She’s Connected: The Impact of Jio on the Digital Gender Gap in India

by

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Abstract

This thesis investigates the relationship between the affordability of mobile internet and internet connectivity for women in India. The digital gender gap (or gender equality in access to the internet and mobile phones) is an increasingly important marker of development. The critical question is whether affordability is the leading barrier women face to mobile internet adoption. A challenge to answering this question is finding gender-disaggregated data and identifying a setting that allows researchers to disentangle the role of affordability relative to other potential barriers. This thesis helps overcome both challenges, combining data on monthly wireless subscribers with national survey data while controlling for state-wise economic indicators, including the Human Development Index, Gender Development Index, and Gender Inequality Index, to examine the correlation between low-cost mobile internet and the digital gender gap. As anticipated, there are many important factors that influence the digital gender gap, including standard of living, education, income, and safety and security. The results indicate that the increased and robust diffusion of affordable internet through the low-cost provider, Jio, is closing the digital gender gap; however, the effect on the digital gender gap is more substantial in states with high HDI and particularly for rural subscribers.

Keywords: Telecommunications, digital gender gap, internet access, affordability, gender inclusion, digital inclusion

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Introduction and Background

Mobile phones and internet access can be considered primary needs in the digitized age. The infrastructure, scale, and capabilities of internet technology enable users to access information, vital life services, benefits, financing and create businesses (EIU, 2021). Often, mobile phones can be a user's first foray into the internet, and the substantial benefits of both internet and mobile connectivity are so crucial to productivity that having access to those services can be life-changing. Over 3 billion people in developing countries are connected online (Global System for Mobile Communications (GSMA), 2021). However, this usage is not the same across gender lines. Globally, while 83% of women use a mobile phone, less than 58% access the internet (GSMA, 2021). The top barriers for women worldwide in accessing mobile internet are literacy, affordability, and safety and security (GSMA, 2021).

India has one of the largest digital gender gaps in the world (GSMA, 2021). Specifically, surveys cite affordability as one of the most prominent barriers driving this gap (GSMA, 2021). Reliance Jio (conglomerate-owned telecom operator) entered the telecom market in 2016 with the launch of its 4G LTE network free of charge in a blitz marketing campaign (Mukherjee, 2021). What followed was rapid price reductions in the market overall and a rise in internet consumption. Mobile internet packs across the country saw declines in price per gigabyte from $2 to ₵13 by 2018 (Kapoor & Yadav, 2018) bringing mobile internet within the reach of newer segments such as rural subscribers and women. Close to 400 million Indians came online for the first time between 2016-2021 (Reliance Jio Infocomm Limited 10-K, 2021). In India, 81% of women had never used the internet on a mobile device in 2016, which dropped to 57% by 2021 (GSMA, 2021). This thesis studies the correlation between women present online as represented by the digital gender gap and the affordability of mobile internet through Jio's low-cost structure.

Digital Gender Gap

The ‘digital gender gap’ is a term used to describe differences in access to information and communications technology, particularly access to and use of the internet (Norris, 2001). The digital gender gap measures and highlights the difference in access and use between various groups, including countries of varying GDPs, states in the same region, or even between different counties (or districts in India). This thesis explicitly tracks access to mobile internet and data usage between men and women in India through a state-wide analysis.

“Internet Access, universal and affordable... by 2020” was a critical part of the United Nations Sustainable Development Goals (SDGs). The goals include making access to the internet universal, affordable, open, secure, and high quality, ensuring that every person from the most developed to the least-developed countries has equal access. Recently, COVID-19 has raised internet access to even greater importance with the realization that it is an essential tool for daily life. The gap in internet access discriminates against women and racial and ethnic minorities, rural and indigenous populations, and people with disabilities (Hanna, 2016). While the larger SDG agenda had the time horizon of 2030, internet access was set for 2020, reflecting the urgent need to bring people around the world online to realize all other rights and goals (Access Now). But the goal was not achieved. Globally, an International Telecommunications Union (ITU) report shows that only 54% of the population has internet access, which leaves more than 3.5 billion people in the digital dark, with most people in developing or underdeveloped countries.

