2020; Viollaz & Winkler, 2021). For example, mobile phone technology in rural Uganda improves household income, gender equality, and nutrition (Sekabira & Qaim, 2017). A study on the Grameen Bank's village phone scheme shows that owning a mobile phone contributes to the generation of income through increased business transactions and information dissemination (Aminuzzaman et al., 2003). Puspitasari & Ishii (2016) put more emphasis on information and telecommunication (ICT) literacy to narrow gender inequality in low- and middle-income countries. Therefore, knowledge and access to digital technologies can reduce gender inequality by improving women's economic status.

Mobile and smartphones have brought new possibilities and opportunities to the developing world (Aker & Mbiti, 2010). They are an important economic asset for the poor as they are more valuable than landline phones in terms of ease of carrying and using and require lower fixed costs in physical infrastructure (Lee & Jayachandran, 2009). These attributes make mobile phones a reasonable and affordable proxy for other digital devices (e.g. computers, laptops, tablets, etc.) for the poor and marginalised. Many researchers have shown a positive impact of mobile phones on the economic growth of developing countries (Andrianaivo & Kapodar, 2012; Lee et al., 2012; Waverman et al., 2005). Mobile phones affect various aspects of development such as gender equality and nutrition (Sekabira & Qaim, 2017), women physical mobility and contraceptive use (Rajkhowa & Qaim, 2022b), efficiency in agriculture (Islam & Grönlund, 2007), market performance (Jensen, 2007), individual wealth (Krell et al., 2021), income growth and subjective

well-being (Ma et al., 2020; Nie et al., 2021), the status of women (Lee & Jayachandran, 2009), rural livelihoods (Sife et al., 2010), farm performance and agrochemical expenditures (Ma & Zheng, 2022; Zheng & Ma, 2021), off-farm employment and household income (Rajkhowa & Qaim, 2022a).

Considering the importance of ICT in today's world, the study aims to achieve three objectives, (1) to examine the gender divide in traditional mobile or smartphone ownership[41] and identify the contribution of individual covariates to explaining the divide in Pakistan, (2) to investigate the effect of traditional mobile or smartphone ownership on the participation of the female labor force in Pakistan, and (3) to analyse the rural-urban divide in traditional mobile or smartphone ownership of the female sample to gain some important insights that can help policy makers understand the dynamics of participation of the female labor force in Pakistan and its relation to digital tools. We endeavour to achieve these objectives using the Social and Living Standards Measurement Survey (2019-20), which includes a section on ICT indicators. We employ the Oaxaca Blinder decomposition to quantify the gender (objective 1) and rural-urban divide (objective 3) in traditional mobile or smartphone ownership into explained (covariate effect) and unexplained (coefficient effect) parts. Furthermore, we use the district-wise 'number of mobile network franchises' as an instrument to see the effect of traditional mobile or smartphone ownership on the participation of women in the labor force.

There is a dearth of literature finding the relationship between mobile telephony and female labor force participation. Empirical literature addressing the gender digital divide and women's labor force participation focusses primarily on the use of internet (Galperin & Arcidiacono, 2021; Jiang & Luh, 2017; Viollaz & Winkler, 2021). However, the requirement for digitalisation varies with the level of development and mobile phones facilitate cheap and effective communication and access to information on several services, including education, employment, health, markets, and the economy (Rotondi et al., 2020). Furthermore, different uses of mobile phones lead to differential impacts on female labor supply decisions. It depends on how much females use mobile phones for work, leisure, and home production. The present study fills this gap in the literature by assessing the effect of traditional mobile or smartphone ownership on the female labor force participation in a country with the most considerable digital gender divide.

The remainder of the paper is divided into five sections. Section 3.2 explains the context of the study area chosen for the analysis. Section 3.3 briefly talks about the theoretical and conceptual framework describing how ownership of a mobile or a smartphone affects the labor force participation of women. Section 3.4 describes the data and construction of the variables, and the

[41] According to the manual of instructions published by Pakistan Bureau of Statistics, mobile phone (traditional) refers to a portable telephone subscribing to a public mobile telephone service using cellular technology. However, a smartphone is a multi-purpose mobile computing device distinguished from feature phones by their stronger hardware capabilities and extensive mobile operating systems.

methods we employ to perform the analysis. Section 3.5 discusses the results and interpretations. Finally, Section 3.6 provides conclusions, recommendations, and limitations.

3.2 Context of the study

Pakistan is one of the poor performers in gender equality, as it joins the lower category of countries in the Global Gender Gap Report (2022). In terms of economic participation and opportunities, the country slipped from 112th (2006) to 145th (2022). Looking at Figure B1, we can see huge differences in the labor force participation rates of men and women in Pakistan over the last three decades. Many researchers find several factors that contribute to women's low labor force participation rates. For example, Field & Vyborny (2016) found that restrictions on physical mobility outside the home pose a major obstacle to women's inclusion in Pakistan's labor market, especially in urban areas. Family size and the number of children in the household are associated with lower female labor force participation (Ejaz, 2007). Additionally, marital status and household income are found to be negatively associated with female labor force participation in Pakistan (Batool et al., 2019).

The gender digital divide is not much different from the gender divide in the labor force participation. According to GSMA (2022), South Asia has the largest difference in the ownership of mobile phones in all regions, and these differences are the largest in Pakistan. Figure 3.1 shows gender disparities based on access to different digitalisation indicators. In terms of access to various digital tools, households have more access to mobile devices / smartphones compared to computers / laptops / tablets and the use of the Internet. Furthermore, there are noticeable gender differences in the use of the internet and in the ownership of mobile / smart phones. However, the gender digital divide is more pronounced in rural areas than in urban areas. Jamil (2021), using qualitative analysis, identifies certain contextual factors responsible for the increased digital divide in Pakistan. These factors include educational and income inequalities, religious and cultural barriers, gender inequality, and the urban-rural divide. Furthermore, inequitable access to mobile phones and the internet in Pakistan is responsible for widening gender-based development gaps and demands the collective efforts of all stakeholders (Shahid & Afreen, 2021).

Over the years, there has been an increase in mobile cellular subscriptions worldwide (Figure A2). Pakistan's telecommunication statistics have shown impressive growth over the last few years. Pakistan also faces a surge in mobile cellular subscriptions, accelerating from fewer than ten inhabitants per 100 in 2005 to more than 82 inhabitants in 2021.[42] Along with the expansion of 3G and 4G services (Figure A3), there are around 110 million broadband subscribers in 2021. However, there is a flip side to this growth in the ICT sector.

Regarding gender disparities, the Pakistan Telecommunication Authority (2021) reports that of 182 million mobile subscriptions, only 38 million are taken by women. Considering the importance

[42] https://data.worldbank.org/indicator/IT.CEL.SETS.P2?locations=PK

of digitalisation in the financial sector and its role in grabbing economic opportunities, women make only 3.3 percent of the total online transactions in Pakistan. 18.8 million women have branchless banking accounts for digital financial services compared to 55.7 million males.

Considering the importance of ICT in today's world, our objective is to examine the effect of ownership of traditional mobile devices or smartphones on female labor force participation in Pakistan, along with finding the factors responsible for the large gender and rural-urban (female) digital divide.

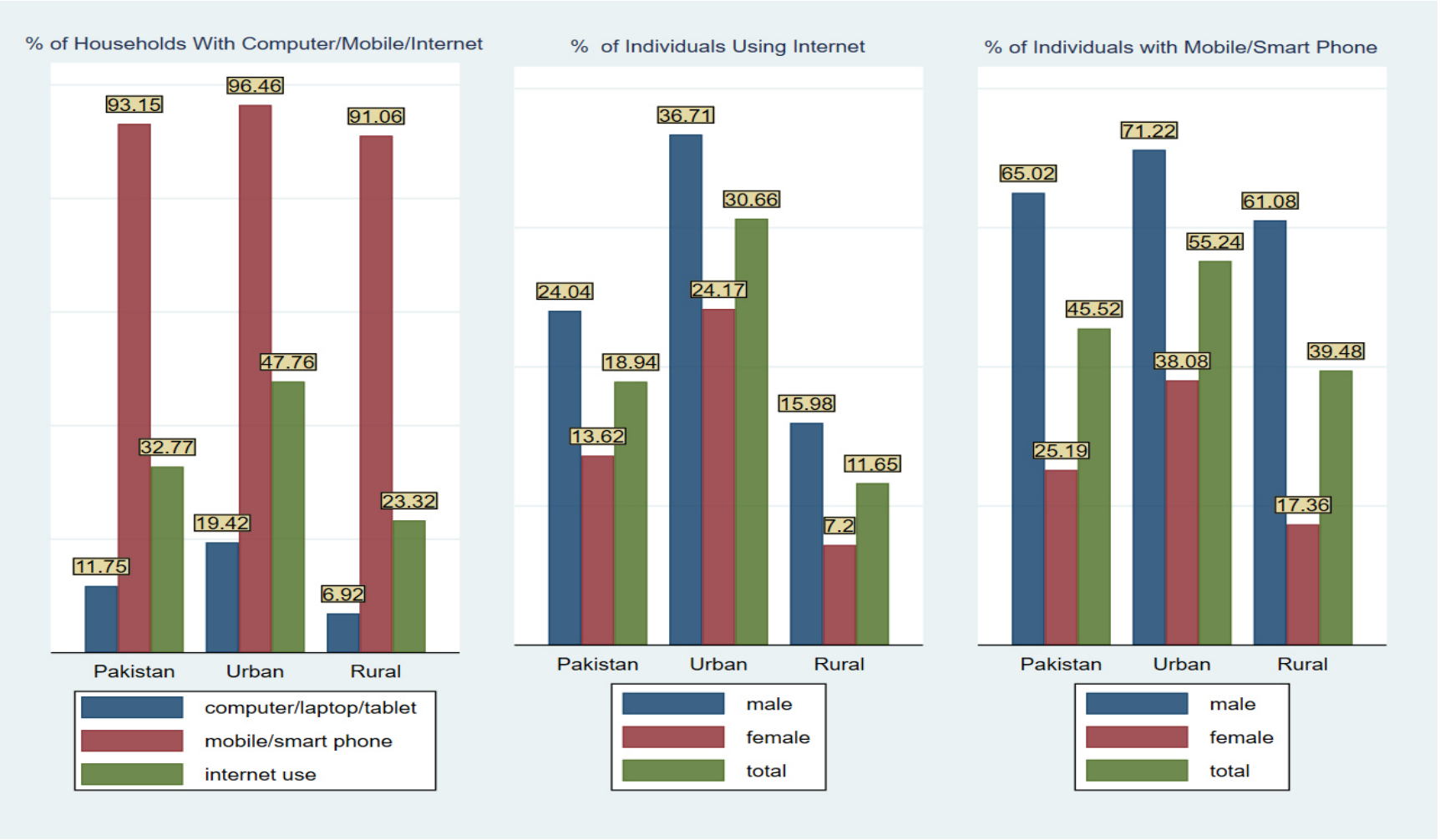

Figure 3. 1 Gender Digital Divide in the Ownership and Use of Different Digital Tools (2019-2020).
Source *Author's construction from Pakistan Social and Living Standards Measurement Survey (2019-2020)*

3.3 Conceptual framework

The conceptual framework of this study relies on the neoclassical labor supply model, which attempts to identify the determinants of individual labor supply decisions. According to this framework, an individual tries to maximise utility by allocating time between work and leisure. Therefore, the individual must allocate his time between the market and home to maximise current utility (Dettling, 2017). The theory of the allocation of time proposed by Becker (1965) argues that time spent at home is not only leisure time, but also used productively to perform different duties related to home production. For example, cooking, cleaning, shopping, caring for children and the elderly, etc. The production of commodities depends on various combinations of purchased inputs and the time used to make the final product (Dettling, 2017). For example, an individual faces a trade-off between preparing a meal and ordering ready-made food. Thus, labor supply decisions involve a trade-off between the time spent in the market (wage) and the time consumed at home. The time consumed at home is divided between leisure and home production (reservation wage). The reservation wage suggests that an individual will not work if the market wage is less than the reservation wage and vice versa (Borjas & Van Ours, 2010).

The emergence of new technologies, especially mobile and smartphones, has led to various new activities that can affect the reservation wage. For example, making calls, text messages, visiting social networks, playing games, watching videos, listening to music, etc. Individuals who find these activities enjoyable would want to exchange for time spent in leisure, increasing their reservation wage, and decreasing their labor market participation. According to a survey (Statista, 2022) conducted in the United States, 46% of the respondents stated that on average they spent five to six hours on their phones, which does not include work-related activity. Sylvester (2016) uses quantitative and qualitative methods covering six developing countries (including Pakistan) and finds that women tend to overuse (for leisure activities) mobile phones more than men. Furthermore, the results suggest that men use the mobile phone primarily for employment purposes and to make and nurture social connections. Excessive use of a mobile phone or smartphone can also lead to addiction. Various studies on mobile and smartphone addiction report a higher prevalence of addiction in boys than in girls (Basu et al., 2018; Chen et al., 2017; Gangadharan et al., 2022 and Nikhita et al., 2015).

Moreover, with the help of mobile or smartphones, individuals can find information about goods and services, pay bills, use online banking, access government services, use maps and traffic information, use a ride-hailing app, etc. These activities facilitate females in home production and decrease their reservation wage, increasing their participation in the labor force. According to Robinson & Godbey (1997), mobile technologies enable people to programme their tasks in advance; hence, this time-shifting property expands the possibility of multitasking. Facilitating coordination among multiple demands of work and home is vital given the mismatch between

work, school, transport, and shopping hours (Wajcman, 2008). Mobile phones allow working mothers to stay connected with their children back at home, reducing the non-monetary cost (psychic cost of being away from children) of working. Palen & Hughes (2007), following the work of Rokaw (1992), show that mobile phones allow mothers to be predictably available without being physically available, allowing remote mothering. With the emergence of ride-hailing platforms (using mobile applications), female drivers working with Uber and Careem report the flexible nature of the job as an important motivation to enter the labor market along with financial obligation (Rizk et al., 2018).

Mobile or smartphones as job search tools can directly impact labor force participation. Mobile phones increase people's socialisation skills and help create external social networks from home (Chen, 2007). Social network mobilisation facilitates job search activity and success (Wanberg, 2020). Furthermore, ownership of mobile phones contributes to the inclusion of the labor market by reducing the cost of acquiring information related to job search activity. Rajkhowa & Qaim (2022a) show that the ownership of mobile phones increases off-farm employment in rural India by reducing the transaction cost of acquiring information and by reducing search and negotiation costs. Furthermore, they report a higher association between mobile phone ownership and off-farm employment for female-headed households. Previous empirical literature has also examined the importance of the internet as a job search tool. Viollaz & Winkler (2021) find a positive and significant relationship between internet adoption and participation of women in the labor force in Jordan. They show that older and more experienced women experience an increase in employment in response to the adoption of the internet. Furthermore, the increase in online job search explains some, but not all, of the total increase in the participation of female labor force in Jordan. Glassdoor (Zhao, 2018) research reveals that women are more likely to use mobile phones as job search devices than men.

Mobile phones can indirectly contribute to the participation of women in the labor force by improving women's bargaining power through channels such as financial autonomy, freedom of movement, and increased decision-making power. Aker et al. (2011) determine that the mobile money cash transfer programme in Niger is positively associated with changes in intra-household decision making for women. Physical mobility is considered an obstacle to women's economic participation, especially in developing countries due to conservative social norms and harassment in public places (Field & Vyborny, 2022). The acquisition of a mobile phone gives women a sense of security when travelling without accompanying a male family member. Rajkhowa & Qaim (2022b) find that the use of a mobile phone is associated with a 5% increase in the physical mobility of women in India.

Different uses of mobile devices or smartphones lead to an indecisive prediction of the net effect of mobile or smartphone ownership on female labor supply. It depends on many factors, including the degree to which individuals use mobile or smartphones for home production, leisure, work, and job search. It also depends on interpersonal differences in tastes and preferences. In the present

study, we aim to quantify the net effect of the likelihood of traditional mobile or smartphone ownership on female labor force participation in a developing country context.

3.4 Data and methods

3.4.1 Data

We used a nationally representative PSLM district level survey, which was conducted in 2019-2020. The survey covered 176,790 households in rural and urban areas. The data provides information on various sociodemographic characteristics of the households along with individual-level labor market outcomes, education, income, and use of ICT. The questionnaire includes a section on ICT, reporting the ownership and use of different digital technologies. The survey adopts a two-stage stratified random sampling design.[43] Since the analysis focusses on labor market outcomes, we restrict our sample to the working-age (between age 15 and 64) individuals and construct variables based on individual and household characteristics. Table B1 provides information on the sample used for the analysis. Data on the number of mobile franchises in each district were obtained from the websites of the major mobile service providers in Pakistan (Figure B4).

The first variable of interest is the ownership and use (MS) of traditional mobile or smartphones. MS is a dummy variable with "1" for people who owned and used a traditional mobile or smartphone and "0" otherwise. For the sake of brevity, we will use the ownership of mobile phones synonymously with traditional mobile or smartphone ownership and use. As described by Ma et al. (2018) traditional mobile phones provide simplified core functions such as voice calls and text messages; smartphones however provide wider functionality due to the possibility to install various software applications. Taking into account that more females own a mobile phone rather than a smartphone, we combine the ownership and use of the mobile and smartphone. Another variable of interest is labor force participation which includes employed and unemployed individuals. Employed individuals are those who worked for pay, profit, or family gain during the last month for at least for one hour on any day during the survey period. These also include individuals who have had a job or enterprise, such as a shop, business, farm, or service establishment during the last month. Unemployed people are the ones who are not employed but are seeking work during the survey period. Labor force participation (LFS) is a dummy variable with "1" for individuals who are either employed or unemployed and "0" otherwise. Table A2 presents information on the construction of other variables (individual and household characteristics) used in the analysis.

[43] Information on sampling design is available at https://www.pbs.gov.pk/content/pakistan-social-and-living-standards-measurement.

3.4.2 Non- Linear Oaxaca Blinder decomposition

To investigate the existing digital gender divide in Pakistan, we apply an extension of the Oaxaca Blinder decomposition proposed by Yun (2005) and further elaborated by Powers et al. (2011). The technique was originally developed by Oaxaca (1973) and Blinder (1973) to explain the differences in the mean value of an outcome variable (based on linear regression models) between two groups into different components, that is, explained and unexplained. Yun (2005) generalises the decomposition technique to consider the functional form. The method provides estimates for overall decomposition and detailed decomposition, which helps to identify the contribution of each covariate to the different components of the overall gap (Powers et al., 2011). For our analysis, the decomposition analysis helps determine the differences in the likelihood of mobile phone ownership between men and women by decomposing the digital gender gap into two components. The first component, the explained component, captures the differences attributable to individual and household characteristics (covariates). The selection of covariates is based on the existing literature (Alozie et al., 2017; Antonio & Tuffley, 2014; Galperin & Arcidiacono, 2021; Hilbert, 2011) on the gender digital divide (especially in the context of developing countries), including labor force participation, age, age square, marital status, literacy, different levels of education, individual's income, different income quintiles, household size, number of children between 0 and 4 years of age, location, wealth index, and ownership of agricultural land,, non-agricultural land and residence. The second component reports the differences caused by the differences in coefficients due to institutional factors and prevailing social and cultural norms that hinder women from taking advantage of digital technologies.

In the first step, we estimate the effect of individual- and household-level characteristics on the likelihood of mobile phone ownership by employing Logit regression. Following this, we apply an extension of the Oaxaca Blinder decomposition proposed by Yun (2005) and further elaborated by Powers et al. (2011).

In the context of our study, taking males as the comparison group and females as the reference category, the gender digital divide can be decomposed as follows:

$$\bar{Y}^m - \bar{Y}^f = \left[F(\overline{X^m\beta^{m)}} - F(\overline{X^f\beta^{m)}}\right] + \left[F(\overline{X^f\beta^{m)}} - F(\overline{X^f\beta^{f)}}\right] \qquad (1)$$

where $\bar{Y}^m - \bar{Y}^f$ represents the difference in the likelihood of mobile phone ownership between females and males. The first term in the parenthesis $\left[F(\overline{X^m\beta^{m)}} - F(\overline{X^f\beta^{m)}}\right]$ is attributable to gender differences due to the difference in characteristics or endowments. The second term$\left[F(\overline{X^f\beta^{m)}} - F(\overline{X^f\beta^{f)}}\right]$, reports gender differences in the ownership and use of mobile or smartphones due to differences in coefficients.

In addition, the model estimates the detailed decomposition to capture the contribution of all individual and household covariates to the differences in the likelihood of ownership of mobile phone between males and females. Yun (2005) proposed a two-stage method to assign weights to each variable included in the model. The first stage evaluates the function using mean

characteristics, and in the second stage, a first-order Taylor expansion rule linearises the endowment and coefficient effects. The following equation shows the weighted total of each factor's contribution:

$$\bar{Y}^m - \bar{Y}^f = \sum_{i=1}^{k} w_{\delta X}^i \left[F(\overline{X^m \beta^{m)}} - F(\overline{X^f \beta^{m)}} \right] + \sum_{i=1}^{k} w_{\delta X}^i \left[F(\overline{X^f \beta^{m)}} - F(\overline{X^f \beta^{f)}} \right] \qquad (2)$$

where $w_{\delta X}^i$ in equation (2) is the decomposition weight calculated separately for characteristics and coefficients.

3.4.3 Instrumental variable approach

The second objective of this paper is to estimate the effect of mobile phone ownership on female labor force participation in Pakistan. The following equation estimates the proposed relationship:

$$lfp_{ij} = \beta_0 + \beta_1 MS_{ij} + \beta_2 X_{ij} + \beta_3 P_j + \varepsilon_{ij} \qquad (3)$$

where subscripts $i\ and\ j$ denote the female i living in district j. MS_{ij} is the main explanatory variable and lfp_{ij} is the outcome variable. The construction of variables has been described in Section 3.4.1. We include a vector of individual and household characteristics (X_{ij}) to consider the confounding factors that can influence both the explanatory and the outcome variables. These characteristics include age, age square, marital status, education level, literacy, female head of the household, education of household head, income quintiles, location, wealth index, ownership of agricultural land, ownership of non-agricultural land, own residence, household income security, and district male employment rates (Afridi et al., 2018; Ejaz, 2007; Klasen et al., 2021; Klasen, 2019; Klasen & Pieters, 2012; Sarkar et al., 2019; Schaner & Das, 2016). We include provincial fixed effects (P_j) to control for the regional differences. We estimate Equation (3) by clustering standard errors at the district level and household level.

The ownership of a mobile phone is potentially endogenous because women decide to own and use a phone based on observed and unobserved characteristics. Furthermore, mobile phone ownership and participation in the labor force can be jointly determined by specific factors that are not observed. Hence, we use a two-stage least-squares instrumental variable approach to overcome these challenges. According to Chiburis et al. (2012), researchers use two common approaches to measure the causal impact in a model with binary endogenous and outcome variables. Standard linear instrumental variable (IV) estimation ignores the binary nature of the outcome and the endogenous variable. The second approach is based on the maximum likelihood estimation of a bivariate probit model. The existing literature provides mixed advice on either method (Angrist, 2001; Bhattacharya et al., 2006). The coefficients for both methods differ substantially when the sample size is less than 5000. For our analysis, the sample size is 245,254 females. The method requires a variable that is not present in the primary regression estimation and is uncorrelated with the error term, but is correlated with the endogenous explanatory variable (Murray, 2006; Ullah et

al., 2021). In the presence of many covariates, misspecification of the bivariate probit leads to biased estimates (Chiburis et al., 2012). Therefore, we use linear two-stage least squares (2SLS) to estimate the impact of mobile phone ownership on female labor force participation in Pakistan. To estimate Equation (3), we follow a 2SLS procedure. In the first stage, we regress our endogenous explanatory variable MS_{ij} on the instrument MF_{ij} and other variables used in the equation (3). The first-stage equation is given by:

$$MS_{ij} = \gamma_0 + \gamma_1 MF_{ij} + \gamma_2 X_{ij} + \gamma_3 P_j + \varepsilon_{ij} \qquad (4)$$

where MF_{ij} in equation (4) is the number of mobile phone franchises in each district where female i lives. This is a good instrument for several reasons. First, it is correlated with the likelihood of owning a mobile phone, as mobile phone franchises facilitate the provision of different services. In the context of Pakistan, these services include post and prepaid connection sales, billing services, sim or duplicate sim, easy load, mobile accessories, repair services, and internet connection. Ullah et al. (2021) argue that choosing an instrument outside your unit of analysis increases the chances that the instrument satisfies the exogeneity condition. Our instrument, the number of mobile phone franchises, is a district-level variable, while our unit of analysis is individual females. One concern about the instrument's validity is that these mobile franchises generate employment opportunities and there is a possibility of correlation with labor force participation. However, considering Pakistan's prevailing social and cultural norms, it is implausible that women work in these franchises. Our instrument shows a positive and significant association with mobile phone ownership (first-stage regression) and passes the validity test (See Table 3.4). However, we cannot rule out the possibility that mobile network franchises might co-drive some vital economic variables, as the franchises would be located where there is more economic activity and a higher capacity to pay for the services. Therefore, we report our results as an association rather than as a causality.

In the second stage, we obtain the fitted values $\widehat{MS_{ij}}$ from equation (4) and use it as an explanatory variable with other covariates (X_{ij}, P_j) to estimate the primary equation (3). The procedure will give us a consistent estimate of β_1 which quantify the effect of mobile or smartphone ownership and use on female labor force participation through the instrument.

3.5 Results and discussion

3.5.1 Descriptive statistics

Table B3 reports the summary statistics for the variables of interest and other digital indicators for the sample disaggregated by gender. Statistics show that there are substantial gender gaps in different digital technologies along with labor force participation. Around 79% of men own a mobile phone compared to 28% of women. However, the table also shows that there exist negligible gender differences in the use of mobile phones. The reason is mobile sharing within

poor households; Porter et al. (2020) find that in sub-Saharan Africa, phone usage surpasses ownership due to the high frequency of sharing among family, friends, and neighbours. It could also be because of the type of question the survey asked from the respondents without giving them any time window. The question asked them to report whether they had used a mobile phone, a smartphone or none.

Table B4 further disaggregates the participation of the labor force and mobile phone ownership by gender and location. The results show a considerable gender digital divide between rural and urban areas in Pakistan. It indicates that the gender digital divide drives the rural-urban digital divide. However, one can also observe a significant rural-urban digital divide between women. Urban women are much more likely to own a mobile phone than rural females.

Table 3.1 shows the summary statistics of the control and outcome variables used in the Oaxaca Blinder decomposition disaggregated by gender. The results indicate that there are significant differences between men and women for all the variables except age. On average, males are more educated and literate, earning more and participating more in the labor force. On the other hand, more females belong to lower-income quintile households, and most females are married compared to males. Finally, we see a significant difference in the ownership and use of mobile phones between men and females, where on average, males are more likely to own and use mobile phones.

Table 3. 1 Summary statistics by gender

	Male	Female		
	Mean	Mean	Difference	SE
MS ownership and use	0.769	0.269	0.501	0.001***
Labor force participation	0.805	0.151	0.654	0.001***
Age	33.096	33.068	0.029	0.038
Age square	1277.915	1260.508	17.407	2.792***
Marital status	0.637	0.758	-0.121	0.002***
Literacy	0.677	0.429	0.247	0.002***
Primary education level	0.261	0.17	0.091	0.001***
Secondary education level	0.226	0.134	0.092	0.001***
Tertiary education level	0.075	0.052	0.023	0.001***
No formal education	0.436	0.643	-0.207	0.002***
Log of individual's income	8.332	0.7	7.632	0.013***
1st Income quintile	0.152	0.216	-0.064	0.001***
2nd Income quintile	0.182	0.188	-0.006	0.001***
3rd Income quintile	0.201	0.196	0.005	0.001***
4th Income quintile	0.218	0.196	0.022	0.001***
5th Income quintile	0.247	0.204	0.043	0.001***
HH size	6.348	6.384	-0.036	0.009***

Children (0-4)	0.633	0.703	-0.07	0.003***
Location	0.324	0.308	0.015	0.002***
Ownership of agricultural land	0.248	0.259	-0.011	0.001***
Ownership of non-agricultural land	0.042	0.043	-0.002	0.001***
Own residence	0.845	0.851	-0.005	0.001***
Wealth index	77.481	77.148	0.332	0.105***
Observations	244663	245254		

****p<0.01, **p<0.05. *p<0.1.*

Table B5 reports the summary statistics of the outcome and control variables of the female sample disaggregated by females who own mobile phones and those who do not own mobile phones. On average, females who own mobile phones are more educated, literate, and are more likely to live in urban areas. They also live in households where the head of the family is female and more educated. Females who do not own mobile phones are likely to be from lower-income households. In addition, we can see significant differences in the outcome variables between the two groups; women who own mobile phones are more likely to participate in the workforce. Table B6 lists the summary statistics of the rural-urban digital divide for the female sample. We can observe that women who reside in urban areas are less likely to participate in the labor force than women who live in rural areas. However, this is a surprising result because women in urban areas are more likely to own a mobile phone, and females that own a mobile phone are more likely to participate in the labor market. To examine whether these differences in labor force participation are due to the differences in the ownership of mobile phones, we employ 2SLS, and the results are presented in Section 3.5.3.

3.5.2 Non-Linear Oaxaca Blinder decomposition

Table 3.3 reports the results of the gender digital divide between men and women in Pakistan based on the estimation results of the logit regression given in the Table 3.2. The average marginal effects for men and women reveal some important information. First, the significant and positive effect of tertiary education and individual income is more distinct for women. Regarding household characteristics, women belonging to lower-income quintile are less likely to own a mobile phone. The calculated marginal effects for location show that women in urban areas are more likely to have a mobile phone. However, the results are insignificant for the male sample.

Table 3. 2 Average marginal effects of the total sample and also the sample disaggregated by male and female

	Total Sample	Male	Female
MS ownership and use	Coefficient	Coefficient	Coefficient
Gender	-0.308***	-	-

	(0.008)		
Labor force participation	0.042***	0.086***	-0.020
	(0.009)	(0.008)	(0.014)
Age	0.033***	0.032***	0.033***
	(0.001)	(0.001)	(0.001)
Age square	-0.000***	-0.000***	-0.000***
	(0.000)	(0.000)	(0.000)
Marital status	0.108***	0.081***	0.133***
	(0.005)	(0.004)	(0.001)
Literacy	0.088***	0.069***	0.150***
	(0.008)	(0.007)	(0.001)
Primary level of education	0.022***	0.029***	-0.050***
	(0.007)	(0.006)	(0.009)
Secondary level of education	0.091***	0.081***	0.020**
	(0.006)	(0.006)	(0.009)
Tertiary level of education	0.187***	0.118***	0.160***
	(0.009)	(0.013)	(0.012)
Log of individual's income	0.009***	0.006***	0.010***
	(0.001)	(0.001)	(0.001)
2nd income quintile	-0.055***	-0.015**	-0.091***
	(0.006)	(0.007)	(0.008)
3rd income quintile	-0.027***	0.002	-0.056***
	(0.006)	(0.007)	(0.008)
4th income quintile	-0.018**	0.009	-0.045***
	(0.006)	(0.007)	(0.008)
5th income quintile	0.016***	0.035***	-0.002
	(0.008)	(0.008)	(0.010)
Household size	-0.014***	-0.008***	-0.021***
	(0.001)	(0.001)	(0.001)
Children (aged 0 to 4)	0.010***	0.009***	0.009***
	(0.001)	(0.001)	(0.002)
Location	0.006	-0.006	0.014*
	(0.006)	(0.006)	(0.008)
Ownership of agricultural land	0.012***	0.023***	0.004
	(0.004)	(0.005)	(0.005)
Ownership non-agricultural land	0.021***	0.012	0.032***
	(0.008)	(0.009)	(0.009)
Own residence	-0.004***	-0.002	-0.005
	(0.004)	(0.004)	(0.005)

Wealth index	0.002***	0.001***	0.002***
	(0.000)	(0.000)	(0.000)
Provincial fixed effects	Yes	Yes	Yes
Pseudo R-square	0.3711	0.2395	0.2310
No. of observation	489,917		

****p<0.01, **p<0.05. *p<0.1.*

Numbers in brackets represent standard errors

Table 3.3 presents the aggregate and detailed decomposition of the gender digital divide and further separates that into covariate and coefficient effects. The results show that men, on average, are more likely to own a mobile phone, making them an advantaged group in our analysis. The total differences in the covariates explain only 0.094 unit of the 0.500 units gap in the likelihood of MS ownership between males and females. This means that if women had the same characteristics as men, they would be more likely to own a mobile phone. Among the covariates, literacy and individual income turn out to be the most significant contributors to the explained part. Table 3.3 shows that the coefficient effect (the unexplained part) is primarily responsible for the observed differences in MS ownership for men and women. The coefficient effect explains 0.397 unit of the 0.5 units gap in the MS ownership between males and females. Two potential explanations can be provided for the coefficient effect on the gender divide in MS ownership. The first is the case of unobserved factors in which the model may have not included (due to unavailability of information) significant predictors of MS ownership. For example, the language of the the content of mobile or smartphone is an essential factor that should also be taken into account. Using a mobile phone requires basic English skills, as 90% of the online content is in English (United Nations e-Government Survey, 2012). The PSLM survey includes a question about the literacy of individuals without focussing on their English language skills.

The second reason is the sociocultural and institutional factors responsible for the digital gender divide. According to Antonio and Tuffley (2014), the amalgamation of policies, laws, and societal customs in developing countries prohibits women from owning assets and obtaining loans for technology acquisitions. This discrimination leads to a vicious circle that hinders women from getting financial independence to afford digital technologies that can improve their economic well-being (Hafkin & Taggart, 2001). Restrictive social and gender norms help to explain the gender gap in the ownership of a mobile phone. Acquisition of technology is often considered a realm of men, and gender norms about men's access to and use of technology limit women's prospects to learn, use, and benefit from technology (Hafkin & Taggart, 2001). As pointed out by Kabeer (2012), gender inequalities are determined by unjust structures and practises rather than choices made by individuals. Women in different societies make choices based on limits imposed by rules, norms, and resources (Kabeer, 2012). The actual and perceived benefits of digital tools are also determined by socio-cultural factors (Ono & Zavodny, 2007), making women unaware of the benefits of using these tools.

An interesting finding regarding the coefficient effect is the significant contribution of the constant term that derives this gender digital divide. The constant term represents the base category which includes the most disadvantaged individuals, i.e., the individuals (men and women) from rural areas with no formal education, illiterate, and belonging to households with low income and with no ownership of land and property. The results reveal that disadvantaged males are much more likely to own a mobile phone than females with the prevailing socio-cultural norms in Pakistan. Hence, the constant term depicts the extent to which the gap in the likelihood of mobile phone ownership among the most disadvantaged females would disappear if they faced the same socio-cultural norms as their male counterparts.

Table 3. 3 Decomposition of the gender divide in the ownership of mobile or smartphones

MS ownership	Coefficients	Std. Err.		
Overall Decomposition				
Male	0.769***	0.007		
Female	0.269***	0.013		
Total difference	0.500***	0.009		
Covariates effect	0.094***	0.006		
Coefficients effect	0.379***	0.008		
Interaction effect	0.026***	0.008		
Detailed Decomposition	Covariates		Coefficients	
	Coefficients	Std. Err.	Coefficients	Std. Err.
Labor force participation	-0.016	0.011	0.021***	0.003
Age	0.001	0.002	0.065	0.052
Age square	-0.009***	0.002	-0.006	0.024
Marital status	-0.019***	0.001	-0.041***	0.008
Literacy	0.045***	0.003	-0.039***	0.005
Primary level of education	-0.005***	0.001	0.017***	0.002
Secondary level of education	0.002**	0.000	0.011***	0.001
Tertiary level of education	0.003***	0.000	0.000	0.001
Log of individual's income	0.095***	0.012	-0.003***	0.001
2nd income quintile	0.001***	0.000	0.017***	0.002
3rd income quintile	-0.000***	0.000	0.013***	0.002
4th income quintile	-0.001***	0.000	0.012***	0.002
5th income quintile	-0.000	0.000	0.010***	0.002
Household size	0.001**	0.000	0.099***	0.009
Number of children in the HH (0-4 age)	-0.001***	0.000	0.000	0.002
Location	0.0002	0.000	-0.008**	0.003
Ownership of agricultural land	-0.000	0.000	0.006***	0.001

Ownership of non-agricultural land	-0.000	0.000	-0.001**	0.000
Own residence	0.000	0.000	0.003	0.005
Wealth index	0.001	0.000	-0.092***	0.015
Constant	None		0.267***	0.033
Provincial fixed effects	Yes			

****p<0.01, **p<0.05. *p<0.1.*

3.5.3 Two-Stage least squares

Table 3.4 reports the results of the effect of mobile ownership on female labor force participation. The results of logit regression show a positive and statistically significant effect of mobile phone ownership on female labor force participation. Furthermore, the results of the second stage (2SLS) suggest a significant and much larger positive association with female labor force participation. On average, women who own mobile phones have a 36.2 percentage point higher probability of participating in the labor force than females who do not own mobile phones. Our results are consistent with other quantitative studies that explored the same relationship with different digital tools (Dettling, 2017; Non et al., 2021; Viollaz & Winkler, 2021; Zheng et al., 2023). From the coefficients of individual and household controls, we can observe that women who reside in urban areas are less likely to participate in the labor force than females who live in rural areas, however, the coefficient is not significant. A plausible reason for the lower participation in the labor force of urban females who are more likely to own mobile phones could be the time spent on mobile phones on activities that increase their leisure time (as described in the conceptual framework). On the other hand, rural women use mobile phone for more work-related activities. For example, Islam and Slack (2016) study the use of mobile phones among rural women in Bangladesh and find that 71% of the respondents use mobile phones to access information on economic opportunities. Furthermore, women in rural India use mobile phones for a range of activities including social networking, employment, education, and health-related services (Mehta & Mehta, 2014).

Table 3. 4 Regression results of the effect of mobile phone on female labor force participation

Labor Force Participation	Avg. marginal effects (Logit)	IV 2SLS First Stage	IV 2SLS Second Stage
	Labor force participation	MS ownership and use	Labor force participation
MS ownership and use	0.03***		0.362**
	(0.006)		(0.188)
Mobile Network Franchise		0.001***	
		(0.0002)	

Age	0.017***	0.026***	0.007
	(0.001)	(0.001)	(0.004)
Age square	-0.000***	-0.0003***	-0.000
	(0.000)	(0.000)	(0.000)
Marital status	-0.067***	0.146***	-0.113***
	(0.008)	(0.009)	(0.028)
Age of the head	-0.001***	0.0002	-0.001***
	(0.000)	(0.000)	(0.000)
Female head	-0.010	0.224***	-0.062
	(0.007)	(0.009)	(0.043)
Education of the head	-0.003***	0.006***	-0.005***
	(0.000)	(0.000)	(0.001)
Literacy	-0.060***	0.099***	-0.070***
	(0.009)	(0.008)	(0.022)
Primary	0.041***	-0.006	0.019***
	(0.007)	(0.007)	(0.006)
Secondary	0.063***	0.092***	0.003
	(0.008)	(0.007)	(0.017)
Tertiary	0.342***	0.280***	0.154***
	(0.016)	(0.013)	(0.053)
2nd income quintile	-0.019*	-0.025***	-0.014
	(0.011)	(0.007)	(0.014)
3rd income quintile	-0.047***	0.005	-0.058***
	(0.012)	(0.007)	(0.013)
4th income quintile	-0.059***	0.016**	-0.070***
	(0.013)	(0.007)	(0.014)
5th income quintile	-0.076***	0.055***	-0.094***
	(0.014)	(0.008)	(0.018)
Household size	0.001*	-0.013***	0.006**
	(0.008)	(0.000)	(0.002)
Children (0-4)	-0.003*	0.004**	-0.004**
	(0.001)	(0.001)	(0.002)
Nuclear Family	0.010***	0.028***	0.001
	(0.003)	(0.003)	(0.006)
Location	0.009	-0.016*	-0.016
	(0.008)	(0.008)	(0.010)
Ownership of agriculture land	0.046***	0.001	0.050***
	(0.008)	(0.004)	(0.011)

Ownership of non-agriculture	0.010	0.029***	0.001
land	(0.009)	(0.008)	(0.011)
Own Residence	-0.027***	-0.001	-0.023***
	(0.006)	(0.004)	(0.006)
Wealth index	-0.001***	0.002***	-0.001***
	(0.000)	(0.000)	(0.000)
Employment rate of males	0.905***	-0.351***	1.022***
(district wise)	(0.161)	(0.119)	(0.240)
Household income security	-0.009**	-0.021***	-0.016
	(0.004)	(0.002)	(0.005)
Provincial FE	Yes	Yes	Yes
R-Square	0.121	-	0.127
First Stage F-statistic	-	-	22.501
Number of observations	245,254		

****p<0.01, **p<0.05. *p<0.1.*

Numbers in brackets represent standard errors

3.5.4 Robustness checks

As explained in Section 3.4.3, in the presence of an endogenous regressor, the instrumental variable approach is the appropriate method by which the instrument controls for unobservable variables, reverse causality, and self-selection into owning a mobile phone (Woolridge, 2010). To confirm the validity of our estimates we apply some robustness checks including inverse probability weighted regression adjustment (IPWRA) and control function approach of IV. The average treatment effect and average treatment effect on the treated for IPWRA are consistent with logit estimates as IPWRA cannot account for selection bias related to unobserved heterogeneity (Lu et al., 2021; Zheng et al., 2023), however, control function approach estimates are consistent with 2SLS estimates.[44]

3.5.5 Non-Linear Oaxaca Blinder decomposition for female rural-urban divide

An important insight from the above analysis shows a significant digital divide between rural and urban women in Pakistan (Figure 3.1, Table B4, and Table B6). To further probe this insight, we perform a decomposition analysis of the rural-urban digital divide for the female sample. Summary statistics (Table B6) show that on average, urban females are more educated and literate, earn a higher income, belong to higher-income households, and are more likely to own a mobile phone.

[44] See Table B7 for results.

The results of the Oaxaca Blinder decomposition for the female sample (Table 3.5) indicate significant differences in rural-urban MS ownership. As shown, the differences in the ownership of mobile phones between rural and urban females are driven by observable characteristics. If women in rural areas had the same characteristics as those in urban areas, the digital divide would disappear. The differences in literacy, education, income, and wealth index are the main contributors to the observed digital divide.

Table 3. 5 Decomposition results of mobile phone or smartphone ownership by location

MS ownership and use	Coef.	Std. Err.		
Overall Decomposition				
Urban Females	0.411***	0.018		
Rural Females	0.205***	0.010		
Total difference	0.205***	0.019		
Covariates effect	0.152***	0.021		
Coefficients effect	-0.006	0.010		
Interaction effect	0.059***	0.021		
Detailed Decomposition	**Covariates**		**Coefficients**	
	Coefficients	Std. Err	Coefficients	Std. Err
Labor force participation	0.003***	0.001	0.034	0.089
Age	0.010**	0.004	-0.094	0.260
Age square	-0.007*	0.004	0.042	0.118
Marital status	-0.007***	0.001	-0.084	0.216
Literacy	0.042***	0.004	0.034	0.085
Primary education	-0.001**	0.000	-0.017	0.045
Secondary education	0.006***	0.002	-0.009	0.024
Tertiary education	0.014***	0.002	-0.003	0.008
Log of income	0.002**	0.001	-0.006	0.017
2nd income quintile	0.009***	0.001	-0.004	0.010
3rd income quintile	-0.001	0.0004	0.002	0.008
4th income quintile	-0.003***	0.0005	0.003	0.001
5th income quintile	-0.003**	0.001	0.016	0.041
Household size	0.012***	0.003	-0.109	0.281
Children (0-4)	-0.002***	0.0005	0.006	0.017
Own agricultural land	0.001	0.002	0.009	0.027
Own non-agricultural land	0.0003	0.0002	-0.000	0.001
Own residence	-0.002	0.001	-0.035	0.088
Wealth index	0.118***	0.013	0.009	0.024

Constant	None	0.077	0.244
Provincial fixed effects	Yes		

****p<0.01, **p<0.05. *p<0.1.*

3.6 Conclusions, implications and limitations

In this study, we examine the gender dimension of the mobile phone ownership divide and its relevance for female labor force participation in the context of developing countries, i.e., Pakistan. Using the Oaxaca Blinder decomposition, we find a significant gender digital gap in Pakistan that is mainly attributed to socio-cultural norms that prohibit women from taking advantage of advances in technology. The constant term of the coefficient effect reveals that women from rural areas are the most disadvantaged group as they continue to face inequalities in ownership and use to digital technologies (mobile or smartphone), education, income, and wealth that limit their prospects to contribute to agricultural productivity, hence rural development. Moreover, considering low female labor force participation in Pakistan, we investigate the effect of mobile phone ownership on female labor force participation using 2SLS. In line with existing studies (using different digital tools), the results reveal that the ownership of a mobile phone is positively associated with labor market inclusion of females. We find a significant digital divide in mobile phone ownership between rural and urban women in Pakistan. The decomposition analysis of the rural-urban digital divide highlights those differences in observable characteristics, including income, education, literacy, labor force participation, household size, and household wealth index, explaining almost all of the differences between mobile phone ownership between rural and urban females. The result is consistent with the first decomposition results that affirm the marginalization of rural women, who play a key role in deriving agricultural productivity and rural development.
Our results show that a combination of individual, household, institutional, and sociocultural factors explain the differences in mobile phone ownership between genders. Considering the importance of mobile phone ownership in facilitating female labor supply decisions, there is a need to expand employment opportunities for rural females through digitalisation along with providing them with digital tools and upskilling them to bridge the gender digital divide. Interventions that provide digital training and upskilling programmes for lower-income urban women and women from rural households may not only bridge the gender digital divide but also help them in uplifting their economic well-being through increased participation in the labor force. The results indicate that rural females continue to face limitations in their access to digital technologies, education, and finances that limit their potential to contribute to rural and agricultural development. Digitalization has a great potential to derive economic growth towards an inclusive future by stimulating greater productivity and sustainability of agricultural produce, as well as improved livelihood options (on- and off-farm employment) for women. Interventions that ensure that rural women have affordable and reliable mobile network along with improvement in the provision of education and health facilities can serve as instruments for attaining gender equality, hence economic growth. More

customized approaches, for example, agricultural advisory and market information about prices, information on weather conditions, and quality of inputs along with off-farm employment opportunities through interactive voice response (IVR) or short messages, can help women contribute to rural development.

The findings of the association of mobile phone ownership and women's participation in the labor force are subject to some limitations. First, the main variable of interest adds the ownership of mobile and smartphone devices, which may have a different impact on the female labor force participation. Second, due to the limitation of data on the lack of sufficient information about the purpose of using a mobile phone, we could not explore the channels through which mobile phones or smartphones can potentially facilitate the participation of women in the labor force. We believe that further research is needed to explore more information-rich data sets. Third, our conclusions are based on a cross section of data that limits our analysis of the dynamic relationship between mobile phone ownership and women's labor market inclusion.

CHAPTER 4

4 Impact of Public Transport and Ride-hailing Services on Female Labor Force Participation in Lahore, Pakistan[45]

Abstract

In many developing countries, restricted mobility is a significant barrier to women's economic empowerment. Mobility constraints can hinder women's ability to access job opportunities and attain financial independence, perpetuating gender disparities and limiting their involvement in economic activities. This study employs a mixed-method approach to investigate the impact of mass transit and ride-hailing services on female labor force participation in Lahore, Pakistan. Using a synthetic control method and labor force surveys spanning over two decades (1999-2020), we evaluate the impact of mass transit and ride-hailing services on female labor force participation by constructing a synthetic Lahore series to compare it to the actual Lahore series. The results show that the provision of mass transit has led to a small but positive increase in female labor force participation compared to the synthetic counterpart. However, ride-hailing services did not show any significant impact. Additionally, qualitative analysis revealed that spatial mismatch significantly affects women's mobility choices. Although most metro users have access to stations, inconvenient locations necessitate additional costs and time-consuming modes of transportation. Time-saving emerged as an important factor for women, with the metro bus system being a more efficient option due to its dedicated route and frequency. Finally, safety concerns remain a significant issue for women using different modes of transportation, highlighting the need for gender-sensitive transport planning to address the specific needs of women commuters.

Keywords: mobility constraints, transportation services, female labor force participation, synthetic control method, thematic analysis, ride-hailing
JEL Classification: J16; J21; O18; R40

4.1 Introduction

Infrastructure development in cities is the foundation for achieving inclusive growth as it provides direct access to education, work, healthcare, and other services. However, inadequate mobility

[45] **Amber, H**., Chichaibelu, B. B., & Hussain, A. (2023) Impact of public transport and ride-hailing services on female labor force participation in Lahore, Pakistan: A mixed-method approach. International Growth Center (IGC) working paper.

infrastructure is often considered a serious problem that exacerbates inequalities by reducing the opportunities for women to realize their full potential. The ability to move around freely is fundamental to the empowerment of women, as it enables them to seize opportunities and resist the limitations imposed by the pervasive patriarchy (Tiwari & Jian, 2013). It is well established that the transport sector has been gender-blind by ignoring the differences in the mobility patterns of men and women (Litman, 2007; Njoh, 1999; Priya Uteng & Turner, 2019; Thondoo et al., 2020; Turner, 2012). Research on travel behaviour has provided ample evidence that highlights the contrast between the transportation needs and experiences of women and men (Priya Uteng, 2012). Due to various factors such as distinct attitudes towards public and private transportation, differences in employment and commuting patterns, and differences in caregiving responsibilities for children and elders, it has become evident that women require different treatment (Loukaitou-Sideris, 2020; Mahambare & Dhanaraj, 2022; Mahadevia & Advani, 2016; Nobis & Lenz, 2005; Scheiner & Holz-Rau, 2017; Singh, 2020).

The limited access to urban spaces and different modes of transportation, the existence of slums, and the pervasion of cultural or social norms in society place a burden on women's participation in the outside world (Priya Uteng, 2012). These factors can result in longer travel times, greater difficulty accessing transportation, and limited job opportunities, particularly in areas with inadequate transport infrastructure. A crucial factor that can ensure increased participation of women in the labor force is the access to opportunities that come with ease in mobility. Notwithstanding the accumulation of factors typically linked to increased female labor force participation rates,[46] such as an increase in female education, a decrease in fertility rates, and high levels of economic growth observed in most developing countries over the past 25 years, there exists a heterogeneous regional trend. While the Latin America and Caribbean regions have experienced an increase in female labor force participation, South Asia has exhibited a decrease from previously low levels (Klasen, 2019).