Telecommunications in India

With a population of over 1.3 billion and a gender gap of 36% (percentage of women online subtracted from the percentage of men online divided by the percentage of men online), India has an estimated 114 million fewer women than men owning a mobile phone (GSMA, 2021). With India's large population, reaching the remaining unconnected women should also be a focus for mobile stakeholders. As reported by the Telecom Regulatory Authority of India (TRAI), India is the second-largest telecommunications market with a total of 780 million internet subscribers, following China's 940 million. Government policies toward the telecom industry have been liberal with easy market access to equipment and a governing body – Telecommunications Regulatory Authority of India (TRAI) -- that is proactive and pro-consumer. Foreign direct investment, particularly in Reliance Jio, has been a fast-growing segment of the economy and a top-five employment generator in the country (IBEF).

The industry remained government-owned until 1984, after which private players were able to enter the market. The National Telecom Policy of 2012 was the first government-initiated effort for accessible connection, with key focus areas being increased broadband connection in rural areas and increasing phone lines in rural areas to improve the teledensity (connections per 100 households) to 70%. Another impetus to the telecom industry was the Aadhaar card, introduced in 2009. Aadhaar is a 12-digit identity number linked to biometric data. In 2017, the government mandated that Aadhaar cards were required to access social and welfare benefits, like ration services or primary education (Perrigo, 2018). Aadhaar cards are linked to mobile numbers and bank accounts, and that linkage is required to access Aadhaar Online Services – incentivizing unbanked and disconnected citizens to avail of those services (UIDAI, 2021).

In 2016, India was ranked 155th for mobile broadband internet access out of 230 countries (World Bank, 2016). The telecom sector was burdened with costly 4G infrastructure projects, and 1 gigabyte (GB) of data (by usage) in India cost approximately 225 rupees ($3), while the daily GDP per capita was only $4.75 (World Bank, 2016) – making it untenable even for the short-run. Furthermore, internet penetration in the country's rural areas was less than 17% year (TRAI, 2008). The rapid diffusion of low-cost internet in India as a natural experiment makes it an ideal setting to investigate the role of affordability in the digital gender gap.

Reliance Jio

"In the year since it launched (2016), Jio has acquired over 100 million users – many connecting to the mobile internet for the first time in their lives. To give some context, this effectively makes Jio the fastest adopted technology in human history." – Trushar Barot (Nieman Lab, 2017). Reliance Industries also owns businesses in energy, petrochemicals, natural gas, retail, telecommunications, mass media, and textiles. In 2016, while industry incumbents focused on generating revenue through SIM cards, Jio made voice calls completely free. From September 5th to December 31st in 2016, their introductory offer included a free SIM card, free voice calls, 100 free texts a day, and a data package of 4 gigabytes per day at a 4G LTE speed.

Strategically, Jio's entrance into India's telecommunications market changed the market's competitive structure – from revenue based on SIM cards to subscription-based revenue. Jio disrupted by offering free voice calling in an industry structure that derived 75% of revenue from voice calls (Kapoor & Yadav, 2018). By the time the introductory offer ended, India had become the highest mobile data user globally, consuming over 1 billion gigabytes of data monthly, up from 200 million gigabytes in 2015 (Kapoor & Yadav, 2018). Jio users were ravenous consumers of data racking up 11 GB of data per person, 700 minutes of voice calls, and

134 hours of video every month (Reliance Jio Infocomm Limited 10-K, 2017). In 2020, Jio had over 400 million subscribers – larger than the US population.

Although Jio had high penetration in mobile customers and successfully stole market share from incumbents, they were also trying to break the affordability barrier for Indians without phones (GSMA, 2021). Jio could not live up to its full potential if a user didn't have an LTE-enabled smartphone. To bridge this gap, Jio partnered with KaiOS Technologies in 2017 to launch JioPhone branded by them as "India ka Smartphone" (India's Smartphone) (Reliance Industries 10-K, 2018). This came as a significant disruption in the market and a major initiative to integrate the company. Jio offered the phones for 1,500 INR (less than $25), which was steeply discounted on various occasions to increase phone uptake (GSMA, 2020). Four years later, in 2021, "there will be over 100 million JioPhone users in India" (Reliance Jio Infocomm Limited 10-K, 2020). This indicates there is a market for cheap, user-friendly smartphones. Most consumers are blind to brand and prioritize affordability, and more strategically, it captures the user in the Jio ecosystem. Not only does Jio become their pathway to the internet, but it also becomes their first smartphone, or in some cases, first phone altogether. Jio provided high-quality mobile data. It also created an ecosystem of apps called 'Digital Life' as a digital services company to act as an umbrella platform for all the Reliance-owned digital businesses, including Reliance Jio, MyJio JioTV, JioCinema, JioNews, and JioSaavn (music streaming), which were pre-installed in JioPhones.

The price of mobile data plunged for the consumers. While Jio users experienced free mobile data, competitors drastically reduced or price matched internet packs to avoid attrition. The average price per gigabyte dropped to 10 INR ($0.13). According to one estimate, "due to Jio's entry, the annual financial savings to the consumers would be to the tune of $10 billion"

(Kapoor & Yadav, 2018). Additionally, Jio's entry had economic growth benefits through contributions in the telecom sector and positive externalities through the usage of Jio data nationally.

Even as Jio started charging nominal amounts in 2017 for mobile data, the consumers who had come online through their initial strategy stayed online (Ghosh, 2020). Jio's wildly studied launch strategy attracted media attention, with it being touted as the "Jio Effect" (Ghosh, 2020). For the first time, many users joined global apps like WhatsApp, YouTube, and most importantly, Facebook – surging growth and revenue (GSMA, 2017). In June 2020, Jio Platforms Ltd. sold a 22.38% stake worth 1.04 trillion INR ($ 14.75 billion) to ten global investors in eight weeks under separate deals, involving Facebook, Silver Lake, Vista, General Atlantic, Mubadala, Abu Dhabi Investment Authority (ADIA), TPG Capital and L. Catterton. "This is the largest continuous fundraise by any company in the world" (IBEF). In 2020, Jio was the country's best mobile telecom operator by Adjusted Gross Revenue and subscribers.

While Jio's rapid diffusion in India has clear economic benefits, less is known as to how it has contributed to the digital gender gap. In this thesis, the proliferation of Jio is used as a setting to investigate how low-cost internet affects access to mobile internet for women.

Problem Statement and Justification

The potential of the internet to empower those in developing countries and support development goals has been accepted as canon among development economists (Qiang, Clarke, & Halewood, 2006; Unwin, 2009; Walsham & Sahay, 2006). In India, the results of the Social Progress Index (Jitmaneeroj, 2017) established that higher internet access leads to the streamlined provision of social services and, by extension, higher social progress. Findings from subsequent studies in India show high positive correlations between the per capita GDP of Indian states and access to information and communication. The health and education scores of states also positively correlate with access to information and communication (Kapoor & Yadav, 2018).

By association, it has been established that internet access leads to better social, educational, economic, and health outcomes for populations. Studies in Peruvian villages have established the impact of the internet on employment and agricultural production (Barreto & Burga, 2014), which can be expanded to other agrarian economies such as India. But due to a shortage of high-quality gendered data, these findings have not been definite for women or implications for the digital gender gap.

Given the accelerated digitization brought on by COVID-19, it has never been more critical for women to become equally equipped digital citizens of the world. Women value mobile phones and internet access as life-enhancing tools with crucial information to augment their daily lives such as digital banking that they “would not have received otherwise” (GSMA, 2020). The mobile internet user journey crosses multiple stages –from mobile ownership, awareness of mobile internet, access to mobile internet adoption, and finally, regular mobile internet use (Bhandari, 2019). This thesis focuses on the access to mobile internet adoption stage, as significant research has been done on the other stages of internet usage. According to GSMA, 53% of Indian women are aware of mobile internet, which is still the lowest among South Asian countries. Per the same report, awareness has been increasing but doesn't translate into usage. The gap between awareness and adoption highlights the need to investigate the barriers to access, especially for women who understand the internet's utility and potential value (GSMA, 2021).

The purpose of this research is to examine the relationship between women coming online through mobile internet and new wireless connections through Reliance Jio in a state-wise analysis. If more women are online in states with higher penetration of Jio services, it establishes a link between the affordability of mobile internet and access for women. Through the insights this connection provides, especially accommodating for socio-economic differences between states that might skew the correlation, a quantitative framework will be created that can estimate the impact of affordable internet on the digital gender gap. The analysis will be based on panel data from the national regulatory body and ground survey data from the NFHS to generate a multiple regression using the Wireless subscribers as the independent variable and the digital gender gap. Then, the implications of the analysis to Jio, state governments, and corporations invested in India's internet growth will be discussed.