Despite experiencing approximately 9% growth in female labor force participation, women in Pakistan continue to exhibit significantly lower rates of workforce engagement compared to regional averages (Amber & Chichaibelu, 2023a). Furthermore, women who live in urban areas are less likely to participate in the labor force than women who live in rural areas (Amber & Chichaibelu, 2023b). A significant barrier to women's participation in the labor force in the urban areas of Pakistan is the constraint on their physical mobility outside their homes (Field & Vyborny, 2016). The emerging low-income communities on the outskirts of urban areas often lack adequate transportation infrastructure, posing a significant accessibility challenge, particularly for women (Mahadevia, 2015). The societal restrictions against women interacting with men who are not relatives, coupled with fear of harassment, social stigma, and discomfort, further act as an obstacle to women's freedom of movement and their reliance on different modes of transportation (Sajjad

[46] Labor force participation rates are used for the quantitative analysis, but we interviewed females who are currently employed for the qualitative analysis. It is worth noting that labor force participation encompasses women who are actively seeking employment but are not currently employed. In our study, we use both terms interchangeably.

et al., 2018). Therefore, the factors of accessibility, affordability, and safety are crucial to consider when addressing the constraints on women's mobility.

Public transportation provides an affordable option for women to commute. However, the research (Sajjad et al., 2017) shows that in Pakistan, women deal with various challenges concerning safety, harassment, and worries about their social reputation while traveling by public transport. In contrast, private transportation services offer better accessibility and safety, but they are not affordable compared to public transportation. Using a smartphone app, individuals can reserve a ride from any location through ride-hailing services (Rayle et al., 2016). However, the service remains more expensive than public transportation and does not attract transit users, particularly females (Singh, 2020). Furthermore, residents in more well-off neighbourhoods tend to rely more on private cars, taxis, and ride-hailing services for transportation, while those in low-cost and middle-class neighbourhoods prefer public transit for commuting and use ride-hailing for leisure trips (Qiao & Yeh, 2023).

Considering the importance of the provision of public and private transportation services in facilitating female labor force participation, this research aims to answer the following questions: (1) What would have been the female labor force participation in Lahore if there were no provision of 'Lahore metro' transportation services? (2) What would have been the female labor force participation in Lahore if there were no provision of 'ride-hailing' transportation services? (3) What are the factors associated with the use of public and private transportation services that facilitate or hinder women from participating in the labor force (commuters' perspective)? And (4) What are the perspectives of service providers on mobility constraints faced by women, and how are they addressing these constraints? To answer these questions, we use a mixed-method approach combining quantitative and qualitative research methods to gain a more holistic understanding of the impact of transportation services on female labor force participation in Pakistan.

The study makes a notable contribution to existing literature by employing a mixed-method approach, qualitatively explaining quantitative mechanisms (Creswell & Clark, 2018). Specifically, it investigates factors influencing women's transportation choices and their impact on labor market inclusion. The approach strengthens the understanding of how provision of transportation services alleviates barriers women face in the labor market, particularly those related to limitations on their physical mobility (Johnson et al., 2007). First, employing a synthetic control method with labor force surveys conducted between 1999 and 2020, the study investigates the causal impact of mass transit and ride-hailing services on female labor force participation. To our knowledge, Martinez et al., (2019) are the only ones to examine the causal impact of mass transit on women's employment in Lima, using the difference-in-difference approach. Additionally, Christensen & Osman (2021) examine the causal impact of price reductions provided to Uber riders and their subsequent effect on mobility demand through an experimental approach. In Pakistan, Field & Vyborny (2022) use an experimental approach to quantify the impact of transportation to work on both men and women in Lahore. Furthermore, Majid et al. (2018)

demonstrate the causal impact of mass transit on commuting and report that access to mass transit reduces both time and cost of commuting. Second, using qualitative data collected from employed females that use the metro bus and ride-hailing services in Lahore and the service providers, we perform thematic analysis to gain insights into the role mobility constraints play in female labor force participation and the determining factors in women's selection of the modes of transportation.

The remainder of the paper is divided into six sections. Section 4.2 provides the context of the study. Section 4.3 explains the conceptual framework of the study along with relevant literature. Section 4.4 describes the details of the research methods along with secondary and primary data used for the analysis. Section 4.5 communicates the results and discussions of the quantitative and qualitative analysis. Finally, section 4.6 provides conclusion and policy recommendations.

4.2 Context of the project

4.2.1 Study area

The section provides an overview of the study area, delineating the specific context in which the research was conducted. We selected Lahore as the research site for analysing the impact of transportation services provision for several reasons, which are described below.

Lahore is the 21st most populous city in the world and the second largest in Pakistan. It is one of the fastest-growing cities in the country with a population of 11.1 million[47] and a population density of 6275.39 inhabitants per square kilometre. The city is the capital of the Punjab province, which ranks highest in terms of the working-age population, that is, around 88.4 million.[48] The city is home to a huge population including indigenous and immigrants who come to the city in search of better living conditions, including health, education, employment, and commercial activities. However, rapid urbanization along with the inadequate provision of public services has given rise to congestion, pollution, inequality, and social exclusion.

Females make up almost 48 percent of Lahore's working-age population. However, their labor force participation rate is only 13.5 percent compared to 64.6 percent for men.[49] Even though the city has a better transport infrastructure (compared with other big cities), access to safe and affordable modes of transportation is still a dilemma for the females who are spatially isolated from the job market. According to the Women's Economic and Social Well-being Survey (2018), 34% of women, aged 15 to 64 (in Punjab) cite a lack of transport as a barrier to entering the labor market. The survey also reports that only 3.3 percent of females who are in paid employment have dedicated pick-and-drop facilities. Hence, restrictions on physical mobility outside the home act

[47] https://www.pbs.gov.pk/content/final-results-census-2017
[48] https://www.pbs.gov.pk/publication/labor-force-survey-2020-21-annual-report
[49] Same as above

as a critical hindrance to the labor market inclusion of women in urban areas in Pakistan (Field and Vyborny, 2016).

Through a series of public and private planning endeavours, the provision of transportation services in Lahore city has developed over the last decade. Lahore being the pioneering city in Pakistan where mass transit infrastructure was initially implemented, offers a valuable opportunity to examine the impact on women's employment over an extended period. The dominant modes of public transportation include the Lahore metro bus, the orange line, and speedo buses. Furthermore, private transportation modes comprise (excluding personal vehicles) ride-hailing (Uber, Careem, and InDriver), taxis, auto rickshaws, and motorcycle rickshaws.

4.2.2 Lahore metro bus system

Bus rapid transit (BRT) technology is based on the idea of providing transportation service through buses similar to rail-transit modes that include dedicated routes, institutional branding, electronic ticketing, and proper stations (Flores, 2013). The Lahore metro bus (MBS) is the first BRT in Pakistan. It is operated by the Punjab Mass Transit Authority (PMTA) along with a system of feeder routes (speedo buses) that connect different spatial locations to the metro stations (Figure C1). PMTA is one of the regulatory authorities and is directly responsible for the operation and maintenance of metro buses. The Lahore MBS was constructed and inaugurated in 2013 (in less than a year) at a cost of 11 million dollars per kilometre. However, it was the completion of an idea that took almost 20 years of consideration (Sajjad, 2014) as it had first been proposed in 1991. The Lahore metro bus is currently based on a fleet of 64 articulated air-conditioned buses with a capacity of 108 passengers per bus.[50] These buses operate on a single route of 27 kilometres with 27 stations. The buses operate on totally separate corridors with nine elevated stations (8.3 km) and are not stalled by city' traffic, which has markedly reduced travel time between Shahdara (start point) and Gajjumata (ending point). The fare per trip for one side is Rs. 30 (approximately 0.11 USD / 0.10 euros). The passenger is required to exit the system within an hour and 15 minutes after taping at the entry turnstile. Two modes of ticketing allow passengers to buy a token (for a single ride) or a metro bus card (a package for multiple rides). The buses operate from 06:15 am to 10:00 pm with a headway time of 2.25 to 3.0 minutes. However, during the last hour (09:00 pm – 10:00 pm), the headway time is 6 minutes from Gajjumata to Shahdara. The system has separate seating and standing area for women along with the female staff at the ticket counters and waiting area.

The route of the metro bus is not accessible to many areas in Lahore, therefore, PMTA has introduced a network of feeder routes (Figure C1) ensuring accessibility to different metro stations. According to PMTA, the metro bus system has achieved the highest passenger volume of 179,104 per day. Furthermore, up to May 2017, the system had transported 210 million passengers.

[50] The information about metro bus system has been reported from PMTA (https://pma.punjab.gov.pk/.)

4.2.3 Ride-hailing

Ride-hailing (also known as ride-sharing) is a tech service that connects two sides of the market place i.e., riders and drivers. Ride-hailing services are well established in Lahore as well as in other metropolitan cities across Pakistan. There are multiple tech service providers in Lahore; nonetheless, considering the market share and period of the study, we focus primarily on Uber and Careem. Careem started its operations in Lahore in 2015 a year earlier than Uber. However, Careem became a wholly-owned subsidiary of Uber in January (2020), preserving its brand.[51] According to an independent research report by Oxford Economics[52] (2021), Careem has around 800,000 registered captains (drivers) in Pakistan. The female registered captains are nearly 1586, which have taken more than 570,000 rides. On the customer side, out of 9 million registered customers, 36% are females. Considering safety as an important determinant of female mobility choices, about 51% of females feel that Careem is a safe mode of transportation compared to only 3 percent who feel it is not safe.

For the sake of brevity, we only discuss important details regarding Careem App. The service is available 24 hours a day and 7 days a week. Careem has different categories of car types which vary in price, size, and comfort level. The passengers can simply select the one that suits their preferences. The options include (1) Go: the most affordable ride for everyday use (2) Go+: extra comfort at an affordable (3) Business: Perfect for corporate and business rides with top-rated captains (4) Dabba: perfect for group commute, airport rides or grocery shopping (5) Rickshaw auto rikshaw rides at an extremely affordable price (6) Bike: an affordable and good option for skipping traffic (7) Delivery: only available to deliver stuff on a bike. The customers can simply select the one that suits their preferences. Cancelation is possible for a new booking within two minutes after a driver has been assigned. After that, a cancellation fee will apply.

The rates for all available cars and booking types for each city are available on the Careem App. The fare per kilometre is different for each vehicle. There is an option of "Help" on the Careem App which people can contact to report various issues regarding rides, food delivery and, Careem pay. Considering the safety option, there is also an option for safety and security that addresses different issues regarding COVID-19, ride insurance, accidents, and support to make a claim. There is also an option of "Share ride details" that allows riders to let their friends and family track the ride in real-time.

4.2.4 Conceptual framework and related literature

The conceptual framework of our study relies on the neoclassical model of a labor-leisure choice framework, which attempts to investigate the labor supply behaviour of individuals. The model

[51] https://www.uber.com/en-JO/newsroom/uber-careem-close-jo/

[52] https://blog.careem.com/wp-content/uploads/2021/11/EIR_Infographic_consolidated_v2.pdf

explains the labor supply choice of an individual striving to maximize her utility by allocating her time between the labor market (wage) and home (reservation wage). The reservation wage is the minimum wage an individual requires to enter the labor market, and if the market wage is lower than the reservation wage, the individual will not work. The decision to work is determined by comparing the market wage, which shows how much an employer is willing to pay, and the reservation wage, which shows how much the worker needs to start working (Borjas & Van Ours, 2010). The reservation wage, often viewed as the marginal utility of non-work, encompasses all determinants of labor supply decisions for women, except for the anticipated market wage (Klassen & Pieters, 2012). An interplay of social, economic, cultural, and regional factors influence women's labor supply decisions (Mehrotra & Parida, 2017), including childcare responsibilities (Cassirer & Addati, 2007; Clark et al., 2019; Dang et al., 2022; Narayanan, 2008), household income (Klassen & Pieters, 2012; Afridi et al., 2018), social norms (Cavapozzi et al., 2021; Jayachandran, 2021), and constraints in physical mobility (Field & Vyborny, 2016; Lei et al., 2019; Martinez et al., 2019; Williams et al., 2019).

Transportation infrastructure plays a crucial role in facilitating women's employment through its direct impact on transport affordability. Affordable transportation services can have a significant impact on reducing reservation wages for women. The reservation wage hypothesis suggests that higher transportation costs are likely to result in a higher reservation wage, which in turn can limit the geographic range of job opportunities available to workers (Patacchini & Zenou, 2005). Therefore, reducing transportation costs can expand the search radius for job opportunities and increase the labor force participation of women (Martinez et al., 2019). The fare structure that is disadvantageous for multistep journeys can result in higher transportation costs, which may make it more difficult for women to afford transportation (Dominguez Gonzalez et al., 2020). According to Williams et al. (2019), more affordable commute services are associated with higher job participation of Saudi women.

In addition, improved access to employment opportunities through transport infrastructure could potentially decrease the time it takes to find work by broadening job search options and increasing the wages offered for a given job, hence reducing associated reservation wages (Bastiaanssen et al, 2020). As a result, the likelihood of applying for and accepting such work may increase. Ong and Houston (2002) analyse the employment outcomes of unmarried women and find that proximity of transit service to the women's homes plays a significant role in increasing the likelihood of their employment. Furthermore, women's lower access to financial resources has shown to lead to lower access to private and more efficient modes of transportation, resulting in additional penalties due to the time lost in traveling by slower modes of transportation (Singh, 2020). A study in Lahore, Pakistan that examined the effects of access to transport services on men's and women's job search behaviour found that access to transportation significantly affected women's job search behaviour and that providing women-only transport can help reduce physical mobility constraints, making it easier for women to search for jobs (Field & Vyborny, 2022).

The provision of transportation services also influences women's participation in the labor market indirectly. First, safety issues in transportation disproportionately affect women. In many developing countries, the physical mobility of women and girls is restricted due to concerns about their safety and social reputation (Jayachandran, 2015). A review of international studies by Gekoski et al. (2015) reveals that rates of harassment against women in public transportation vary from nearly 15 percent to 95 percent with higher rates for developing countries, which is potentially attributable to cultural and gender norms that favour men. Research (Bhattacharya & Kopf, 2017) conducted in Delhi shows that female students are opting for lower-quality colleges due to safety concerns on their travel routes, affecting their labor market inclusion in the end. However, the integration of infrastructure and technology in mass transit systems has introduced measures ensuring the safety of women, particularly when compared to other modes of public transportation (Martinez et al., 2019).

Second, emerging transportation services such as ride-hailing can also increase women's employment opportunities as they provide flexible and safe job opportunities. Female drivers in Egypt who work for ride-hailing services have identified the flexible nature of the job as a key incentive for them to enter the labor market (Rizk et al., 2018). However, the proportion of women working as drivers on these platforms remains low due to concerns over personal safety and security, lack of financial means to own a car, low access to the internet and smartphones along with various cultural and societal norms that limit women's participation in the workforce.[53] In addition, the importance of considering a gender-sensitive perspective in the provision of transportation services can also increase women's inclusion in the labor market. Women can bring unique insights into the needs and concerns specific to their gender, which can be taken into account during the planning and design of transport systems (ITF Global, 2019).

4.3 Research methods and data

The literature on transportation and women's employment shows that transportation is not just a physical resource like vehicles, roads, and public transport. It is also about the social and cultural factors that affect women's access to transportation and their ability to use it to connect their home and work lives (Dobbs, 2007). Therefore, the study aims to employ a mixed-method approach to provide a more comprehensive understanding of the interplay of physical, social, and cultural factors and their impact on women's employment in the context of a developing country i.e., Pakistan. The following subsections delve into the quantitative and qualitative analysis, presenting detailed information regarding the methodologies employed and the data sets used.

[53] https://www.thecairoreview.com/global-forum/empowering-women-to-ride/

4.3.1 Quantitative analysis: synthetic control methods

Using the synthetic control method developed by Abadie & Gerdeazabal (2003), the study estimates the causal effects of the provision of public and private transportation services on female labor force participation in Lahore, Pakistan, in a comparative case study setting. The method has been considered an eminent innovation in the policy evaluation literature in the last 15 years (Atheys & Imbens, 2017). The synthetic control method aims to estimate the impact of some intervention at the aggregate level that affect a small number of large units for some aggregate outcome of interest (Abadie, 2021). The method treats the region that receives an intervention as a treatment group and compares the outcome variable with a group of units not exposed to the intervention. The aggregate composition of unaffected units provides a good control group rather than a single unaffected unit. The method builds a counterfactual of units using a convex combination of similar units not exposed to the treatment. The convex combination requires nonnegative weights that are determined to ensure that the treatment unit and the synthetic control resemble each other as closely as possible before intervention.

In our study, we consider $j+1$ cities (Table C2) and assume that Lahore is exposed to the intervention (either metro or ride-hailing). Thus, we have j remaining cities as potential controls or donor pools. This is a group of 27 cities in Pakistan for which data has been constructed from labor force surveys (1999-2020). The cities in the sample are examined for the time period $t = 1, 2, \dots, T$. It is important to note that sufficient data should be available before interventions $1, 2, \dots, T_0$ as well as post-intervention $T_0 + 1, T_0 + 2, \dots, T$ to be able to construct a synthetic Lahore and estimate the effect of the intervention. Synthetic Lahore is constructed as a weighted average of potential controls and is represented by a vector of non-negative weights that sum to one such that $W = \left(w_2, \dots, w_{j+1}\right)' with\ 0 \leq w_j \leq 1\ and\ w_2 + \cdots + w_{j+1} = 1$. Each value of W represents a weighted average of the potential control regions, hence a synthetic control (Abadie et al. 2010).[54] The weights are chosen so that the difference between Lahore and the potential control cities on a number of important predictors of female labor force participation (FLFP) and FLFP itself is minimized in the pre-intervention period. As key predictors, we have constructed various variables at the city level including average age, the proportion of married women, the average number of years of education of the household head, the share of females without formal education, the share of females with a primary level of education, the share of females with a secondary level of education, the share of females with tertiary level of education, average household size, the average number of children between 0 and 4 years of age, employment rate of males and log of household income excluding the income of employed women (Table C1). The variables are averaged over pre-intervention period and augmented by adding two years of lagged female labor force participation rate (2001 and 2007).

[54] We suggest reading 'Abadie et al. 2010' for a more detailed technical description of the synthetic control method.

Similarly, predictors are assigned weights (V) to allow more weight to be given based on the relative importance of their impact on the outcome variable. In the study, predictor weights (V) and city weights (W) are jointly chosen so that they minimize mean square prediction error (MSPE) of female labor force participation over the entire pre-intervention period. It is important to mention that we use household-level data for employing the synthetic control method. To the best of our knowledge, Peri and Yasenov (2019) are the only ones to apply a synthetic control method using household data.

By constructing a synthetic counterpart of Lahore using comparable cities as a reference, the synthetic control method aims to offer insights into the overall impact of the introduction of metro bus and ride-hailing services on female labor force participation. The utilization of the synthetic control method necessitates the availability or construction of data at an aggregate level. Therefore, in this study, the quantitative analysis is based on annual labor force surveys (1999-2020)[55] to measure female labor force participation and the predictors of labor force participation at the city level. LFSs provide information on the sociodemographic attributes of the households as well as individual-level information on age, gender, marital status, level of education, etc. The outcome variable of interest is the female labor force participation rate at the city level, which includes employed and unemployed women. Employed women are those who worked for pay, profit, or family gain during the last week, at least for one hour on any day. It also includes women who did not work last week but had a job or an enterprise such as a shop, business, farm, or service establishment. The unemployed females are the ones seeking work during the survey period. Since the project aims to address labor market outcomes of females, we restrict our sample to women of working age (15-64). The labor force participation rate is calculated by dividing the number of employed and unemployed females by the total population of working-age females. The study constructs several predictors of female labor force participation rates at the city level.

We construct data for 28 cities (Table C2) across four provinces of Pakistan. The selection of cities is based on the availability of labor force surveys and the coding schemes so that we can construct data on listed cities for all the available LFSs. To examine the impact of the metro bus on the participation of women in the labor force in Lahore, we used data until 2018 due to the launch of another 'orange line metro train system' of mass transit in 2020. The first stretch (27 km) of the Lahore metro was inaugurated in February 2013, giving us around 10 years of pre-intervention data. We excluded Islamabad, Rawalpindi, and, Multan from the control cities pool that had the same intervention in 2015 and 2017 respectively. In addition, three years of post-intervention data, spanning over six years (three data points) to make reasonable predictions of the effect of this infrastructure intervention seems acceptable. The synthetic group or synthetic Lahore was constructed as a weighted average of potential control cities. The ride-hailing (Uber and Careem) was launched in 2015/2016 in Lahore along with other cities. However, no labor force survey was

[55] We have data sets from 1990 to 2020. However, the coding schemes were not available for all the data sets which reduces the pre-intervention years for the analysis. Additionally, the labor force surveys for the years 2000, 2002, 2004 are not available and the labor force surveys were not conducted for the years 2011, 2015, 2016 and 2019.

conducted in 2015/2016. For the sake of analysis, we took 2014 as the intervention year which gave us eleven years of preintervention data. Furthermore, we eliminated Faisalabad, Rawalpindi, Multan, Sargodha, Gujranwala, Sialkot, Bahawalpur, Islamabad, Karachi, Hyderabad, Sukkur, Peshawar, Quetta, and Mardan from the control states pool because of the introduction of ride-hailing (Uber or Careem) in the post-intervention period (spanning over four years) i.e., 2017-2020.

4.3.2 Qualitative analysis: thematic analysis

For the qualitative analysis, we used a semantic approach to thematic analysis, since we are primarily interested in women's perceptions and their experiences with using public and private transportation services when travelling to their workplaces. Thematic analysis is used when research aims to explore an issue or problem, and focus more on words, not numbers (Creswell 2016; Miles and Huberman 1994). The method allows one to analyse data in a flexible manner, helps organize data into themes, and interprets the research question (Braun and Clarke, 2006).
In thematic analysis, one can use either a deductive (top-down) or inductive (bottom-up) approach. Alternatively, both can be used together to enhance the analysis of the study (Braun and Clarke, 2006). In the study, we followed both deductive and inductive approaches to the thematic analysis. Following the deductive approach, we constructed themes and subthemes (Table C3) based on the literature review (Ali et al., 2022; Bastiaanssen et al., 2020; Dobbs, 2007; Dong, 2020; Field & Vyborny, 2016; Field & Vyborny, 2022; Gautam et al., 2019; Hadi, 2017; Joshi et al.,2021; Joshi et al., 2022; Mahadevia, 2015; Majid et al., 2018; Malik et al., 2020; Martinez et al., 2019; McLafferty & Preston, 1992; Noor & Iamtrakul, 2023; Olivieri & Fageda, 2021; Quinones, 2020; Sajjad et al., 2018; Shah & Hisashi, 2022; Singh, 2020; Weersinghe, 2017; Williams et al., 2019; Zolnik et al., 2018) and the study context to formulate the questionnaire and analyse these themes. In an inductive approach, themes emerge from the data itself without paying attention to themes included in other studies (Braun and Clarke, 2006). We used thematic analysis to analyse semi-structured interviews conducted with metro and ride-hailing commuters as well as to analyse textual data from key informant interviews. An important step in qualitative research is the selection of respondents which requires thorough consideration, as it is fundamental to the validity of the results (Curtis et al., 2000). Taking into account two distinct research questions that attempt to understand the factors associated with women's mobility related to public and private transportation services and the perception of higher authorities in providing these services to women, the study targeted working women using either metro or ride-hailing services to commute to and from their workplaces. The study area is the district of Lahore comprising of 9 town zones (and cantonment which is an independent municipality under the Lahore cantonment board) and 274 union councils.
We collected data in Lahore through a structured questionnaire, semi-structured interviews, and key-informant interviews in July-August 2022. We conducted structured interviews through a pre-

tested structured questionnaire that included sections on demographic information, employment and income, education, information, and communication technology, and a transportation services section that contains separate sections for metro and ride-hailing users. To select a random sample of females using the metro, we conducted structured interviews with 46 females from every station covering from Shahdra to Gajjumata. There are 27 metro stations including Shahdra and Gajjumata and we selected at least one female from every station. Furthermore, we conducted 10 semi-structured interviews[56] based on the themes (Table C3). With their semi-structured format, interviews provide greater flexibility, as well as adequate responses to the formulated research questions (Creswell, 2013). To conduct semi-structured interviews, only three women from the 46 mentioned above agreed to give semi-structured interviews. The rest were selected by combining snowball sampling and respondent-driven sampling where initial respondents enlist additional respondents from their networks of friends to avoid the risk of limiting ourselves to collecting data from the same network of peers. The structured questionnaire was completed by a total of 53 female participants.

To select ride-hailing commuters, we conducted structured interviews with 38 females. Due to the fact that unlike metro stations there is no place where you can select a random sample of female ride-hailing users, therefore, we endeavoured to select our sample from all 9 towns of Lahore by approaching females visiting different offices and public places in Lahore (Figure C2). Furthermore, similar to metro users, we conducted 10 semi-structured interviews of the females by combining snowball sampling with respondent-driven sampling. The method of contact for all semi-structured interviews was face-to-face and telephone interviews. We have a total of 48 ride-hailing users who completed structured questionnaires.

To understand the perspective of service providers, we conduct four semi-structured interviews with the key informants of the following organizations: (1) Punjab Mass Transit Authority: General Manager Operations (2) The Urban Unit: Senior Research Analyst Transportation Planning and Management (3) Punjab Commission on the Status of Women (anonymous) and (4) Ride-hailing (anonymous). In semi-structured interviews, the respondents and key informants were given the opportunity to share their stories, provide detailed information, and share insights on the research questions posed in the study and related themes. We conducted face-to-face interviews with all key informants.

4.4 Results and discussion

The section presents descriptive and empirical findings, which are further divided into two subsections. The quantitative subsection reports the results and discussion of the synthetic control method, while the qualitative subsection presents the findings and discussion of thematic analysis.