This research question is important because it examines whether affordability is a significant barrier to internet access for women in India. While holding socio-economic variables constant, this regression analysis tests the hypothesis without any confounding variables. Until now, connections and implications have been posited between digital access and social progress (Kapoor & Yadav, 2018), using Facebook ad data to track digital gender gaps (Fatehkia et al., 2018), (Kashyap et al., 2019), (Tyers-Chowdhury & Binder, 2020). The GSMA tracks digital gender gaps worldwide, but no correlation (or hypotheses) has been made with free (and affordable) internet access brought about by Jio and its role in bridging the digital gender gap. While many studies have been done on the benefits of internet access, and the inequities that clearly emerge from gendered differences in internet access, there is little research done in the determinants of internet access. The natural experiment created by the entry of Jio, the availability of survey data by the timely publication of the NFHS, the context in which it started, and the promotional marketing strategy makes it an ideal observation ground to test this hypothesis.

Further, insights may be found on the nature and conditions of states where higher penetration of mobile internet occurs. Bidirectional insights can be made on the wireless subscriber base and the gender gap, and Jio's acceleration can be measured based on states with low and high penetrations of Jio subscriptions. This research can answer many questions in development economics, including accessibility, affordability, and ability to connect to the internet. Existing gender gaps in digital inclusion, if not properly addressed, are likely to lead to gender inequalities in many other areas, including inequalities in labour markets and less financial inclusion of women.

Literature Review

Accessibility, awareness, and affordability of mobile internet worldwide is a United Nations goal, a cornerstone of the Digital age. Equal and equitable access to information has become a top priority for governments and organizations globally. Research has been done in broad areas of (1) the role of internet access in advancing countries, communities, and demographic groups (like women) (2) responses to price elasticity for services like internet and finally (3) rural subscribers and their specific improvements in access and gender gaps. Through a mix of quantitative data leveraging online models and offline development indices and qualitative data, statistically significant results have been found that proves the research question of this thesis to be feasible. The methodology of this thesis builds on best practices from the three prongs of the literature review – considered to be the theoretical framework of the research question.

Internet Access Frameworks

The impact of telecommunications on growth was first found by Andrew Hardy (Hardy, 1980) based on data from 45 countries, with the largest effect of telecommunication investment on GDP found in the least developed economies and the smallest effect, in the most-developed economies. This is primarily while countries at different stages of development cannot be assessed on the same scale. Frameworks surrounding the economic impact of infrastructure investments and social overhead capital on economic growth has been robust, thorough, and consequential (Kefala, 2011). The role that mobile internet is playing in the developing world today is equivalent to that of telephones in the 1970s and 80s (Kefala, 2011). Data suggests that lower-income groups derive higher utility from mobile internet than other groups, and higher still if they live in a developing country. Sridhar and Sridhar (2008) find that mobile phone and internet penetration, without any fixed effects, resulted in a 27.6% CAGR growth effect on Tanzania's national output, averaged to 16.2% for all countries. The conclusions used logarithmic multiple model regressions, which will be the primary method of analysis in this thesis as well. While more robust estimation is possible with complete data, country-specific effects can be sufficiently explained using panel data (Sridhar and Sridhar, 2008).

The relationship between economic growth and affordability of telecom services have been explored as a bidirectional causality. Increases in disposable income and purchasing power increases demand for telecom services. "Chatterjee et al. (1998), point out that income patterns decide the disposable income levels i.e. purchasing power for telecommunication services, and in turn the growth of services" (Sridhar and Sridhar, 2008).

While internet access and affordability are determined by micro-economic factors such as standard of living, gender and economic indicators at the state level - individual differences in resources, wealth and awareness can play a significant role in internet adoption. A research paper that studied the digital divide in Thailand, another developing country, explored the effects of individuals' resources and social categories on internet access opportunities (Lopez-Sintal et al., 2020). While internet awareness can differ significantly from person to person, adoption was still conclusively determined by affordability (Lopez-Sintal et al., 2020).

Digital technologies promote development by three mechanisms: inclusion, efficiency and innovation (World Bank, 2016, p.2, 9-10). For women specifically, the largest opportunities for inclusion of women are employment, service delivery, changing social norms and values, e-governance, and digital skills development and education (Herbert, 2017). The extent and speed of digital development is unequal and is contributing to unequal development trajectories (UNCTAD, 2017). At an aggregate level the literature reveals it to be exacerbating and deepening some old development divides (e.g. gender, income and rural-urban divisions), to be creating some new divides (e.g. age), and may be rebalancing some divides (e.g. (dis)ability) (Hanna, 2016).

In India specifically, the most recent analysis in 2018 by Kashyap et al. observed the impact of various demographic and socio-economic variables on the digital gender gap demonstrated on Facebook, including age, device, education, industry, - and state-wide statistics including gross domestic product, sex ratio, and internet penetration. While the socio-economic variables available through Facebook were highly co-related with the gender gap online, particularly the device used and certain industry employments, the subnational indicators only explained 7.3% of the variation in gender gaps. The model including internet penetration did not possess a high explanatory value, possibly caused by the measurement of the penetration and the lack of a microscopic view on the effect of free internet. Interesting to note, however, that internet penetration is not the surpassing factor for the digital gender gap on Facebook.

Telecom Price Elasticity

The second framework that supports this thesis is the impact of price elasticity on telecommunications demand. In assessing the gender gap online, this thesis is also assessing the response on price-change while accounting for gender. While gender specific economic indicators are the primary axis of analysis, elementary change in demand is also a function of price elasticity. Significant work has already examined the effects of both constant price elasticity and log-linear demands, as well as short run and long run elasticities of demand. Several scholars have enhanced the model with the help of economic indicators in order to "increase explanatory power to explain demand" (Agiakloglou and Yannelis, 2006). The study was conducted in developing countries and saw a price elasticity range of 6-14% varying by country. The variation can be construed as the lower bound for elastic demand change since Jio's level of price decrease has been unprecedented and unmatched (Ghosh, 2020).

The latest parallel study on mobile voice communication by Sawadago (2021) compares the price elasticity between developing and developed countries. "Controlling for cross-price elasticity with internet data prices reveals that voice communication is a substitute for internet data usage in developed countries." In developing countries, telecom service price elasticity has decreased over time, "and operators in markets with low penetration (India) experience a higher price elasticity than those in more deeply penetrated markets" (Swadago, 2021). Most importantly, the study concludes that there is no evidence of differential price elasticity between incumbents and followers. Thus, this study would suggest that Jio didn't experience any elasticity advantages from being a new entrant purely in an industrial framework.

Urban-Rural Divide

Rural India has seen vast improvements in the past decade – however, broadband internet connection remains at a low 29.3% compared to higher than 50% in urban areas. The specific struggles in rural areas also diverge from urban (Kumar et al, 2022). A key stakeholder shift occurs, bringing the burden from the user to the provider. Low tele-density, accompanied by very low ARPUs (Average Revenue Per User) signal losses and a disinvestment to national providers (Khalil et al, 2017). In order to make these many options for connectivity available to both end users and providers, there is a clear need for a flexible legal and regulatory regime, allowing users and providers the power to connect using a variety of different means, including opening the infrastructure to startups and technology companies experimenting with newer methods. Some potential solutions are discussed later in the thesis. Large coverage gaps in many areas of India create a barrier to studying access, because those regions are plagued by a lack of internet. Further problems include challenges in ensuring last-mile coverage at the offered data rate, and adequately forecasting data volume demands over the varied geography.

The national coverage and bullish expansion of Jio in rural markets make it a opportune backdrop to study rural growth. At the start of 2020, Jio surpassed Vodafone to be the number 1 operator in rural areas – prescribed to the low-cost internet and rollout of its accompanying low-cost 4G feature phone (JioPhone) that competitors don't offer (The Economist). The frequency of measurement of the data, along with state-wise granularity make the rural focused analysis unique. Researchers in the past have used empirical models of innovation diffusion such as the Gompertz Model to estimate the 4G LTE subscriber adoption in rural areas of Spain (Ovando et al, 2015). However, performing regressions at the aggregate level stop short of specific geographical conditions such as economic controls.