[56] It is important to mention that all the females (metro and ride-hailing users) who were part of the semi-structured interviews also took part in the structured questionnaire.

4.4.1 Quantitative section

Figure C3 shows the trends in female labor force participation in Lahore and all other cities under metro bus transit and ride-hailing intervention specifications. The plots suggest that the control group of all other cities may not provide a good comparison group for Lahore to analyse the impact of the provision of different transportation services on female labor force participation. The trend began to converge in 2007 and onwards under the MBS control group. However, it is quite heterogeneous for the control cities chosen under ride-hailing which shows that these cities (excluding major metropolitan cities across four provinces) do not provide a good estimate for comparison. Hence, the construction of a synthetic control group becomes necessary for impact evaluation. Furthermore, we can observe that female labor force participation is higher in Lahore than the overall averages in the control groups under both specifications. In order to assess the impact of metro bus transit and ride-hailing in Lahore, the main question is how the participation of women in the labor force would have evolved in Lahore after 2013 and 2016, respectively, in the absence of the aforementioned interventions.

4.4.1.1 Metro bus system

Table 4.1 compares the pre-treatment characteristics of Lahore with that of synthetic Lahore as well as with the averages of the 24 cities in the control group for metro bus intervention.[57] We construct synthetic Lahore as a convex combination of cities in the donor pool that closely approximate Lahore in terms of pre-intervention (metro) values of female labor force participation predictors. We observe that averages of cities that did not have mass transit intervention after 2013 do not provide a suitable control group for Lahore. For example, the proportion of females with no formal education is higher in the average of 24 control cities than in Lahore. However, the synthetic Lahore reproduces estimates much closer to the real Lahore than the average of 24 control states.

Table 4. 1 Female labor force participation predictor means before the metro intervention

	Lahore		**Average of 24**
Variables	**Real**	**Synthetic**	**control cities**
Proportion of married women	0.674	0.672	0.707
Average age	31.5	31.65	31.67
Education of the household head	6.588	6.719	6.151
No formal education	0.334	0.335	0.532

[57] We also calculated pre-treatment characteristics with sampling weights and results are not much different.

Primary education	0.273	0.276	0.223
Secondary education	0.288	0.288	0.189
Tertiary education	0.105	0.099	0.055
Male employment rate	0.774	0.749	0.733
Average household size	6.249	6.307	6.968
Average number of children under 4 years of age	0.728	0.746	0.914
Log of average household income	9.252	9.212	9.177
Female labor force participation rate (2001)	0.152	0.152	0.075
Female labor force participation rate (2007)	0.087	0.096	0.078

Note *All variables are averaged for the 1999-2012 period.*

Table 4.2 shows the list of control cities and the share of each in the construction of synthetic Lahore. The weights indicate that female labor force participation in Lahore before the intervention of metro bus transit is best reproduced by the weighted averages of Bahawalpur, Karachi, Sialkot, Hyderabad, Faisalabad, and Gujranwala. The weights of other cities in the donor pool are zero.

Table 4. 2 City weights in the synthetic Lahore (metro intervention)

City	**Weight**	**City**	**Weight**
Lahore	Treatment city	D.G khan	0
Faisalabad	0.042	Larkana	0
Rawalpindi	-	Mirpur Khas	0
Multan	-	Malakand	0
Gujranwala	0.012	Kohat	0
Sargodha	0	D.I Khan	0
Sialkot	0.214	Hazara	0
Bahawalpur	0.398	Bannu	0
Islamabad	-	Mardan	0
Karachi	0.258	Sibbi	0
Hyderabad	0.076	Kalat	0
Sukkur	0	Mekran	0
Peshawar	0	Zhob	0
Quetta	0	Nasirabad	0

Source *Author's own construction.*

Figure 4.1 presents the female labor force participation rate of Lahore and synthetic Lahore during the period 1999-2018. We can observe that compared to the average female labor force participation rate in other control cities, female labor force participation in synthetic Lahore very closely follows the path of this variable for the entire pre-intervention metro period. Our estimate

of the impact of the large-scale public transport infrastructure provision (metro bus) is the difference between the female labor force participation rate between Lahore and synthetic Lahore from the 2013 to 2018 period. The gap between the two after 2013 shows a small positive effect of the Lahore metro bus system on female labor force participation in Lahore. To the best of our knowledge, Martinez et al. (2019) are the only ones to investigate the causal impact of bus rapid transit and elevated light rail investment on women's employment outcomes. The study reports large gains (around 7%) in employment for women through increased accessibility to jobs.

To comprehend these findings, we examined various pathways (through qualitative analysis) that demonstrate how the metro bus transit can facilitate women's labor market inclusion in Lahore. Firstly, the metro bus together with its feeder routes (speedo buses), offers accessibility that connects women to employment opportunities. Based on primary data collected from female metro commuters, the majority of them reported that the metro is an accessible mode of transportation for commuting to their workplaces. Bastiaanssen et al. (2020) report that improved access to employment opportunities could potentially decrease the time needed to find a job and increase the wage offered for a given job. Majid et al. (2018) find that the introduction of mass transit in Lahore has reduced both the time and cost of commuting for those who depend on public transportation for commuting. Nevertheless, the challenge faced by working women when using public transportation is that the routes and station locations do not always suit the available infrastructure in their neighbourhood, resulting in lengthy or expensive commutes.

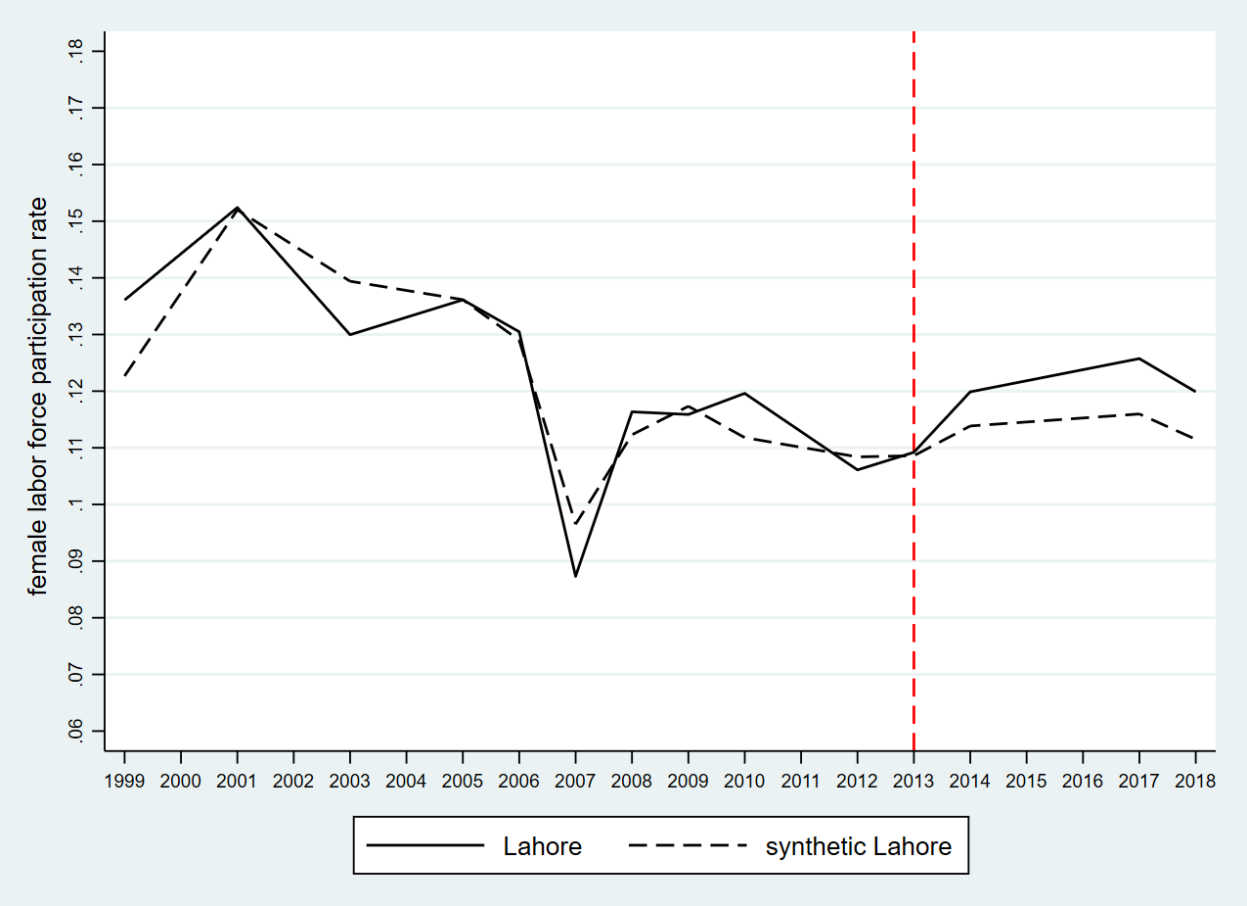

Figure 4. 1 Female labor force participation in Lahore and synthetic Lahore

Secondly, affordability is the primary factor that attracts low-income women to use the metro bus for commuting to work. For all the female participants (structured and semi-structured interviews) who use the metro bus, the transportation cost is easily manageable within their budget. As described in the conceptual framework section, lower transportation costs enable women to accept jobs that pay less or are located farther away from their homes. Although the current fare system is subsidized, a considerable number of commuters expressed their willingness to continue using the service even if the fares were increased. This is because the system offers faster and better-quality service and attracts commuters who have a higher earning power (Majid et al., 2018). A majority of the ride-hailing female commuters in our sample have expressed their willingness to use affordable metro service provided that it is easily accessible to them.

Another important pathway that promotes employment opportunities for metro commuters is the safety features provided. The risk of harassment has made public transportation unsafe for women in Pakistan, restricting their mobility, and access to jobs, and contributing to cultural expectations that limit women's participation in the workforce (Field & Vyborny, 2022). However, public transport in the form of mass transit has certain safety features that represent a significant improvement in comparison to other forms of public transportation in the city (Martinez et al.,

2019). The presence of guards or security personnel at metro stations, along with an operating helpline for complaints and suggestions, has substantially reduced concerns regarding the harassment of women. From the qualitative survey, we found that 91 % of the women in our sample reported that they had never faced harassment at the metro stations.

Figure C4 (left panel) displays the yearly gaps in female labor force participation in Lahore and synthetic Lahore. It suggests that metro intervention caused an average increase of around 1.0 per cent in female labor force participation during the 2013-2018 period. The magnitude of this impact is not quite substantial; however, observing the low participation of females from urban areas in developing countries (Klasen, 2019; Klasen & Pietres, 2015), the ease of mobility brought about by the metro bus transit can serve as an important driver of female employment in Pakistan.

There are several reasons that lead to a smaller-than-expected positive impact of metro bus intervention. First, the use of household data to construct city-level aggregates does not provide us with all the predictors of female labor force participation at an aggregate level. Other important predictors of female labor force participation include fertility rate, regional or city-level GDP, regional human development index, urbanization, degree of industrialization, etc (Cipollone et al., 2014; Gaddis & Klasen, 2014; Kumari, 2018; Mammen & Paxson, 2000; Taşseven & Turgut, 2016). For instance, not including a relevant variable such as fertility rate can potentially lead to a smaller impact of the metro intervention on female labor force participation. Given that the fertility rate has a significant association with female labor force participation as it reflects the decision-making process regarding family planning and a trade-off between work and child-rearing responsibilities (Klasen, 2019).

Second, in terms of accessibility, a large population of potential female employees does not have access to metro stations. Many ride-hailing users reported the unavailability of public transport infrastructure (metro bus and orange train) in their neighbourhood. Hence, limited or inadequate access to mass transit can act as a barrier for female employees, hindering their ability to commute efficiently and access employment opportunities. In addition, due to the change in coding schemes after 2017, the construction of aggregate level variables also includes the urban areas outside the main Lahore city. For the labor force surveys from 1999 to 2017, we aggregated data on 28 cities by combining codes of large-sized cities and codes of other urban areas. The district-level urban areas were taken into account while constructing aggregate variables for the years 2018-2020. Therefore, the inclusion of other urban areas that lack direct or indirect access to metro stations accompanied by lower female labor force participation may have potentially contributed to a diminished impact of metro buses on female labor force participation in Lahore. Finally, existing research presents varied findings regarding the effects of transport infrastructure development in both the short and long run (Hong et al., 2011; Jiwattanakulpaisarn et al., 2012; Zhang & Cheng, 2023). While most researchers highlight a positive impact of transport infrastructure development on economic growth in both timeframes, Leeson (2014) reports that the short run effects are more pronounced in less developed areas than in more developed regions. In case of Lahore, being one of the most developed cities in Pakistan, the provision of metro bus infrastructure has contributed

positively, though not significantly (in terms of magnitude), to the increase in the labor force participation of women.

To evaluate the reliability of the estimates, we use placebo tests by iteratively applying the synthetic control method to every other city that did not have a mass transit intervention during the sample period. In each iteration, we reassign the metro intervention of 2013 to one of the cities in the donor pool and shift Lahore to the donor pool. For example, we assume as if one of the cities in the donor pool would have the same mass transit intervention in 2013, instead of Lahore. By following the iterative procedure, we obtain a distribution of estimated gaps for the cities where no mass transit infrastructure was implemented. If the gaps generated by placebo studies are of a similar magnitude to the one calculated for Lahore, it indicates that our results do not offer substantial proof of a positive impact of metro bus transit on the female labor force participation rate in Lahore. Conversely, if the gaps produced by the placebo studies demonstrate that the gap estimated for Lahore is considerably more significant than the gaps for cities that did not have mass transit intervention then we conclude that our analysis presents significant evidence of a positive impact of metro bus transit intervention in Lahore (Abadie et al., 2010). We expect the estimated effect for Lahore to be an outlier in the distribution of placebo tests (Gharehgozli, 2017) Figure C5 shows the results of the placebo tests. The grey lines represent the gap estimated from a placebo synthetic control analysis for each city in the donor pool. In addition, the black line represents the gap estimated for Lahore. The right panel shows the gap plots for all control cities in the donor pool. And it does not seem like Lahore is an outlier in the distribution of the placebo effects. In the left panel, we exclude those cities with an MSPE (the average of the squared differences between female labor force participation rate between Lahore and its synthetic counterpart for the pre-intervention period) of three times or higher than Lahore as suggested by Abadie et al., (2010). The remaining cities show a better fit of synthetic control and are better entrants to include in the placebo distribution. We can observe that Lahore is an outlier in terms of its positive effect post-intervention. Some of the control cities show a larger positive effect; however not for the entire pre-intervention period.

4.4.1.2 Ride-hailing

Table 4.3 compares the pre-intervention fit of real and synthetic Lahore along with the average of 13 control cities. As mentioned in section 4.2.3, Uber and Careem started operating in Lahore in 2015/2016 and were soon introduced in other metropolitan cities that are closer to Lahore in terms of economic development. The table shows that the control cities' average does not demonstrate the pre-intervention approximation to Lahore in terms of predictor balance. However, synthetic Lahore provides a better approximation as compared to the averages of 13 control states.

Table 4. 3 Female labor force participation rate predictor means before the intervention (ride-hailing)

Variables	Lahore		Average of 13 control cities
	Real	Synthetic	
Proportion of married women	0.675	0.675	0.733
Average age	31.54	32.03	31.78
Education of the household head	6.614	7.315	6.054
No formal education	0.328	0.363	0.614
Primary education	0.274	0.254	0.197
Secondary education	0.291	0.285	0.149
Tertiary education	0.106	0.098	0.039
Male employment rate	0.771	0.655	0.725
Average household size	6.213	6.504	7.102
Average number of children under 4 years of age	0.721	0.751	0.977
Log of average household income	9.322	9.335	9.235
Female labor force participation rate (2001)	0.152	0.133	0.059
Female labor force participation rate (2007)	0.087	0.098	0.077

Note All variables are averaged for the 1999-2013 period.

Table 4.4 reports the weights assigned to the cities in the donor pool for ride-hailing intervention. The weights show that female labor force participation in Lahore before the intervention of ride hailing is best reproduced by the weighted averages of Hazara, and Larkana.

Table 4. 4 City weights in the synthetic Lahore (ride-hailing intervention)

City	Weight	City	Weight
Lahore	Treatment city	D.G khan	0
Faisalabad	-	Larkana	0.178
Rawalpindi	-	Mirpur Khas	0
Multan	-	Malakand	0
Gujranwala	-	Kohat	0
Sargodha	-	D.I Khan	0
Sialkot	-	Hazara	0.822
Bahawalpur	-	Bannu	0
Islamabad	-	Mardan	-
Karachi	-	Sibbi	0
Hyderabad	-	Kalat	0
Sukkur	-	Mekran	0

Peshawar	-	Zhob	0
Quetta	-	Nasirabad	0

Source *Author's own construction.*

We do not see an increase in female participation in the labor force in Lahore after the ride-hailing intervention. It is also important to mention that due to the unavailability of 2015/2016 data sets[58] we chose 2014 as the intervention year to match the pre-intervention predictor balance. Figure 4.2 shows a reasonable but noisy Lahore-control match for the pre-intervention period and almost no impact after the intervention.

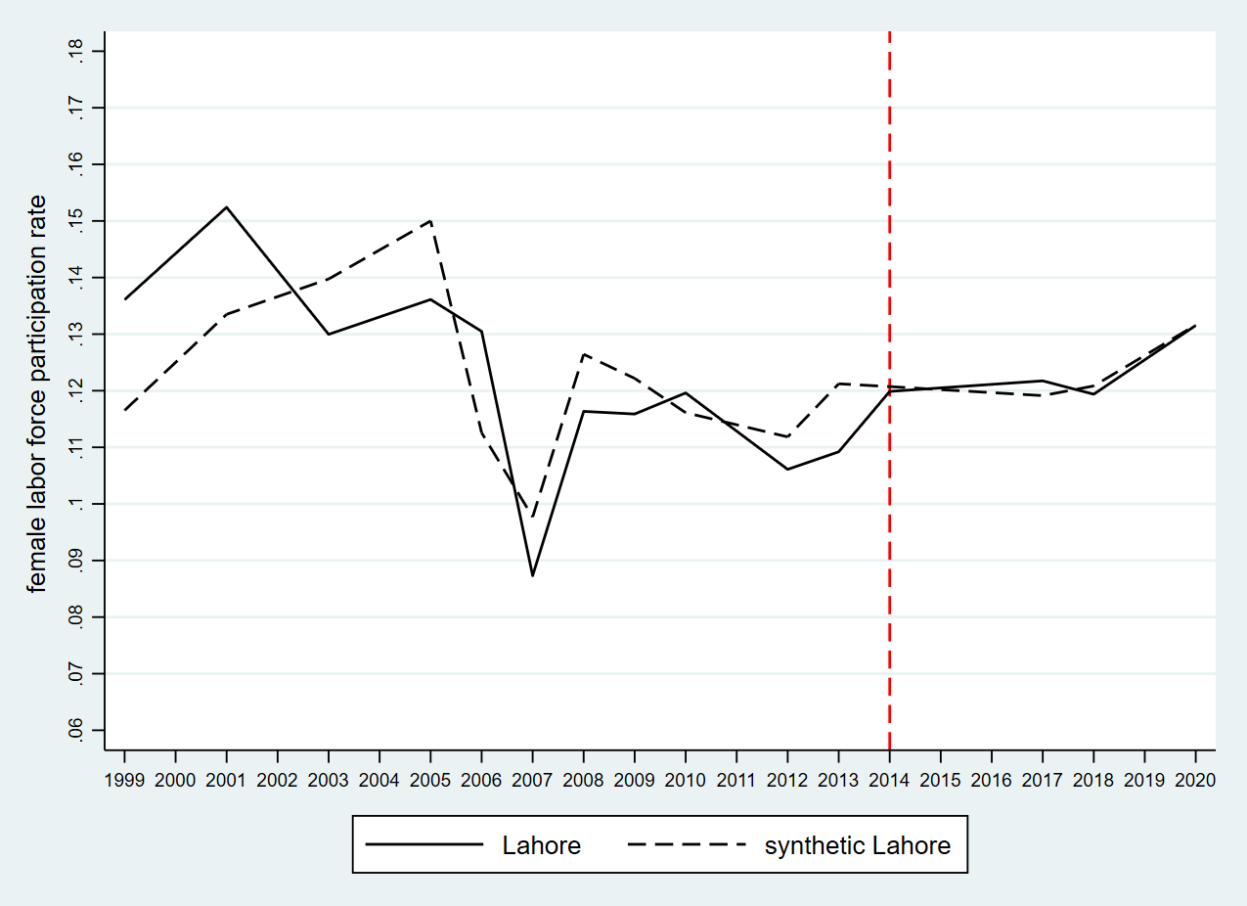

Figure 4. 2 Female labor force participation in Lahore and synthetic Lahore (ride-hailing)

Figure C4 (right panel) shows the yearly gaps in the participation of women in the labor force between Lahore and synthetic Lahore before and after the ride-hailing intervention. We can observe no impact of the intervention in Lahore after 2015/2016 and can infer that the provision of ride-hailing has not contributed to the increase in female labor force participation.

[58] Pakistan Bureau of Statistics did not conduct labor force survey in 2015 and 2016.

There are several reasons for the no impact of ride-hailing on female labor force participation. First, it is worth noting that the launch of ride-hailing in many metropolitan cities in Pakistan, which are similar to Lahore regarding socio-economic conditions, has resulted in a poor match between synthetic Lahore and actual Lahore. This could be a potential reason for the lack of intervention impact.

Second, the labor market behaviour of women in Pakistan shows that it is driven by necessity rather than intent (Amber & Chichaibelu, 2023a). According to Saqib & Arif (2012), monetary poverty is an important determinant of female labor force participation in Pakistan. Furthermore, household income is negatively associated with women's labor market inclusion (Klasen & Pieters, 2015). The descriptive statistics of the primary data collected show that the users of ride-hailing in Pakistan are earning more than metro users, and hence can afford to pay for the premium service (Shah & Hisachi, 2022). As ride-hailing customers come from higher-income households, females belonging to these households tend to participate less in the labor force. The price reduction experiment conducted with Uber riders in Cairo, Egypt shows a notable demand response for the services (Christensen & Osman, 2021). Furthermore, the researchers find the price reduction for ride-hailing services has an uneven impact on women. It leads to an increase in Uber usage, overall mobility, substitution away from buses (less safe transport), and a higher self-reported safety. Despite this, the study find no significant increase in employment or job search activity as a result of the price cuts.

Third, it is commonly understood that the emergence of ride-hailing brings employment opportunities for the rising population of Pakistan. It is also important to mention that globally Uber has been increasing gender diversity in the workforce with 59.7 percent of males and 40.3 percent of females (2020).[59] However, in Pakistan, more than 90 percent of the Careem registered captains are men.[60] Furthermore, according to the information provided by the key informant of a ride-hailing service provider, women drivers constitute less than 2 percent of the registered drivers. Considering the conservative social norms and behaviour of men towards female drivers, it seems highly unlikely that women can take advantage of this great opportunity that provides them with flexible working hours to maintain their work-life balance.[61] An interesting insight shared by the key informant of ride-hailing reveals that (according to a survey conducted by the service provider) 80 percent of Pakistani men reported that they would not take the ride if the driver is a women.

As mentioned in section 4.5.1.1, we perform placebo tests under ride-hailing specifications. Figure C6 (left panel) displays the female labor force participation rate gaps in Lahore and placebo gaps in 13 control cities. We exclude those cities with MSPE three times higher than Lahore and results are presented in the right panel of Figure C6. The remaining cities show a better fit of the synthetic control. We can see that Lahore is an outlier in the distribution of placebo tests in terms of having no impact of the intervention of ride-hailing on female labor force participation.

[59] https://www.statista.com/statistics/693807/uber-employee-gender-global/
[60] https://blog.careem.com/wp-content/uploads/2021/11/EIR_Infographic_consolidated_v2.pdf
[61] https://www.thecairoreview.com/global-forum/empowering-women-to-ride/

4.4.2 Qualitative section

Table 4.5 provides a summary of the demographic characteristics of the metro users in Lahore. It shows that the major share belongs to the age group 25-34 years, followed by 18-24 years old. Under the employment category, all women belong to paid employment (either full-time or part-time). An important insight is that around 79% of females earned less than or equal to 45,000 rupees (158 $) per month. For the education category, most (41%) have a tertiary education level followed by women with no formal education (21 %). Most women travel around 5-10 kilometers every day to and from their workplace.

Table 4. 5 Summary statistics of Lahore metro users

Variable	Classification	Frequency	Percentage
Age	Under 18 years old	1	1.89
	18-24 years old	14	26.42
	25-34 years old	16	30.19
	35-44 years old	10	18.87
	45-54 years old	9	16.98
	Above 55 years old	3	5.66
Marital status	Unmarried	28	52.83
	Currently married	24	45.28
	Divorced	1	1.89
	Widowed	0	0
Employment status	Employer, employing less than 10 people	0	0
	Employer, employing more than 10 people	0	0
	Paid employee (full-time)	33	62.26
	Paid employee (part-time)	20	37.74
	Self-employed	0	0
Monthly income	Less than Rs. 25,000	24	45.28
	Rs. 26,000-Rs. 45,000	18	33.96
	Rs.46000-Rs.65000	4	7.55
	Rs.66000-Rs.85000	4	7.55
	Rs.86000-Rs.1,05,000	1	1.89
	Rs.1,06,000-Rs.1,25,000	1	1.89
	More than 1,25,000	1	1.89
Education level	No formal education	11	20.75
	Primary education	5	9.43
	Secondary education	5	9.43
	Tertiary education	22	41.51
	MPhil	9	16.98
	PhD	1	1.89
Mobile/smartphone	Mobile phone	8	15.09
	Smartphone	38	71.70
	None	7	13.21
Daily travel (km)	Less than 5 km	7	13.21

	5-10 km	23	43.40
	10-15 km	15	28.30
	More than 15 km	8	15.09
Sample size		53	

Source *Author's own construction from structured questionnaire responses.*

Table 4.6 provides demographic information on ride-hailing users. Most of the ride-hailing users belong to the 25-34 years old age category, followed by 35-44 years old. The employment status shows consistency with metro users as the majority of the females (around 88 %) are paid employees. Regarding monthly income, the data shows that ride-hailing users are earning more than metro users with 25% of females earning between 66,000-85,000 rupees (230-300 USD). Under the education category, 50 % of ride-hailing users have a tertiary level of education followed by 39 % of females with 18 years of education. Considering the daily travel section, around 35% of the females are traveling 5-10 kilometres every day, followed by 31% percent of females traveling 10-15 kilometres.

Table 4. 6 Summary statistics of ride-hailing users

Variable	**Classification**	**Frequency**	**Percentage**
Age	Under 18 years old	0	0
	18-24 years old	7	14.58
	25-34 years old	28	58.33
	35-44 years old	10	20.87
	45-54 years old	2	4.17
	Above 55 years old	1	2.08
Marital status	Unmarried	28	58.33
	Currently married	16	33.33
	Divorced	3	6.25
	Widow	1	2.08
Employment status	Employer, employing less than 10 people	3	6.25
	Employer, employing more than 10 people	0	0
	Paid employee (full-time)	34	70.83
	Paid employee (part-time)	9	18.75
	Self-employed	2	4.17
Monthly income	Less than Rs. 25,000	5	10.42
	Rs. 26,000-Rs. 45,000	11	22.92
	Rs.46000-Rs.65000	7	14.58
	Rs.66000-Rs.85000	12	25.00
	Rs.86000-Rs.1,05,000	8	16.67
	Rs.1,06,000-Rs.1,25,000	3	6.25
	More than 1,25,000	2	4.17
Education level	No formal education	0	0
	Primary education	0	0
	Secondary education	3	6.25

	Tertiary education	23	50
	MPhil	19	39.58
	PhD	2	4.16
Mobile/smartphone	Mobile phone	0	0
	Smartphone	48	100
	None	0	0
Daily travel (km)	Less than 5 km	4	8.33
	5-10 km	17	35.42
	10-15 km	15	31.25
	More than 15 km	12	25.00
Sample size		48	

Source *Author's own construction from structured questionnaire responses.*

The demographic characteristics of metro and ride-hailing commuters show that ride-hailing commuters are not only more educated but also earning more compared to metro users. They are also the ones who travel long distances every day to commute to and from their workplaces compared to metro users. The findings corroborate those of Shah & Hisachi (2022) who report that the majority of ride-hailing users in Lahore are young, highly educated, and have above-average income levels.

The following subsections present the findings of the qualitative analysis of the interview data (structured and semi-structured interviews). The findings from interview data are organized around six main themes (Table 4.7): (1) Accessibility (2) Affordability (3) Acceptability (4) Availability (5) Gender inclusion in transport, and (6) Offered suggestions. Overall, the study provides insights into the complex relationship between transport provision and female labor force participation in Pakisan.

Table 4. 7 Summary of the analysis of semi-structured interviews based on predetermined and extracted themes

Themes	Top Two sub-themes	Selected statements from interviews[62] supporting the themes
Accessibility	Spatial position	**Public:** *Where I live, public and private transport options are readily available, but the Metro suits me the best. The metro station is available within walking distance from my place after walking 5 to 7 minutes. PM1* ***Private:*** *The jobs available near me offer a low payment structure and do not provide substantial compensation. To access better job*

[62] PR refers to participant ride-hailing and PM refers to participant metro.

		opportunities that align with my qualifications, I must be willing to travel farther distances. PR4
	Mobility infrastructure	**Public:** *There is a lack of mobility infrastructure in my neighbourhood because the metro station is far from our area. PM 4* **Private:** *Public transport is not available in my area; I have to change 3 to 4 transports to reach the public transport. PR 2*
Affordability	Transportation cost	**Public:** *There is no need to cut other expenditures to pay for the metro bus because the fare is not high and I can easily afford that. PM 2* **Private:** *There has been quite a lot of fluctuation in prices recently; however, the salary remains the same, and sometimes it is difficult to manage. PR 5*
	Choice of transportation	**Public:** *Previously I was using ride-hailing (Uber), but it was very expensive. Now, with the availability of the speedo bus I have switched to the metro, and I am able to afford my travel expenditures. PM 6* **Private:** *I have a very handsome salary, and the office gives me the amount to bear all the expenses to afford Careem. PR 3*
Acceptability	Safety concerns	**Public:** *I haven't faced harassment. However, recently, I witnessed an incident inside the metro bus in which a boy harassed a girl. PM 9* **Private:** *Nothing happened to me because I travel almost in the daytime and I use Uber auto and we know that auto rickshaw is safe. PR 4*
	Women-only transport	**Public:** *I would prefer to travel on a bus that is only for females. Because, on every bus, males take more seats than females. PM 5* **Private:** *Yes, I would prefer women-only transport if it is available on my route. PR 9*
Availability	Peak hours	**Public:** *After 17:00 or 17:30, the buses are extremely crowded. I skip many buses to get on a bus that is less crowded. PM 9* **Private:** *It takes time in peak hours to get a ride, and the fares are double. PR 9*
	Travel time	**Public:** *I would prefer to commute on metro buses because they are time-saving. You are not stuck in traffic. PM 5* **Private:** *Uber is readily available. PR 9*
Gender inclusion in transport	Needs of female commuters	**PMTA:** *Our mission statement is to provide a safe, efficient, and affordable transport system for all. However, we need to do more for women. Manager Operation (PMTA)* **Ride-hailing:** *We focus primarily on youth who are more equipped with digital skills. We do not do more specific mappings as you mentioned for only employed females. Anonymous* (ride-hailing)

	Women's employment in transport sector	**PMTA:** *Females came to join our organization a little bit late. Previously, there was no opportunity for women to become transport engineers. Additionally, there were not many educational institutions offering a degree in transport engineering. As soon as that opportunity came, we had females. Now our manager in Rawalpindi is a woman and we also have other women working in various positions. Manager Operation (PMTA)* **Public:** *I believe that it is important to include women in the decision-making process because they have a better understanding of the issues that affect other women, and this can help create more job and employment opportunities for them. PM 8*
Offered suggestions	User's stance	**Public:** *Metro routes should be expanded to areas where there is a need for public transportation. PM 5* **Private:** *I believe that ride-hailing platforms should increase their recruitment of female drivers and prioritize adherence to traffic rules. PR 2*

Source *Author's own construction from semi-structured interviews.*

4.4.2.1 Accessibility

The accessibility to transportation services emerged as an important theme for labor market participation, according to both public transport and ride-hailing users. The focus is on how the participants perceive and experience their access to transport, which helps them reach their workplaces. The two recurring and most important sub-themes that emerged were the mobility infrastructure in their neighbourhood and the spatial position of their residence which affect their access to job opportunities and transportation services. Female users emphasized the role of neighbourhood infrastructure in facilitating or hindering their access to transportation and economic opportunities. While some had convenient access to metro stations, others had to rely on alternative modes of transportation, such as rikshaws or chingchis, to reach to the metro. Similar challenges have been observed in other cities, such as Istanbul, where women face difficulties in accessing higher paying jobs due to long commutes, transportation costs, and household responsibilities (Beyazit & Sunger, 2019). Overall, the restricted spatial access to employment and transportation for females underscores the need for improved mobility options and addressing spatial mismatch in the labor market (McLafferty & Preston, 1992).

4.4.2.2 Affordability

The theme explored the relationship between the affordability of transportation services and female labor market participation. We define affordability as the ability to travel without

sacrificing essential activities. Participants in the study shared their experiences managing transportation costs while commuting to work. The theme highlights two important sub-themes: transportation costs and choice of transport based on one's employment status. It was found that transportation fares were manageable for women who were metro commuters. It was also observed that as women's income increases, they tend to opt for more convenient and comfortable transportation options such as ride-hailing. However, low-paid employees often can not afford ride-hailing services and may limit their job options due to transportation costs. The transportation choices of female workers are also influenced by their job status, with many opting for public transportation for affordability. A study in Riyadh found that higher commuting expenses for women led to a reduction in female employment underscoring the importance of affordable transportation for women's workforce participation (Williams et al., 2019).

4.4.2.3 Acceptability

The theme underlines personal perceptions towards transportation services that play a critical role in an individual's choice of transportation mode based on their socio-economic background. In Pakistan, social norms influenced by a patriarchal society have discouraged women from using public transport and pursuing certain type of work, limiting their independence, access to services, and economic contribution (Hadi, 2017; Khan, 1999). Safety concerns and women-only transport emerged as important sub-themes from the interviews. Public transportation in Pakistan has been perceived as unsafe for women, leading to limited mobility and restricted job opportunities. Ride-hailing services have gained popularity as a safer alternative. However, in Lahore, both public and private transportation sectors have made significant strides in enhancing the safety features of their services. The idea of women-only transport has been debated, with some respondents appreciating it as a way to address family concerns about safety. Overall, the responses underscore the complex interplay of personal perceptions, social norms, and safety considerations in women's transportation choices and their impact on employment.

4.4.2.4 Availability

Having the availability of different routes, schedules, and frequencies can increase women's labor market inclusion. When it comes to women's access to employment and transportation, it is crucial to take into account the different features of accessible transportation services. The availability theme was discussed, with peak hours and travel time identified as important sub-themes. Crowding during rush hours on public transport poses challenges for females, with theft being a common issue. Ride-hailing services may face availability issues during peak hours due to high demand. In terms of travel time and frequency, metro commuters expressed satisfaction with the frequency of buses and the time-saving nature of dedicated routes. Ride-hailing services are readily available except during peak hours. Overall, addressing availability concerns and considering

travel time and frequency are crucial for improving women's access to transportation and their participation in the labor market.

4.4.2.5 Gender inclusion in transport

The theme discusses two aspects of gender inclusion in the transport sector based on in-depth interviews with authorities responsible for public mass transit and private ride-hailing services. Firstly, gender inclusion entails considering the unique needs, challenges, and perspective of both men and women in transportation planning, including travel patterns, safety concerns, accessibility, and affordability (Das, 2020; Joshi et al., 2022). However, the interviews reveal that gender, particularly females, is not central to decision-making in transport planning in Pakistan. The focus is on overall mobility rather than gender-specific mobility, leading to insufficient provision of transport facilities for women and inadequate consideration for their safety and security. Secondly, gender inclusion means ensuring equal employment opportunities for women in the transport sector (Shah et al., 2017). However, the transport sector in Pakistan has low female participation and male dominance in decision-making positions, marginalizing women's interests and needs.

4.4.2.6 Offered suggestions

Women commuters offered suggestions to improve the transport system for them by sharing their personal experiences and insights on the challenges they face while commuting. The majority of the metro and ride-hailing users expressed their demand to expand the mass transit system in other areas of Lahore. The majority of the metro commuters complained about in-vehicle crowding and suggested that authorities should limit the number of people entering the buses. Furthermore, some females talked about stealing and mentioned that authorities should take proper action against the thieves. The ride-hailing users offered suggestions in terms of the cleanliness of the cars and they also mentioned the lack of proper safety and hygiene measures during the pandemic as drivers were not wearing masks nor they placed sanitizers in their cars. Some women have reported experiences with drivers who were unable to properly use Google Maps, and have suggested that training should be provided to drivers who are not literate and not comfortable using digital tools.

4.5 Conclusion and policy recommendations

The research presents a mixed method analysis examining how public and private transportation services affect the participation of females in the labor force in Lahore, Pakistan. To triangulate the quantitative findings and understand the underlying mechanisms, we employ a thematic analysis and examine various channels through which the provision of public and private transport services can promote women's inclusion in the labor market.

Employing the synthetic control approach, we detect a small but positive effect of metro bus transit provision on female labor force participation in Lahore. However, we do not observe an increase in female labor force participation following the launch of ride-hailing services. Studies[63] indicate that the development of transport infrastructure, including the expansion of metro systems, roads, and rail transit, leads to increased economic activity and job density in the neighbourhood over time. Notably, the impact of such infrastructure projects tend to be more pronounced in regions that are less developed. In Lahore, a comparatively developed city in Pakistan, the introduction of metro bus infrastructure has positively contributed to a modest increase in women's labor force participation, though not significantly in magnitude.

Previous research demonstrates that reducing physical mobility constraints significantly influences job searching among women in Lahore, with the effect being primarily attributed to the women-only transport. Our research findings also indicate a preference among females for women-only transport. However, the metro commuters express satisfaction with the provision of a dedicated section (inside the buses) for them. Moreover, from the perspective of service providers, the qualitative analysis reveals that women-only buses do not consistently reach full capacity with female commuters. Furthermore, in a price-reduction experiment, earlier investigation find that the advantage of more affordable ride-hailing services may be particularly significant for individuals facing safety and harassment risks in alternative transport options, such as public buses. However, these benefits are mainly observed among higher-income users of ride-hailing services. Our findings support the result that women with higher incomes predominantly utilize ride-hailing services. Nevertheless, we did not observe any impact of these services in promoting female labor force participation in Lahore. Our qualitative analysis also indicates that socio-cultural norms in Pakistan do not favour women working as drivers, affecting the employment prospects for female drivers.

Moreover, the results of the qualitative analysis also show that a larger part of the women interviewed consider public transportation (metro bus, speedo bus, and orange train) affordable and easily manageable with the resources (monetary) they have. On the other hand, ride-hailing users reported that ride-hailing is comparatively an expensive option, however, due to relatively higher earnings they can manage to afford it. Regarding accessibility, most women said that their spatial position affects their mobility choices. The challenges persist in terms of infrastructure as the location of stations may not be conveniently situated, necessitating the use of other modes of transportation, which can be both expensive and time-consuming. Females who are using ride-hailing are more than willing to use public transportation if it is accessible to them. Travel time turns out to be an important factor when making choices among different mobility options. Metro bus emerges as time savers in terms of frequency i.e., headway time of three minutes and a dedicated route (no traffic jams). Despite the fact that ride-hailing is readily available, it suffers from traffic jams. Safety concerns turned out to be a major sub-theme under acceptability. The

[63] Baum-Snow et al. (2015), Mejia-Dorantes et al. (2012), and Yen (2020).

most frequent response of the users of public and private transportation services was that they have never faced harassment in either of these mobility options. Regarding women in decision-making, a large number of respondents support the idea that women should be given opportunities to participate in the decision-making process, especially when it comes to designing transport infrastructure. However, the results also show that there is no gender-sensitive transport planning in Pakistan. The authorities at different institutions confirm the notion that the transportation infrastructure is primarily designed to facilitate the masses rather than catering to the needs of different demographic groups.

Based on the findings of our research, we recommend the following policies. First, improving the accessibility of public transportation, particularly by strategically locating metro stations and introducing feeder routes in areas with a high concentration of female worker force. Second, enhancing the safety and security of female passengers in public transportation through the implementation of policies that protect them from harassment and abuse. This can be achieved by increasing the number of female transport personnel, introducing gender-sensitive training, and strengthening the monitoring and reporting mechanism. Third, encouraging the participation of women in decision-making processes related to transport infrastructure planning and design. This will ensure that the unique needs and concerns of female commuters are taken into account and addressed in a gender-sensitive manner.

To increase the use of ride-hailing among female workers who do not have access to affordable public transportation and cannot afford premium service, we recommend following policies. First, by introducing affordable ride-hailing services that cater specifically to female commuters. This can be achieved by collaborating with ride-hailing companies to offer discounted fares or subsidized rides for female workers who meet certain criteria, such as low income or working in certain industries. Second, by collaborating with employers and organizations to provide ride-hailing benefits to their female employees. The employers can offer ride-hailing vouchers or discounts as part of their employee benefits package, or partner with ride-hailing companies to provide a dedicated shuttle service for female employees. Third, by developing ride-hailing apps that are user-friendly and accessible to female commuters who may not have access to smartphones or internet connectivity. This can be achieved by collaborating with telecommunication authorities to provide access to smartphones and internet connectivity, or by developing a simplified version of the app that can be used on basic mobile phones. Fourth, to increase the employment of females as ride-hailing drivers, the service providers can partner with women-focused organizations to reach out to potential female drivers and provide them with training and support. These organizations can also help address the socio-cultural barriers that prevent women from working as drivers. The use of ride-hailing services by predominantly higher-earning females and the lower likelihood of women from well-off households engaging in the labor market highlight the insufficiency of solely providing transportation services. It underscores the necessity of addressing social norms that impede the labor market participation of women from high-income households. An appropriate policy recommendation for women from higher-income households who do not

work would be to address the socio-cultural barriers that hinder their labor force participation. This may involve implementing measures to challenge traditional gender roles, promoting equal employment opportunities and supportive workplace policies, and providing resources and support for women to balance work and family responsibilities.

Lastly, conducting regular assessments of the effectiveness of public and private transportation services, including the impact on female labor force participation, and adjusting policies and interventions as needed will go a long way. Overall, these policies can help, promote greater inclusivity and accessibility in transportation services and support the increased participation of women in the labor force in a developing country urban context.

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Appendix A: appendix to chapter 2

Table A 1 Summary Statistics (1990-2017)

Age group	Labor force participation rate	Observations (#)
15-19	0.104 (0.0029)	189,542
20-24	0.147 (0.0040)	159,658
25-29	0.146 (0.0038)	134,485
30-34	0.155 (0.0046)	117,719
35-39	0.167 (0.0047)	105,017
40-44	0.179 (0.0052)	84,829
45-49	0.175 (0.0049)	73,099
50-54	0.162 (0.0046)	54,679
55-59	0.140 (0.0048)	40,676
60-64	0.103 (0.0042)	32,349
64-69	0.075 (0.0039)	21,007
70-74	0.042 (0.0036)	13,051
75-79	0.024 (0.0032)	5,887
80-84	0.017 (0.0038)	4,237
85 and above	0.014 (0.0051)	2,767
15-85 and above	**0.102(0.00196)**	**1,039,002**
	Marital Status	
nevermarried	0.200 (0.0061)	259,644
married	0.099 (0.0019)	779,358
	Location	
urban	0.063 (0.0014)	437,337
rural	0.133 (0.0025)	601,665
	Education	
no formal education	0.106 (0.0021)	657,423
primary	0.078 (0.0024)	204,542
secondary	0.103 (0.0028)	136,542
tertiary	0.279 (0.0064)	40,391

Standard errors are given in parentheses.

Source *Author's own calculations from labor force surveys.*

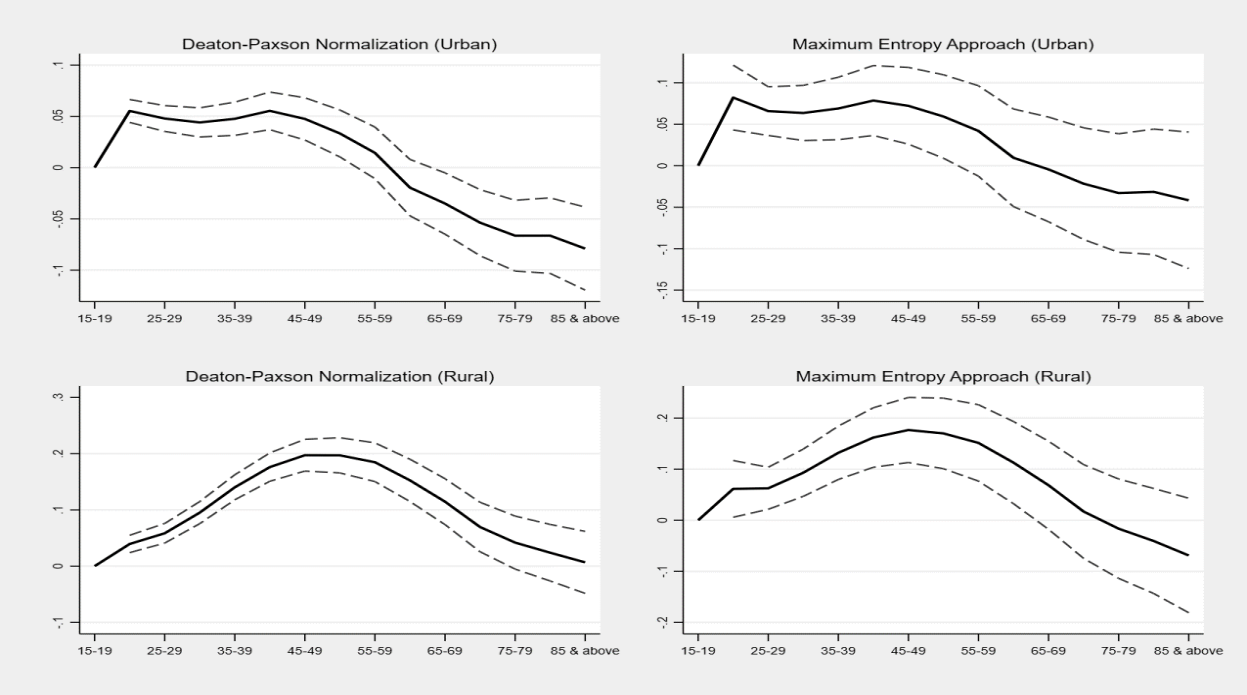

Figure A 1 Age effects of urban and rural females.
Source *Author's own calculations. The connected line represents predicted participation rates and dashed lines are 95 percent confidence intervals.*

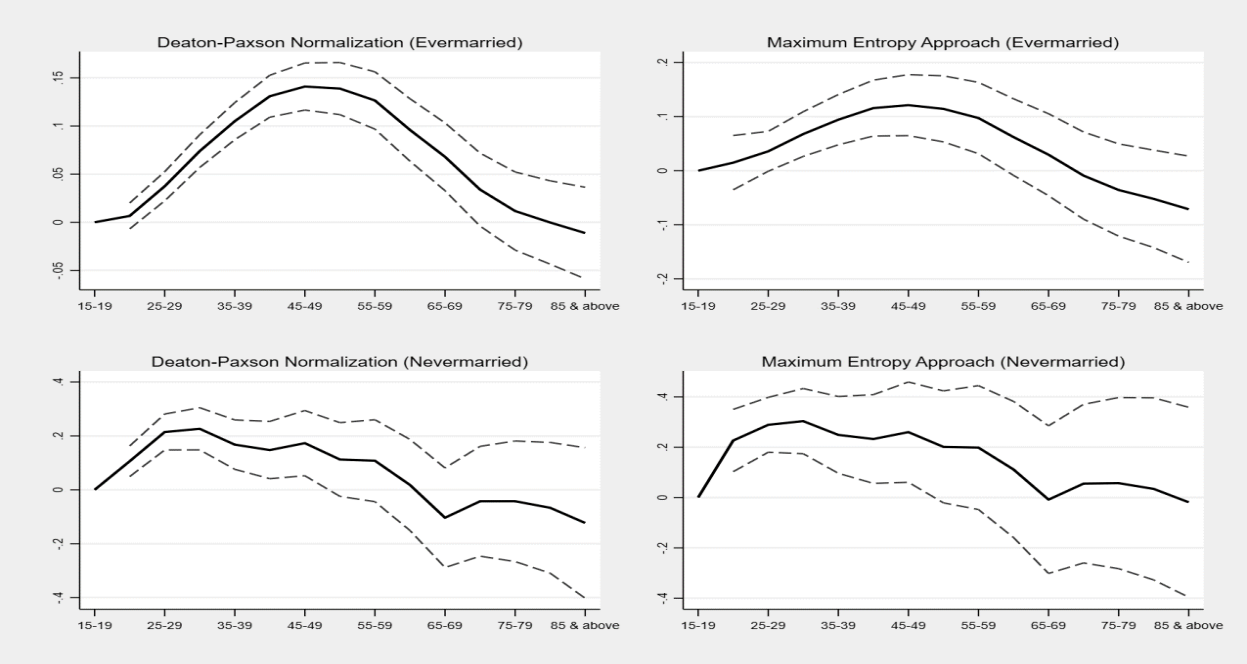

Figure A 2 Age effects of ever married and never married females.
Source *Author's own calculations. The connected line represents predicted participation rates and dashed lines are 95 percent confidence intervals.*