Historically, observations have been made to address the gap including mobile internet to broader measures of ICTs. In the era during and after the mobile phone, they have been a reflection of the prevailing socio-economic, infrastructural, and institutional divides (Andonova, 2006; Baliamoune-lutz, 2003; Kiiski & Pohjola, 2002). However, there hasn't been a consensus on the quantum of effect of any of the factors, nor have the factors or datasets used been consistent. For example, most studies looking at global level digital divide indicate that "education plays a significant role in diffusion of technology in developing countries, but not so significantly in developed countries because of low variability" (Baliamoune-Lutz, 2003; Kiiski & Pohjola, 2002). These limitations are slowly improving with governments and global bodies prioritizing the diffusion of the internet and ancillary technologies while including survey questions from key central bodies such as the census and women welfare.

Methodology

This research employs linear-regression analysis by merging two distinct datasets and descriptive analysis. The first is longitudinal data from TRAI (Telecom Regulatory Authority of India) that tracks monthly wireless subscriber data for each of India's 29 states and 1 union territory. This shows month-on-month growth for Jio subscribers from September 2016 – August 2021, and an additional year before Jio's launch. The second is an on-ground survey of 300,000 households by the National Family Health Survey (NFHS). Two regressions are run, with and without controls. Further, the dataset is split among the states by median HDI (control variable) to assess any potential variation in the model.

Analyzing the period before and after the introduction of Jio, will allow for assessment of the correlation and calculation of the existing digital gender gap and calculation of the digital gender gap before and after this introduction. Correlations can underestimate the true value of the relationships – hence the relation between the two variables will serve as the lower bound for the underlying population (Strahan, and Hansen, 1978).

Table 1: Summary of proposed data methodology

Variable Type	Name	Source	Aggregation	Years Observed
Dependent Variable	Digital Gender Gap (DG)	National Family Health Survey	State-level	2015, 2020
Independent Variable	Jio Subscribers as % of Population (Jio)	Telecom Regulatory Authority of India	Circles (adapted to States)	2015 - 2021
Control Variables				
1.	Human Development Index (HDI)	UNDP	State-level	2018
2.	Gender Development Index (GDI)	UNDP	State-level	2018

3.	Gender Inequality Index (GII)	UNDP	State-level	2018
4.	Sex Ratio at Birth	Indian Census	State-level	2018
5.	Tendulkar Poverty Estimates	Indian Census	State-level	2018

The following linear model is then estimated:

$$\Delta DG_{it} = \alpha 0 + \alpha \Delta Jio_{it} + HDI + GDI + GII + Sex + Poverty + e_{it}$$

where DG_{it} measures the improvement in the digital gender gap of the state i at time t, Jio_{it} represents the change in subscriber count of Jio in state i at time t, HDI is the human development index, GDI is the gender development index, GII is the gender inequality index, Sex is the Sex Ratio at Birth, and Poverty represents the Tendulkar Poverty Estimates, while e_{it} is the error term.

The dependent variable (DG) is the digital gender gap as measured by the NFHS for each of all 30 states. This survey is conducted every 5 years and for the most recent one 2020 (Appendix B), separate surveys were completed on men and women including direct questions on mobile internet usage. In 2015, only household access to mobile internet was captured — along with the percentage of women and men with individual access to mobile phones. A proxy variable for the gender gap in 2015 has been calculated as the difference in usage between men and women as a proportion of usage by men (Appendix A). There is still an absolute lack of internet access across genders, but this methodology focuses on measuring the corresponding inequity. Gender, in both the TRAI and the NFHS data is binary. While India has included a third non-binary gender option in passports, forms and national level surveys for all social research still lacks inclusion from that perspective.

$$Digital\ Gender\ Gap = \frac{\%\ of\ Men\ with\ Internet\ Access - \ \%\ of\ Women\ with\ Internet\ Access}{\%\ of\ Men\ with\ Internet\ Access}$$

The wireless subscriber count is the independent variable (Jio) in the multiple regression. This data set is not gender-disaggregated and only provides an aggregate subscriber growth at a state level. However, the dataset filters the subscriber count by telecom operator, which enables the isolation of Jio subscribers representing the low-price model. Next, the control variables of HDI, GDI, GII, Sex Ratio at Birth, and Tendulkar Poverty Estimates were added.