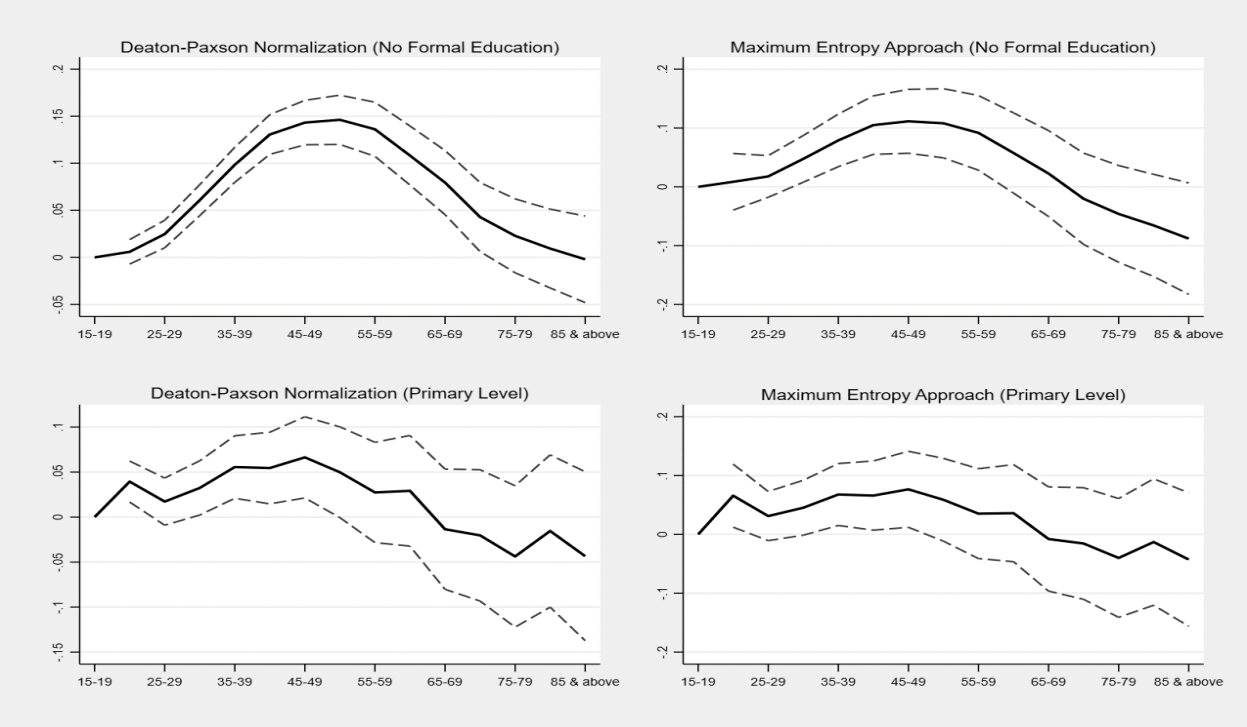

Figure A 3 Age effects of females with no formal education and primary level of education.
Source *Author's own calculations. The connected line represents predicted participation rates and the dashed lines are 95 percent confidence intervals.*

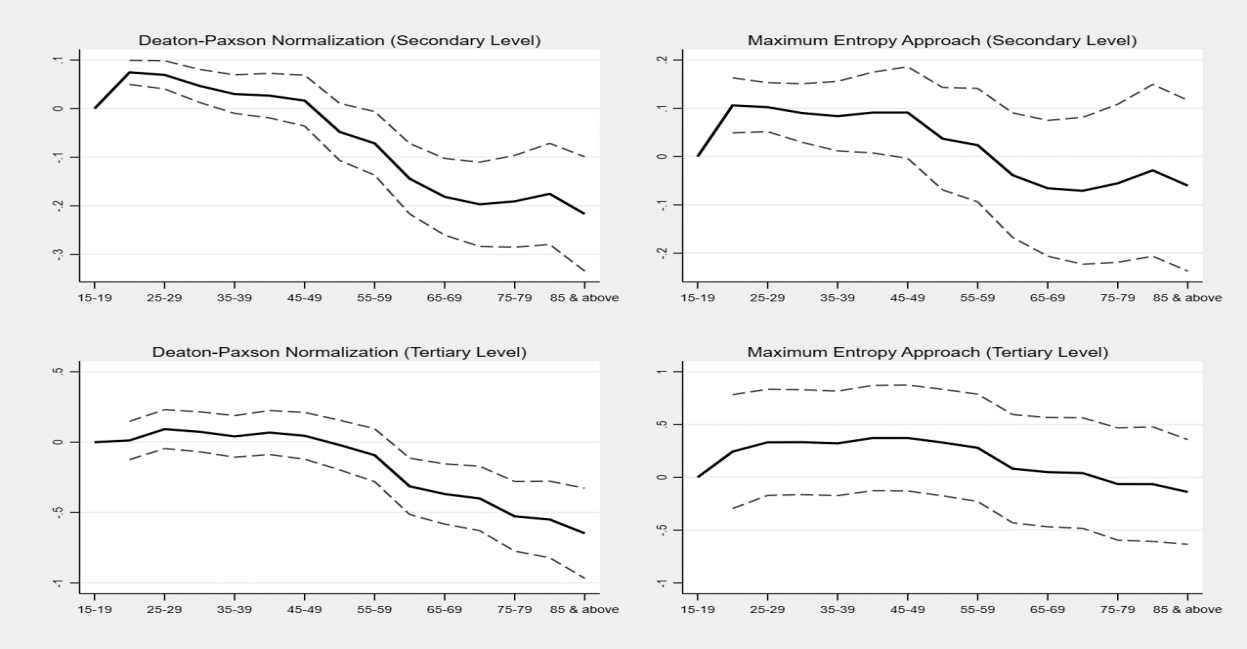

Figure A 4 Age effects of females with secondary and tertiary levels of education.
Source *Author's own calculations. The connected line represents predicted participation rates and dashed lines are 95 percent confidence intervals.*

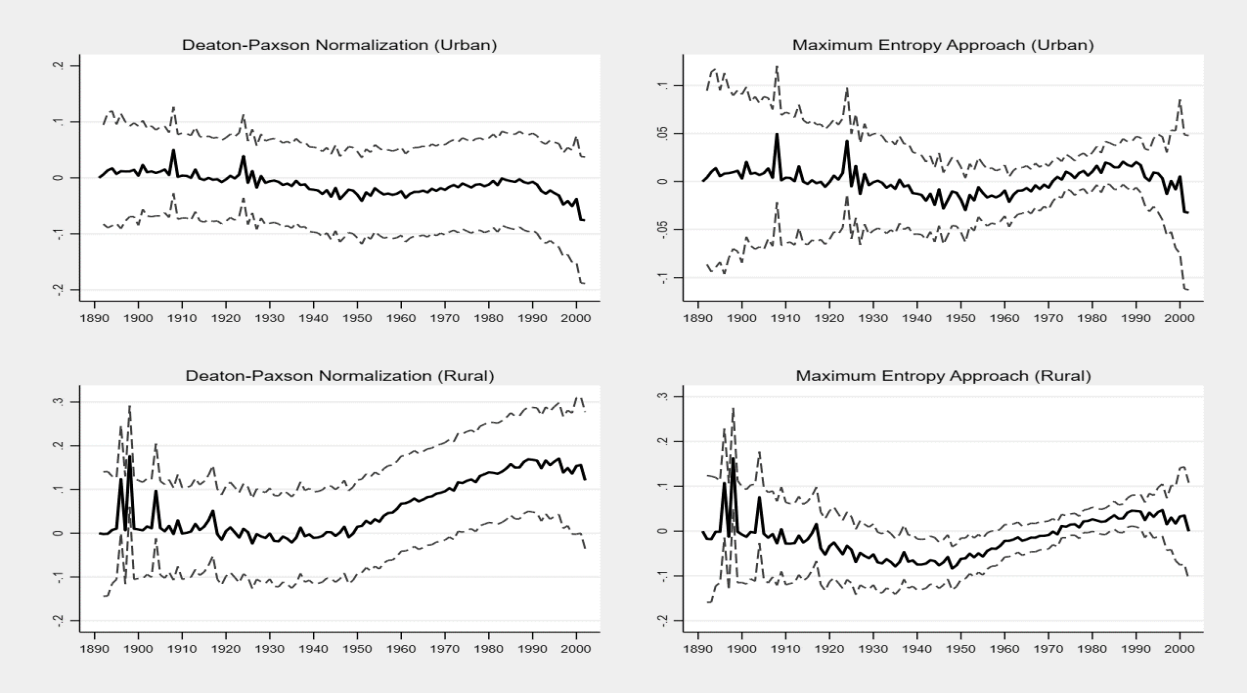

Figure A 5 Cohort effects of urban and rural females.
Source *Author's own calculations. The connected line represents predicted participation rates and dashed lines are 95 percent confidence intervals.*

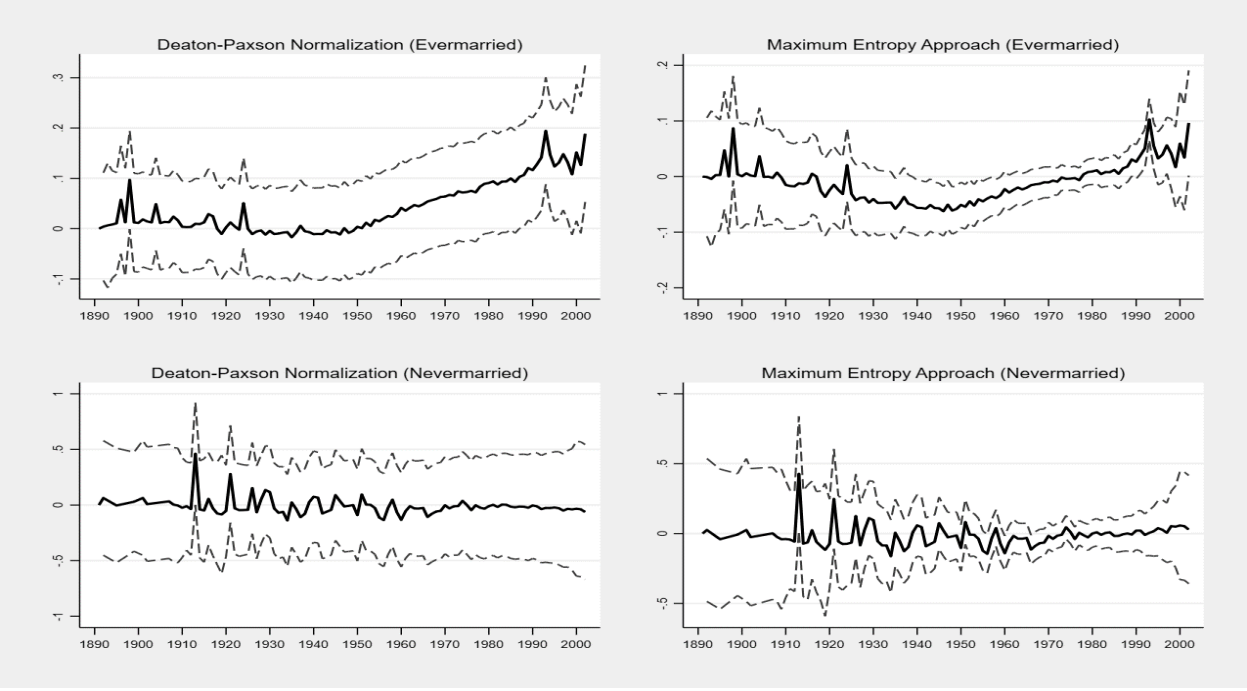

Figure A 6 Cohort effects of ever married and never married females.
Source *Author's own calculations. The connected line represents predicted participation rates and dashed lines are 95 percent confidence intervals.*

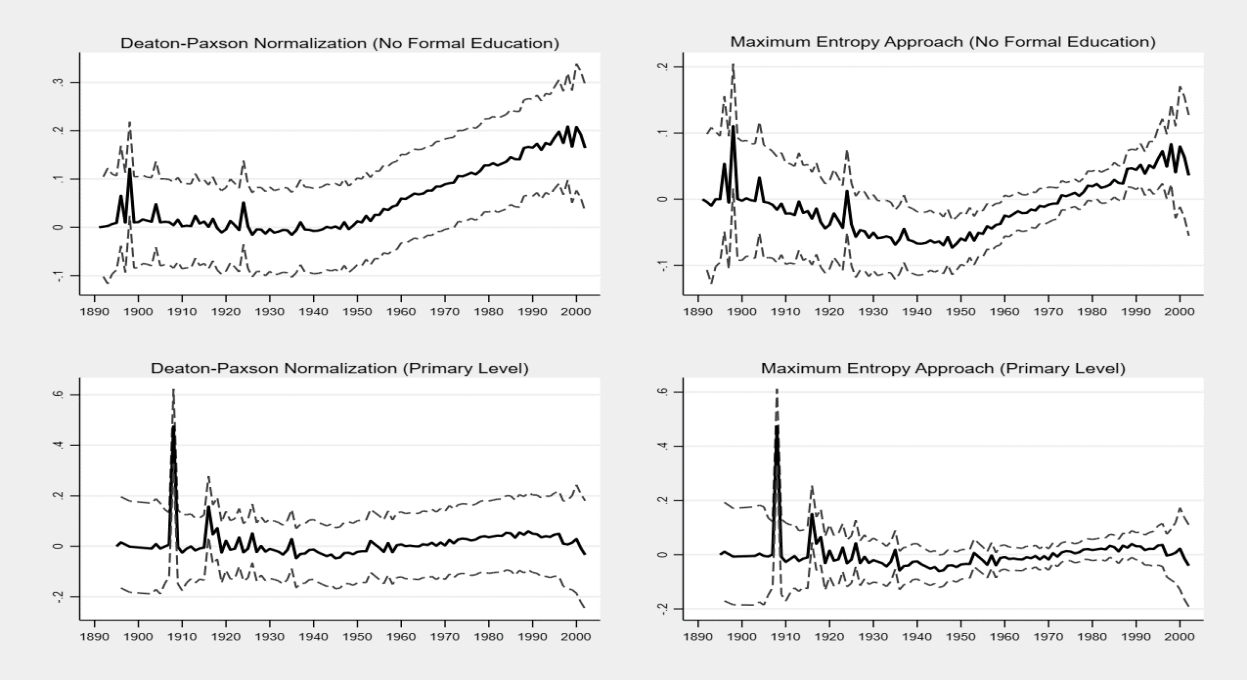

Figure A 7 Cohort effects of females with no formal education and primary level of education.
Source *Author's own calculations. The connected line represents predicted participation rates and the dashed lines are 95 percent confidence intervals.*

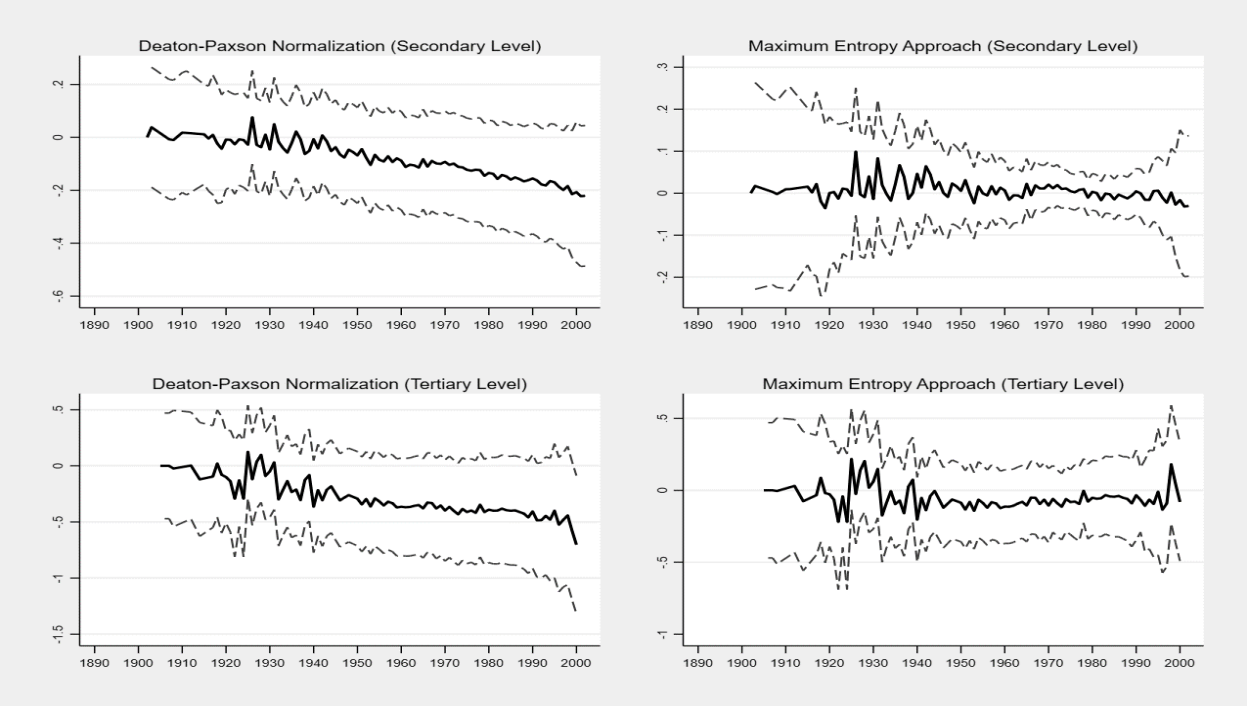

Figure A 8 Cohort effects of females with secondary and tertiary levels of education
Source *Author's own calculations. The connected line represents predicted participation rates and dashed lines are 95 percent confidence intervals.*

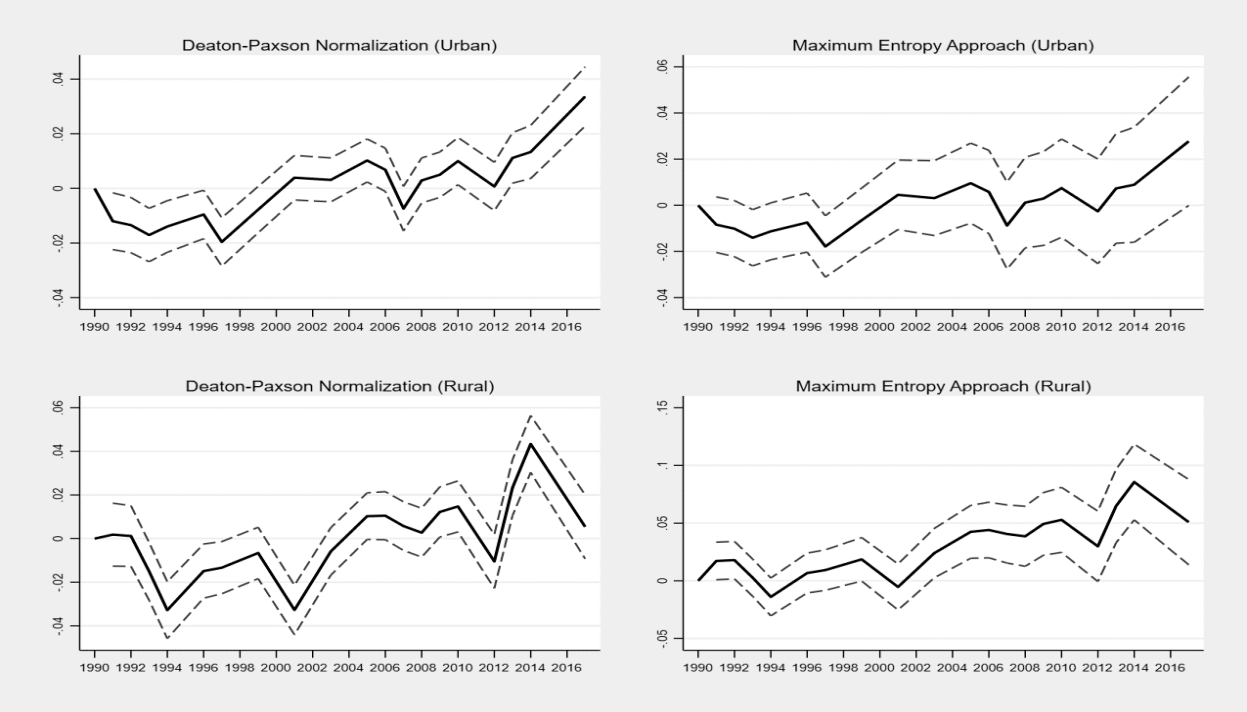

Figure A 9 Year effects of urban and rural females.
Source *Author's own calculations. The connected line represents predicted participation rates and dashed lines are 95 percent confidence intervals.*

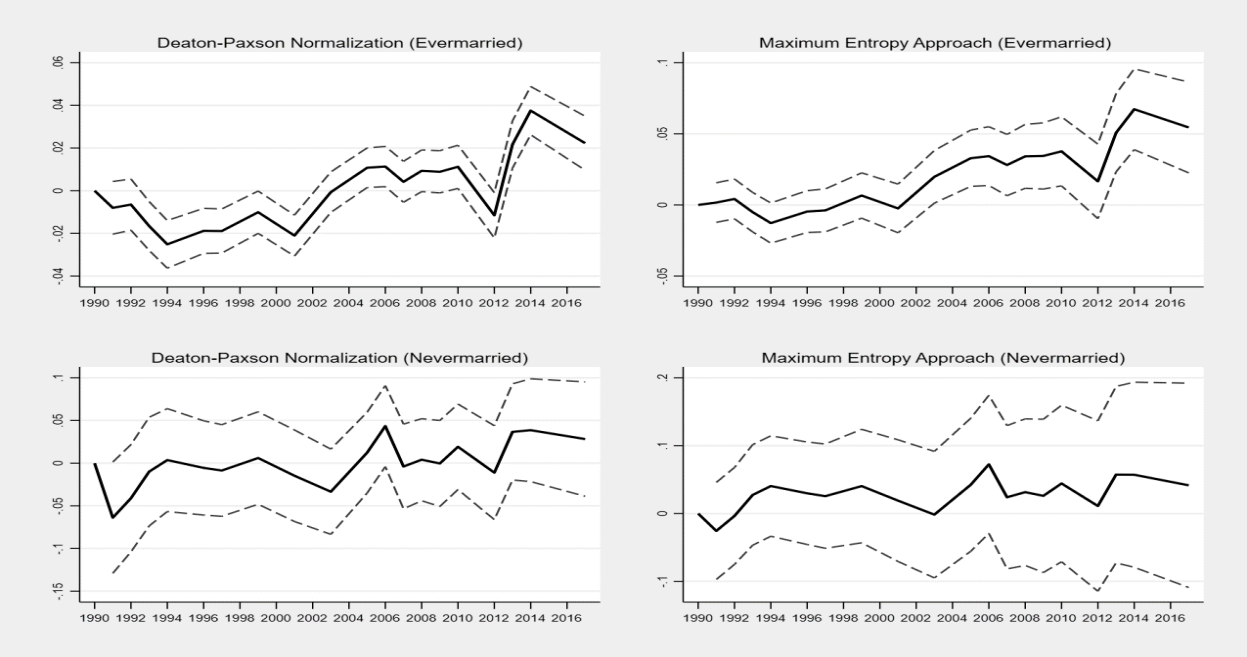

Figure A 10 Year effects of ever married and never married females.
Source *Author's own calculations. The connected line represents predicted participation rates and dashed lines are 95 percent confidence intervals.*

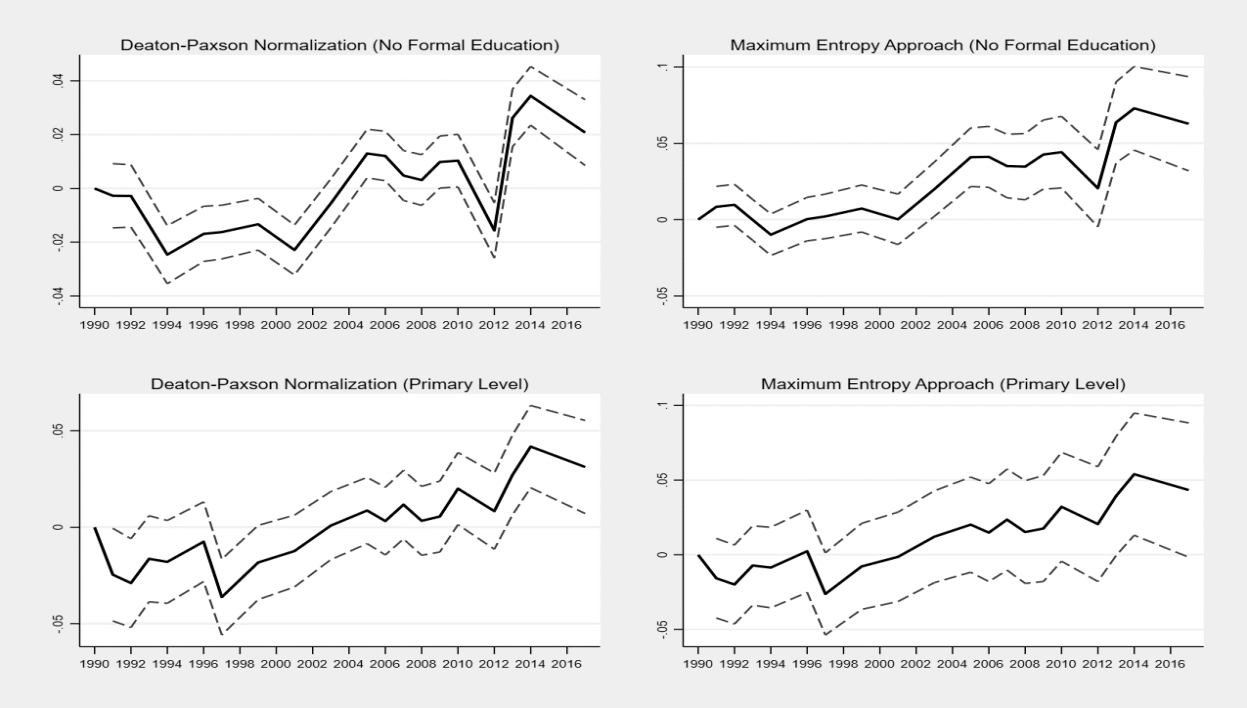

Figure A 11 Year effects of females with no formal education and primary education level.
Source *Author's own calculations. The connected line represents predicted participation rates and dashed lines are 95 percent confidence intervals.*

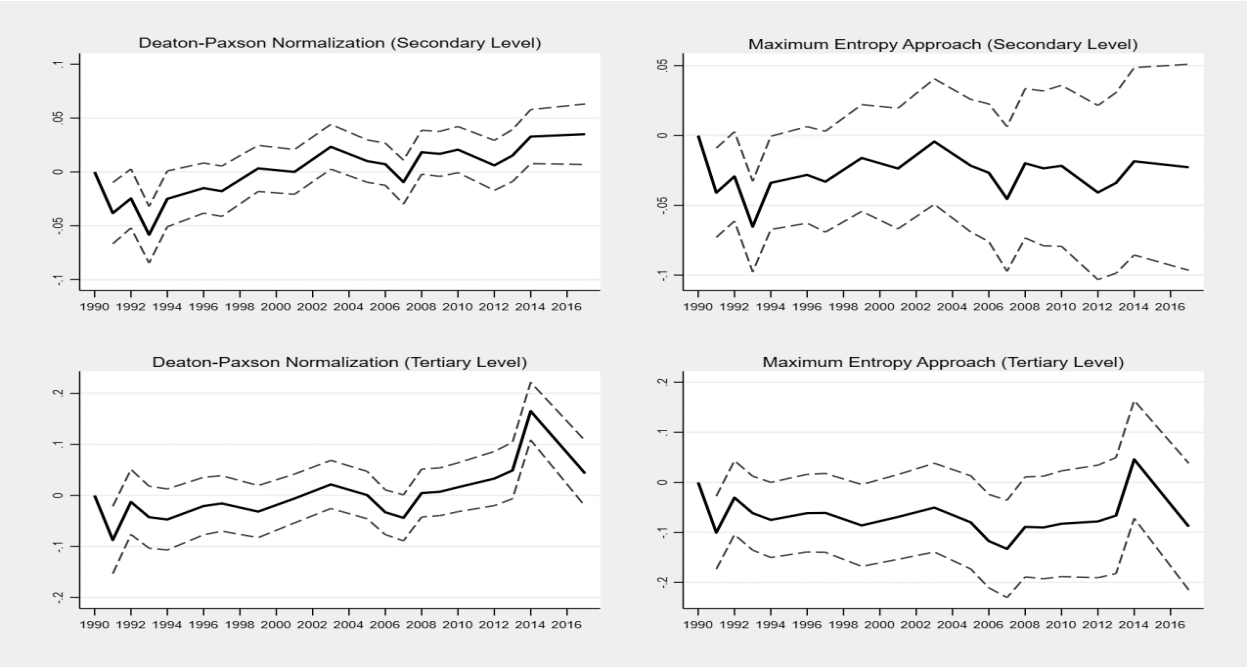

Figure A 12 Year effects of females with secondary and tertiary levels of education.
Source *Author's own calculations. The connected line represents predicted participation rates and dashed lines are 95 percent confidence intervals.*

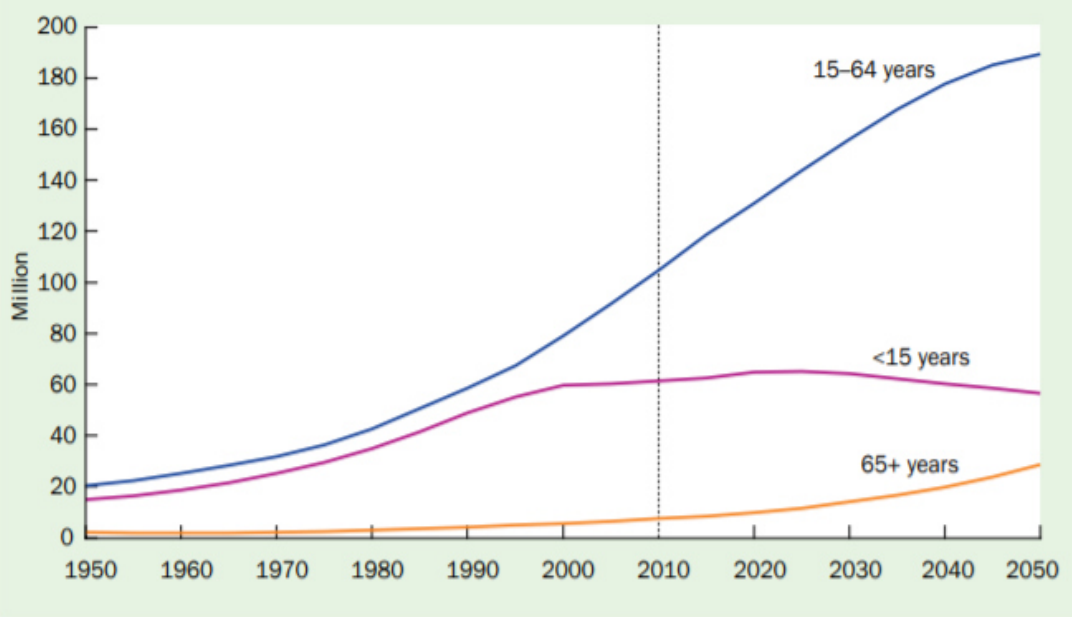

Figure A 13 Population share (1950-2010) and projections (2010-2050) for different age groups.
Source *Population council 2011.*

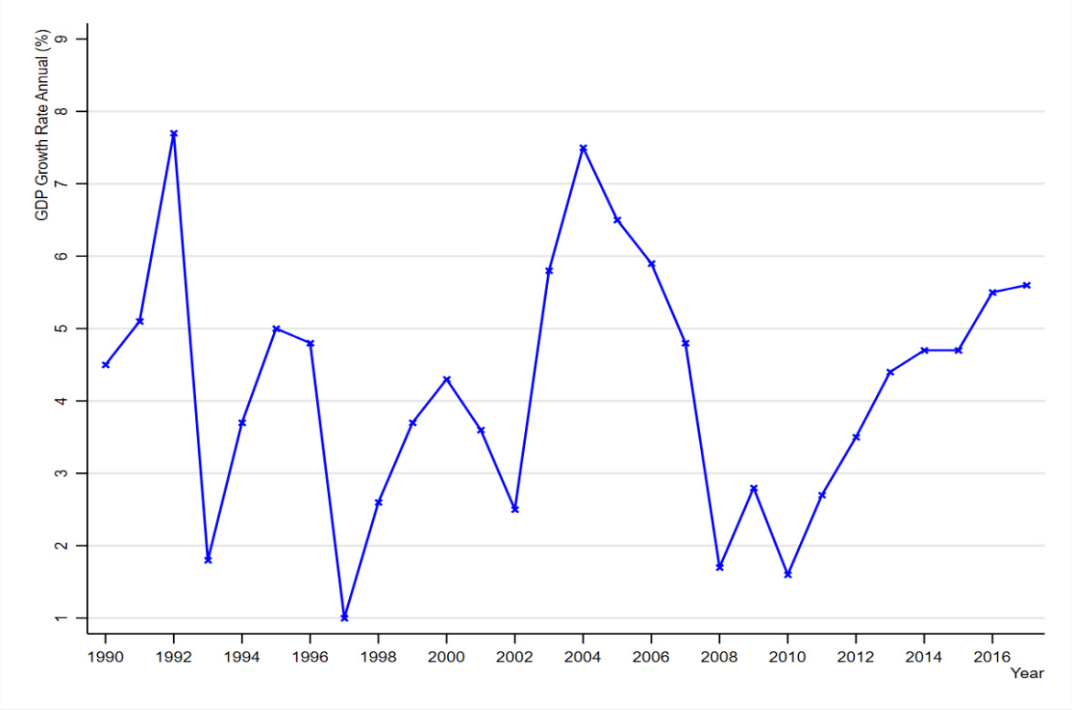

Figure A 14 Annual Growth rate of GDP (1990-2017).
Source *World Bank data*

Appendix B: appendix to chapter 3

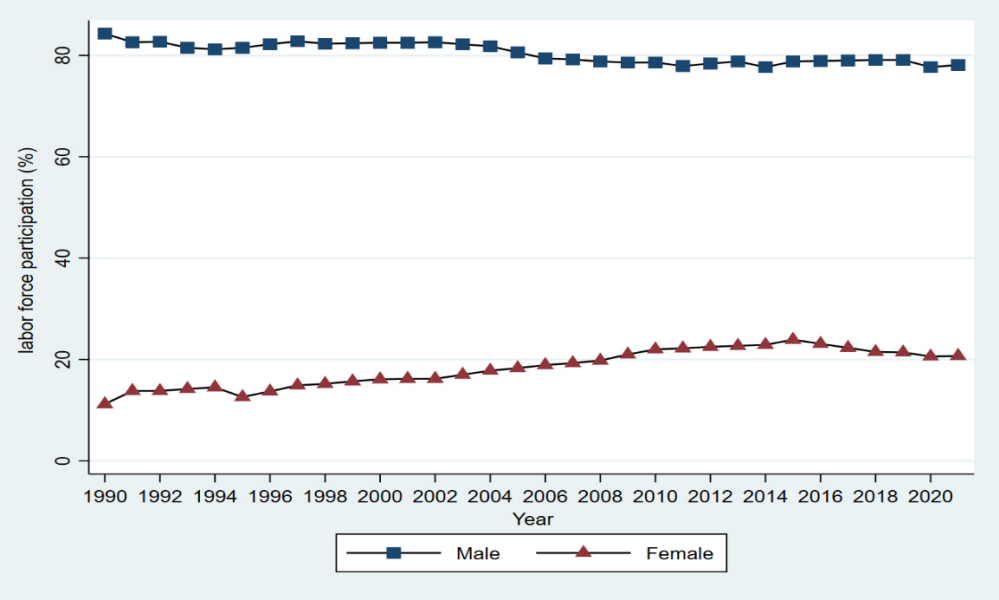

Figure B 1 Labor force participation rate (%) of males and females (1990-2020)
Source *World data bank (ILO modelled estimates)*

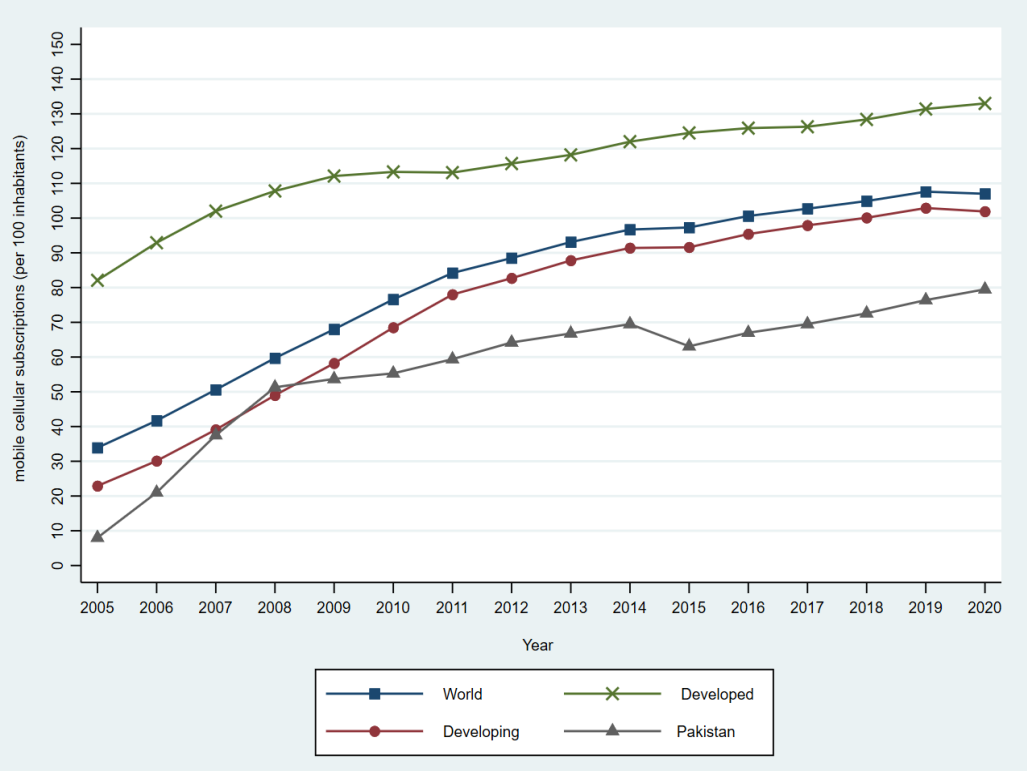

Figure B 2 Mobile cellular subscriptions (2005-2020)
Source *International Telecommunication Union and Pakistan Telecommunication Authority*

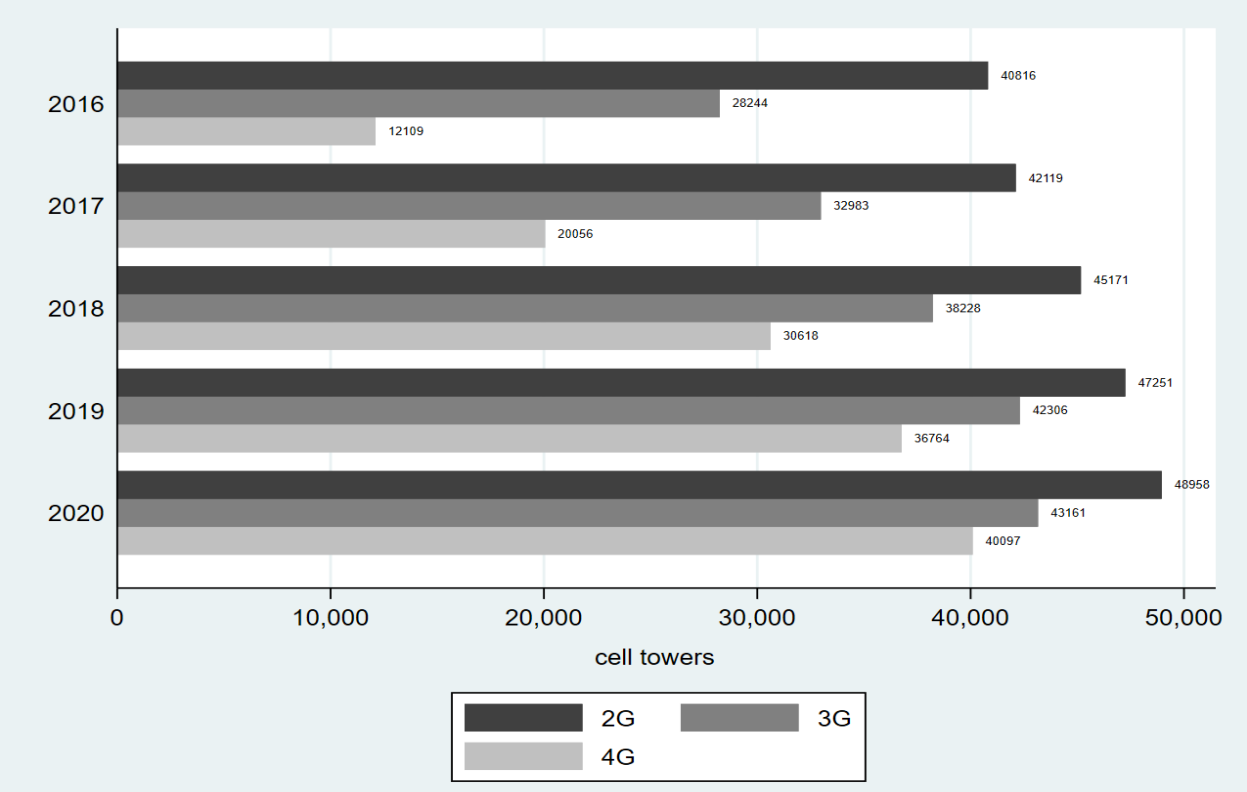

Figure B 3 Cell towers (sites) all around Pakistan (2016-2020)
Source *Pakistan Telecommunication Authority*

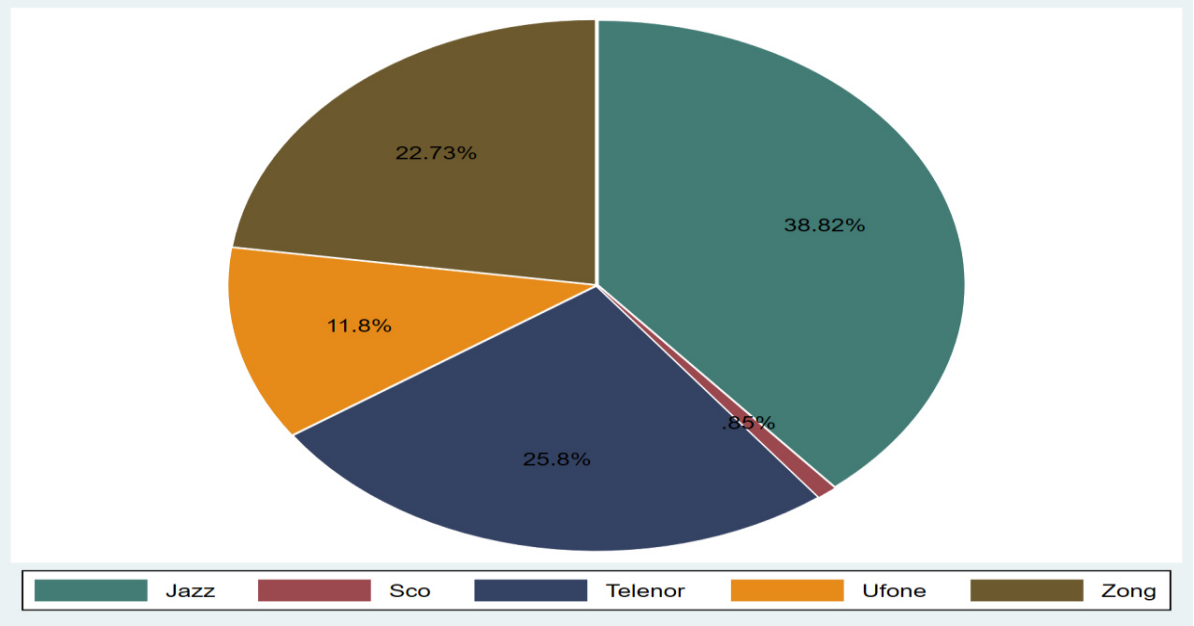

Figure B 4 Mobile cellular providers in Pakistan
Source *Pakistan Telecommunication Authority (PTA)*

Table B 1 No. of Observations (15-64)

	No. of observations	Percent
Male	244,663	49.94
Female	245,254	50.06
Total	489,917	100.0

Source *Authors' own calculation from PSLM (2019-2020)*

Table B 2 Construction of control variables used in the study

Variable	Description
Age	In completed years
Age square	Square of age
Marital Status	"1" if the individual is married and "0" otherwise
Female head	"1" if the household head is female and "0" otherwise
Education of head	Number of completed years of education
Literacy	"1" if the individual can read, write (simple statements) and solve simple Math and "0" otherwise
No formal education	"1" if the individual does not have formal education and "0" otherwise
Primary education	"1" if the individual has a primary level of education and "0" otherwise
Secondary education	"1" if the individual has secondary level education and "0" otherwise
Tertiary education	"1" if the individual has a tertiary level of education and "0" otherwise
Log of annual income	Log of individual's annual income in Pakistani Rupees
1st Income quintile	"1" if the household belongs to the 1st income quintile and "0" otherwise
2nd Income quintile	"1" if the household belongs to the 2nd income quintile and "0" otherwise
3rd Income quintile	"1" if the household belongs to the 3rd income quintile and "0" otherwise
4th Income quintile	"1" if the household belongs to the 4th income quintile and "0" otherwise
5th Income quintile	"1" if the household belongs to the 5th income quintile and "0" otherwise
Household Size	The number of individuals living in a household.
Nuclear Family	"1" for the nuclear household and "0" otherwise
Household Income Security	Number of males paid employees in the household
Children (0-4)	Number of children between 0 and 4 years of age in the household
Location	"1" if individuals reside in an urban area and "0" otherwise
Agricultural Land	"1" if the household possesses agricultural land and "0" otherwise

Non-Agricultural Land	"1" if the household possesses non-agricultural land and "0" otherwise
Own Residence	"1" if the household possesses its own residence and "0" otherwise
Wealth index	Index of housing characteristics and durables in possession
Male employment rates	Employment rates of males in each district
Mobile network franchise	No. of mobile network franchises of all mobile network providers in each district (The data has been obtained from respective cellular provider's websites).

Table B 3 Gender digital divide for labor force participation and different digital indicators (aged 15-64)

(%)	Whole Sample	Male	Female
Labor force participation	48	80	15
Mobile phone ownership	36	53	18
Smartphone ownership	18	26	10
Internet use	20	26	13
Computer use	7	10	5
Mobile or smartphone ownership	53	79	28
Mobile or smartphone ownership and use	52	77	27
Mobile or smartphone use	92	94	89

Source *Authors' own calculation from PSLM (2019-2020)*

Table B 4 Rural-Urban divide for labor force participation and mobile or smartphone ownership and use (15-64)

(%)	Male		Female	
	Rural	Urban	Rural	Urban
Labor force participation	81	79	17	11
Mobile or smartphone ownership	76	83	21	43
Mobile or smartphone use	93	96	88	93

Source *Authors' own calculation from PSLM (2019-2020)*

Table B 5 Summary statistics of female sample disaggregated by MS ownership

	Doesn't own & use MS	Own and use MS		
	Mean	Mean	diff	St. Err
Labor Force Participation	0.148	0.159	-0.011	0.002***
Age	32.6	34.2	-1.67	0.059***
Age square	1249.8	1289.5	-39.7	4.33***
Age of the head	46.95	45.86	1.07	0.06***
Marital status	0.721	0.859	-0.138	0.002***
Female head of HH	0.064	0.166	-0.102	0.002***
Education of HH head	4.16	7.09	-2.93	0.023***
Literacy	0.35	0.644	-0.293	0.002***
No formal education	0.728	0.413	0.315	0.002***
Primary education	0.161	0.195	-0.035	0.002***
Secondary education	0.092	0.246	-0.154	0.002***
Tertiary education	0.018	0.144	-0.126	0.001***
1st income quintile	0.21	0.234	-0.024	0.002***
2nd income quintile	0.216	0.112	0.105	0.002***
3rd income quintile	0.2	0.182	0.018	0.002***
4th income quintile	0.194	0.2	-0.005	0.002***
5th income quintile	0.179	0.272	-0.093	0.002***
Household Size	6.66	5.61	1.048	0.015***
Nuclear Family	0.6	0.655	-0.056	0.002***
Household Income Security	0.707	0.589	0.118	0.004***
Children (0-4)	0.73	0.629	0.102	0.005***
Location	0.248	0.471	-0.222	0.002***
Own agricultural land	0.28	0.203	0.076	0.002***
Own non-agricultural land	0.039	0.052	-0.013	0.001***
Own Residence	0.865	0.811	0.054	0.002***
Wealth index	69.9	96.8	-26.9	0.158***
Male employment rates	0.759	0.738	0.021	0.001***
Mobile network franchise	17.7	32.1	-14.3	0.118***
No. of Observations	179,260	65,994		

****p<0.01, **p<0.05. *p<0.1.*

Table B 6 Summary statistics rural-urban digital divide for the female sample

	Rural	Urban			Avg. marginal effects (Logit)
	Mean	Mean	diff	St. Err	Coefficient
MS ownership and use	0.205	0.411	-0.205	0.002***	Outcome variable
Labor force participation	0.17	0.109	0.06	0.002***	-0.02
					(0.014)
Age	32.9	33.2	-0.271	0.057***	0.03***

					(0.001)
Age square	1255.9	1270.6	-14.6	4.16***	-0.004***
					(0.000)
Marital status	0.77	0.731	0.04	0.002***	0.133***
					(0.009)
Literacy	0.337	0.638	-0.301	0.002***	0.151***
					(0.009)
Primary level of education	0.161	0.19	-0.029	0.002***	-0.050***
					(0.008)
Secondary level of education	0.09	0.231	-0.141	0.002***	0.020**
					(0.008)
Tertiary level of education	0.029	0.105	-0.077	0.001***	0.160***
					(0.011)
No formal education	0.72	0.473	0.246	0.002***	Ref. group
Log of income	0.656	0.798	-0.141	0.012***	0.010***
					(0.001)
1st income quintile	0.25	0.142	0.108	0.002***	Ref. group
2nd income quintile	0.216	0.123	0.093	0.002***	-0.09***
					(0.008)
3rd income quintile	0.192	0.203	-0.01	0.002***	-0.05***
					(0.007)
4th income quintile	0.179	0.233	-0.053	0.002***	-0.04***
					(0.008)
5th income quintile	0.162	0.3	-0.138	0.002***	-0.002
					(0.010)
Household size	6.56	5.97	0.593	0.014***	-0.02***
Children (0-4)	0.764	0.566	0.198	0.004***	(0.001)
Ownership of agricultural land	0.347	0.06	0.287	0.002***	0.001***
					(0.002)
Ownership of non-agricultural land	0.046	0.035	0.011	0.001***	0.03***
					(0.009)
Own residence	0.904	0.731	0.173	0.002***	-0.005
					(0.005)
Wealth index	63.2	108.371	-45.1	0.132***	0.002***
					(0.000)
location	-	-	-	-	0.014*
					(0.008)
Number of observations	169,631	75,623			245,254

****p<0.01, **p<0.05. *p<0.1.*

Numbers in brackets represent standard errors

Table B 7 Association between mobile or smart phone ownership and female labor force participation: Robustness checks (Control function approach and IPWRA)

	Control function approach		IPWRA	
	First stage	Second stage	ATE	ATT

	(MS ownership and use)	(FLFP)		
MS ownership and use	-	0.36**	0.05***	0.05***
		(0.180)	(0.009)	(0.005)
Control variables	Yes	Yes		
Constant	-0.169*	-0.578***		
	(0.001)	(0.114)		
IV	0.0013***	-		
	(0.000)			
Residual	-	-0.331*		
		(0.182)		
No. of Observations	245,254	245,254	245,254	245,254

****p<0.01, **p<0.05. *p<0.1.*

Numbers in brackets represent standard errors

Appendix C: appendix to chapter 4

Table C 1 Construction of predictors used in the quantitative analysis

Variable	Description
Age	Average age of the females in completed years at the city level
Marital Status	Proportion of married females at the city level
Education of head	Average number of completed years of education of household head at the city level
No formal education	Share of females with no formal education at the city level
Primary education	Share of females with primary education at the city level
Secondary education	Share of females with secondary education at the city level
Tertiary education	Share of females with tertiary education at the city level
Household Size	Average number of individuals living in the household at the city level.
Children (0-4)	Average number of children between 0 and 4 years of age in the household at the city level
Male employment rates	Employment rates of males at the city level
Household income	Log of average household income (subtracting working female's income) at the city level in Pakistani Rupees.

Source *Author's own construction*

Table C 2 List of cities along with information on the launch date of different transportation services

S. no.	**City name**	**Public transportation (Metro Mass Transit)**	**Ride-hailing (Uber and Careem)**	
			Uber	**Careem**
1	Lahore	2013	2016	2015
2	Faisalabad		2017	2017
3	Rawalpindi	2015	2017	2016
4	Multan	2017	2018	2017
5	Gujranwala		2017	2017
6	Sargodha			2018
7	Sialkot			2017
8	Bahawalpur			2018

9	Islamabad	2015	2017	2016
10	Karachi		2016	2016
11	Hyderabad		2017	2017
12	Sukkur			2018
13	Peshawar	2020	2018	2017
14	Quetta			2018
15	D.G Khan			
16	Larkana			
17	Mirpur Khas			
18	Malakand			
19	Kohat			
20	D.I Khan			
21	Hazara			
22	Bannu			
23	Mardan			2018
24	Sibbi			
25	Kalat			
26	Mekran			
27	Zhob			
28	Nasirabad			

Source Information about the launch date of metro has been gathered from the service provider's official website and confirmed with news sources. However, information about the launch of ride-hailing (Uber and Careem) has been gathered through different news sources and platforms (such as social media, among others).

Table C 3 Themes and subthemes (pre-determined)

Themes	Subthemes
Accessibility	Spatial position in the city (residential location), access to work, education, health, and social life, provision of mobility infrastructure, trip chaining, sidewalks, bus shelters, parking places, supporting services (toilets), spatial expansion of labor market, distance covered, integration of different modes, use of technology.
Affordability	Formal or informal employment, individual's wages or income, household income, expenditures on transportation services, personal vehicle, social relations in the household, non-work vs work trips
Acceptability	Experience in using different modes of transportation, quality of service and vehicle, the idea of modernity, safety concerns, surveillance and protection, ability to travel on one's own, prestige and status in the society, presence or absence of security personnel, the attitude of the staff (drivers, conductors, among others), choice of clothing, confidence, and ability, gatekeeper's behaviour, response to user's needs, masculine choices of mobility,
Availability	Route possibilities, timings, headway time or frequency, peak hours availability, night commuters, use of technology (mobile or internet)

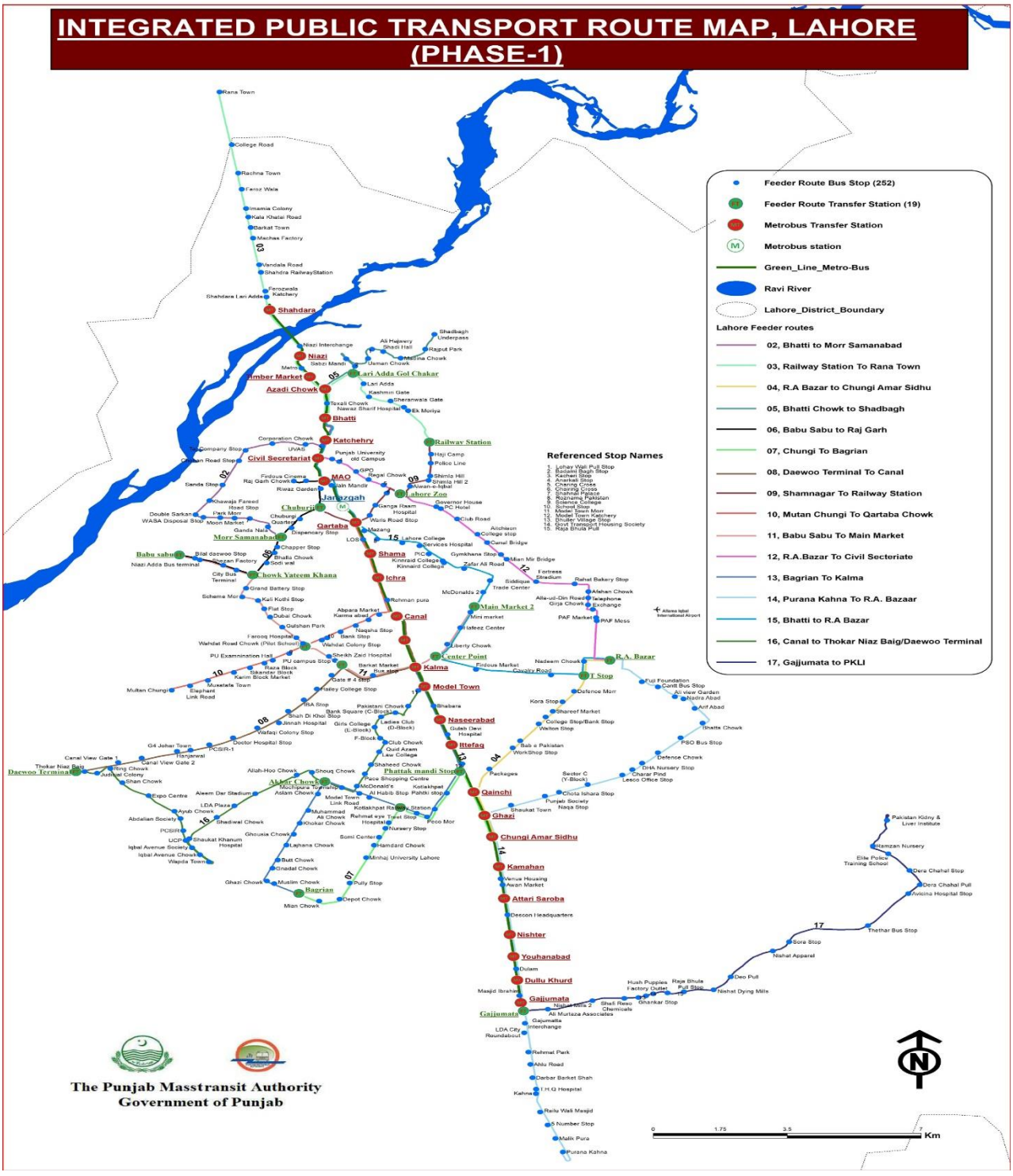

Figure C 1 Route of metro bus and feeder routes connecting other areas to metro stations
Source *Punjab Mass Transit Authority (PMTA)*

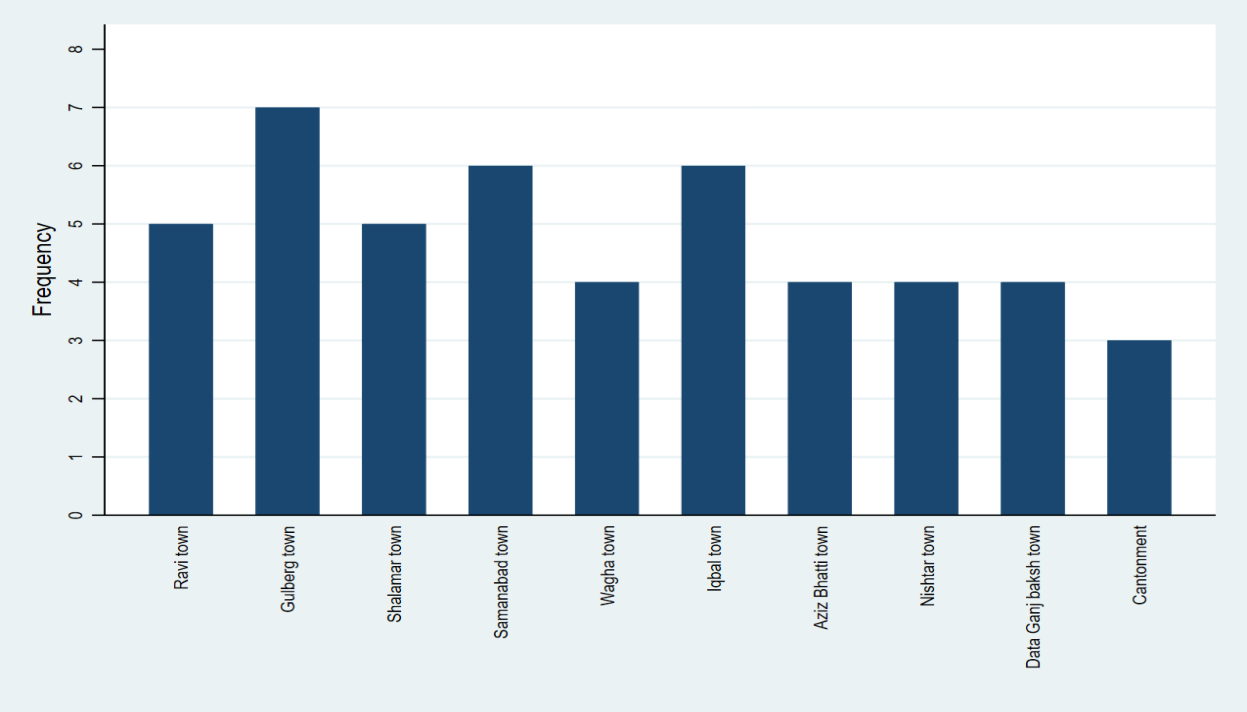

Figure C 2 Geographic location of ride-hailing users

Source *Author's own construction from structured questionnaire responses.*

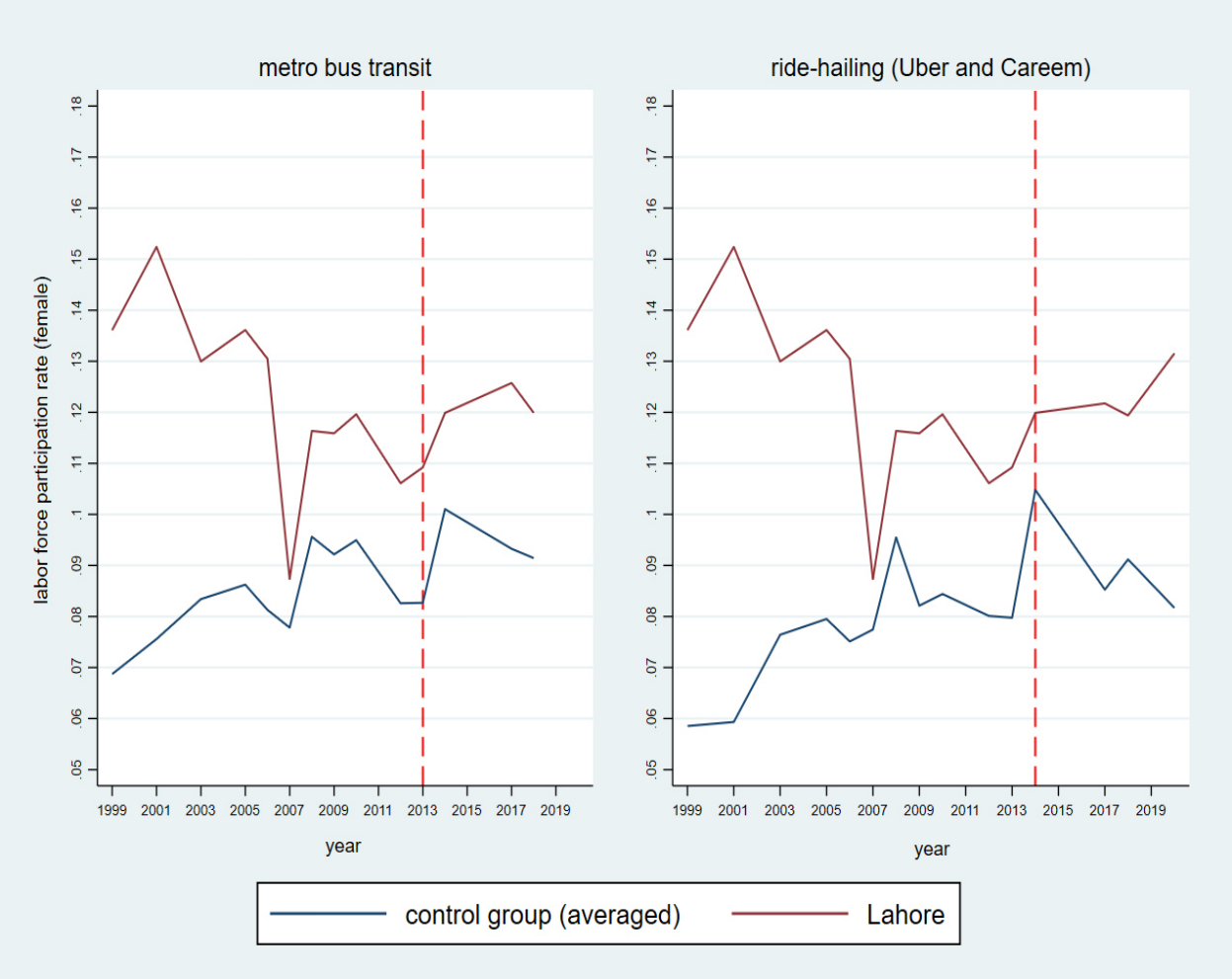

Figure C 3 Trends in female labor force participation (Lahore vs the rest of cities in the control group under the metro bus and ride-hailing intervention specification)

Source *Authors own construction from labor force surveys (1999-2020)*.

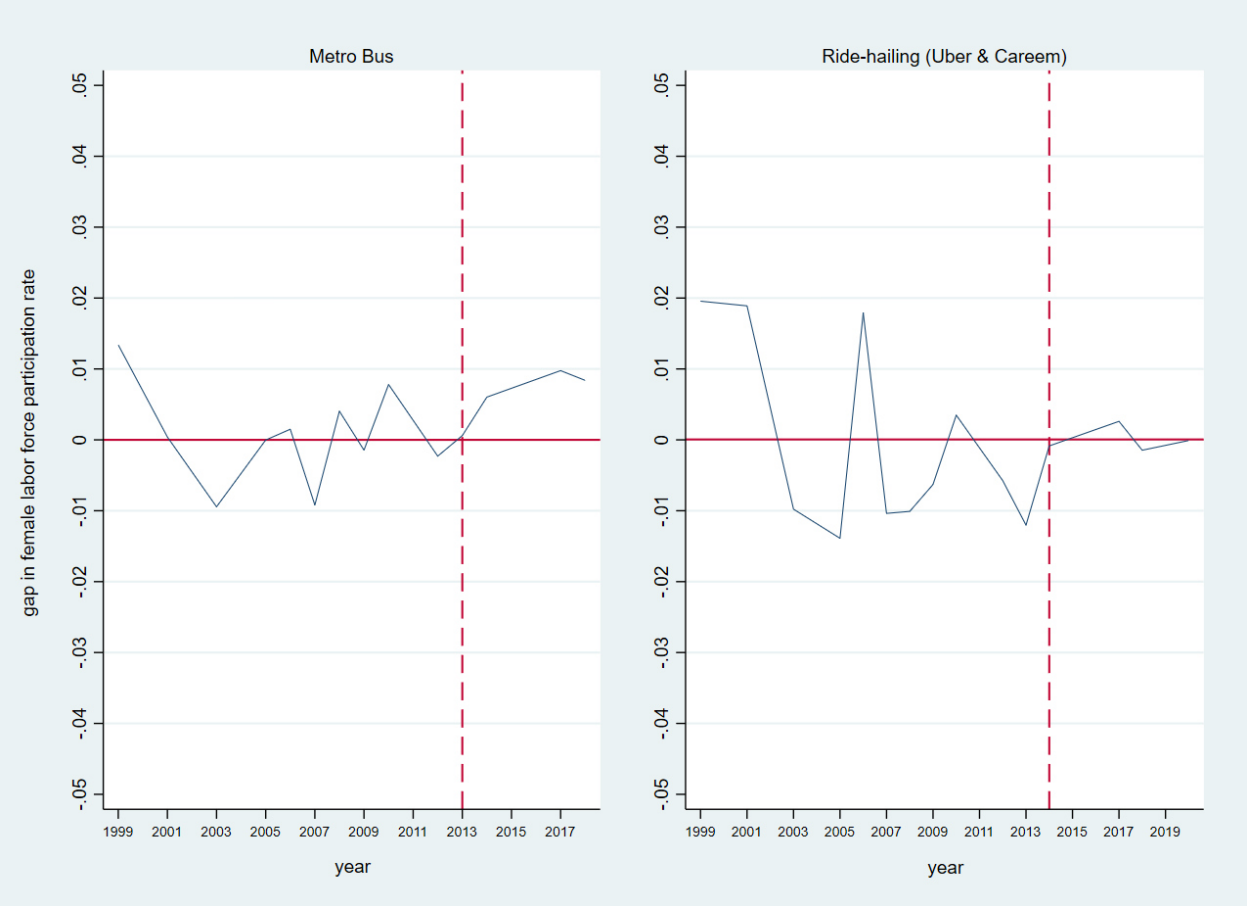

Figure C 4 Female labor force participation rate gaps between Lahore and synthetic Lahore under metro and ride-hailing intervention specifications

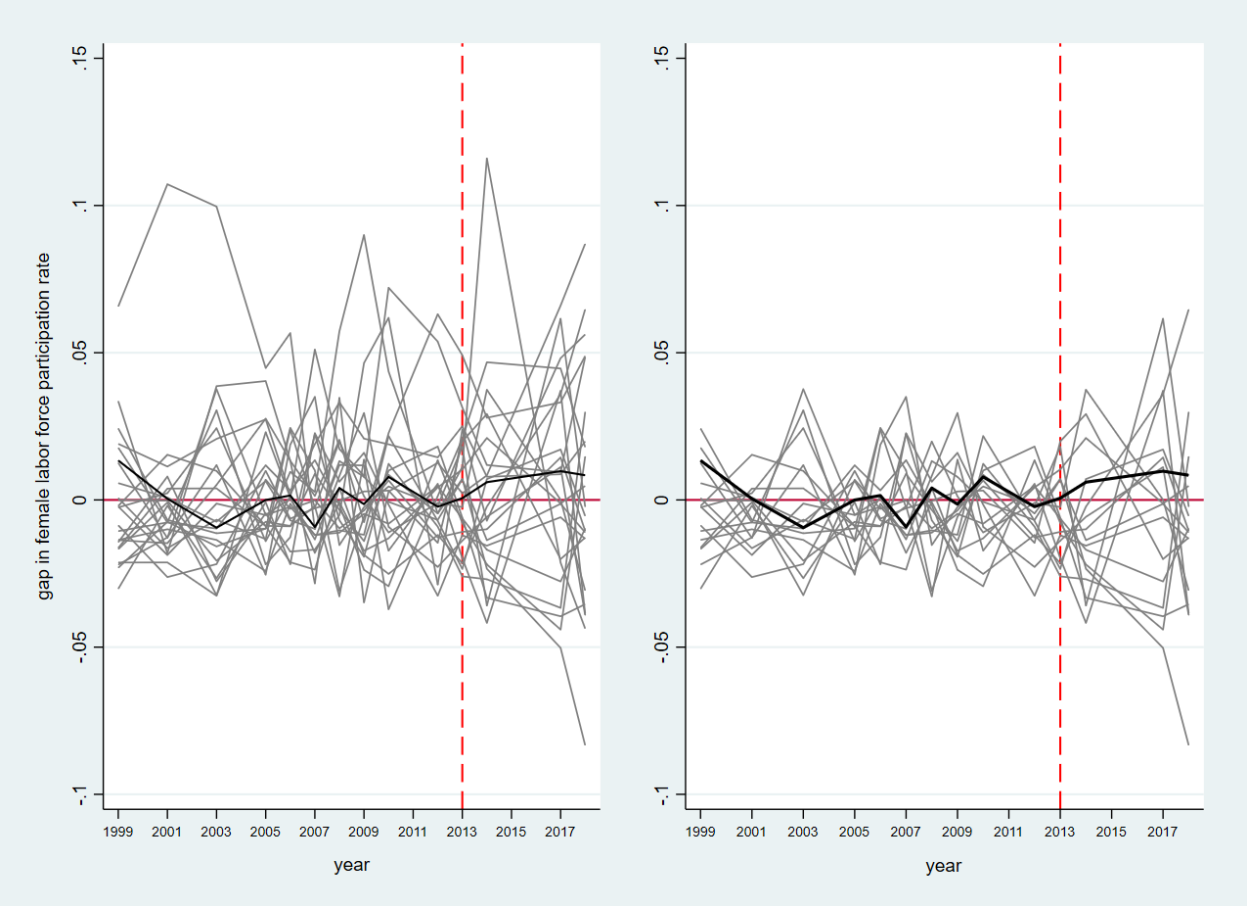

Figure C 5 Female labor force participation rate gaps in Lahore and placebo gaps in control states (metro analysis)

Note: The left panel shows female labor force participation rates gaps in Lahore and placebo gaps in all 25 states. The right panel shows female labor force participation rates gaps in Lahore and placebo in 17 control states (eliminate states with MSPE three times higher than Lahore)

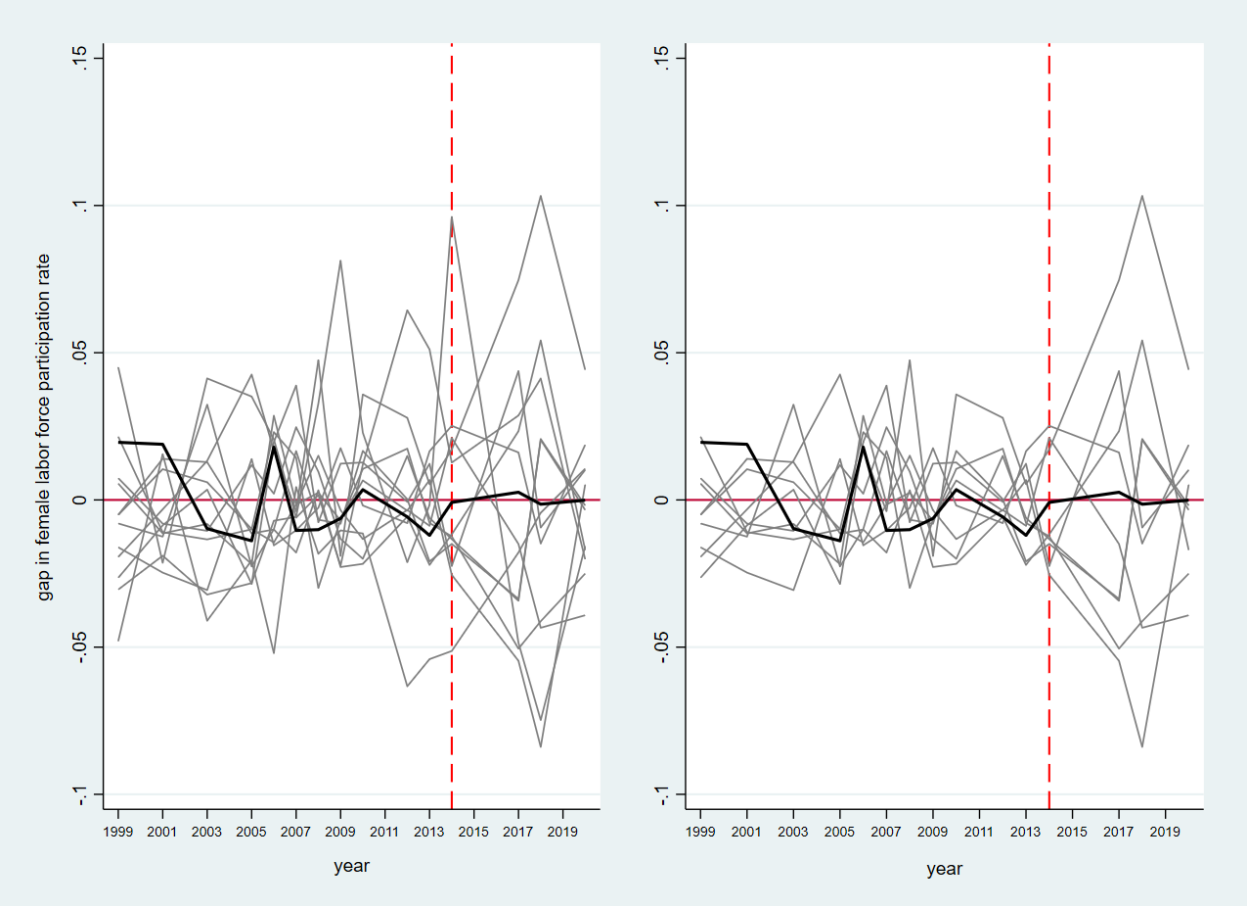

Figure C 6 Female labor force participation rate gaps in Lahore and placebo gaps in control states (ride-hailing analysis)

Note: The left panel shows female labor force participation rate gaps in Lahore and placebo gaps in all 13 states. The right panel shows female labor force participation rate gaps in Lahore and placebo in 10 control states (eliminate states with MSPE three times higher than Lahore.