The TRAI divides the telecom space of India into 22 circles, with each circle representing a region of telecom coverage. Sometimes, a circle directly corresponds to a state; but in sparsely populated regions, it corresponds to more than one state. In those cases, the subscribers in a state have been allocated based on population weights. The final variable is the resultant penetration of Jio in a state represented as the subscriber count as a percentage of the population. From the TRAI — Data for West Bengal includes Kolkata, Maharashtra includes Mumbai and Uttar Pradesh includes UPE & UPW service areas. Data for Andhra Pradesh includes Telengana, Madhya Pradesh includes Chhatishgarh, Bihar includes Jharkhand, Maharashtra includes Goa, Uttar Pradesh includes Uttarakhand, West Bengal includes Sikkim and North-East includes Arunachal Pradesh, Manipur, Meghalaya, Mizoram, Nagaland & Tripura States.

Three socio-economic control variables will be used to assess the relationship between the wireless subscriber growth and internet usage for women while accounting for state-level socio-economic factors. For maximum coverage and to make the correlation as accurate as possible, three indices are being used — Human Development Index (HDI), the Gender Development Index (GDI), and the Gender Inequality Index (GII). These are formulations of monitored economic indicators as detailed below. In addition, two standalone indicators that factor into gender development but are not otherwise included in the tabulation of the indices mentioned previously are used — Sex Ratio at Birth and Tendulkar Poverty Estimates. These indicators will cumulatively account for state-wise differences that could environmentally affect the data as an external factor. This will make sure that economic, cultural and social factors innate to a state do not confound the regression correlation.

Trying to account for gender development is very complicated due to the dynamic and complex growth process; it doesn't follow a uniform path (Kelley 1991; Krishnaji 1997; Rustagi 2000). For any policy-oriented or government planning–related implications, gender development indicators can add specificity that make for compelling and replicable experiments (Rustagi, 2004). The purpose of gender development indicators is to reach conclusions that can be used for interventions, policies, and emancipation for the status of women and other minorities. Hence, gender development indicators need to be standardized, composite, and disaggregated in their calculations (Rustagi, 2004).

1. The Human Development Index (HDI) is a summary measure of average achievement in a country with regard to 'Long and healthy life', 'Knowledge' and 'A decent standard of living.' It is measured by life expectancy at birth, mean and expected years of schooling, gross national income (GNI) per capita. The HDI is the geometric mean of normalized indices for each of the three dimensions (Sen et al., 1994).

2. The Gender Development Index was conceptualized by the United Nations Development Program to measure gender gaps in human development achievement while accounting for disparities between men and women in the three critical areas that the HDI calculates. It directly measures the gender gap showing the female HDI as a percentage of the male HDI (See Appendix G). As a substitute for gross national income, it calculated the estimated earned income for both genders.

3. The Gender Inequality Index (GII) reflects gender-based disadvantage in three

dimensions – reproductive health, empowerment, and the labor market. “It shows the loss in potential human development due to inequality between female and male achievements in these dimensions” (UNDP). It ranges from 0, where women and men fare equally, to 1, where one gender fares as poorly as possible in all measured dimensions (See Appendix H). It considers (i) Reproductive health through Maternal mortality ratio, Adolescent fertility ratio, Women’s share of seats in the legislature, (ii) Empowerment through the measurement of secondary education ages 25 and older, and (iii) labour force participation rate.

Sex Ratio at Birth is critical especially to India – as of the Census in 2011, the national average was 940 females for every 1000 males with some states going as low as 811 (Chandigarh). This inherent difference in gender populations has established a need to account for the sex ratio in gender-based analysis. Evidence from India has proved the existence of a nonlinear link between female disadvantage in natality and education borne out of sex ration at birth (Echavarri, 2010). Further, the Tendulkar Poverty Estimates are vital to measuring the disparities in adoption from the lens of telecom price elasticity. While the methodology for estimating poverty has changed from time to time, a consumption-based poverty line has largely been accepted (Panagariya et al, 2014).

The three main socio-economic indices (HDI, GDI, GII) have been measured from the United States Development Program in 2018 — midway through the time frame used for Jio. The latter two were last captured by the Indian Census in 2011. As is a limitation of global studies, socio-economic indicators vary across states and between rural and urban regions within the same state, it also varies across states and between urban and rural regions within the same state — leading to the possibility of larger standard errors.

Results and Discussion

The digital gender gap has undeniably been narrowing since the introduction of Jio. At the national level, the digital gender gap improved by 7 pp, dropping from 49% to 42% - with rural subscribers seeing a higher improvement in the digital gender gap. In comparison, the region of South Asia is still at 51% (GSMA, 2021). The states of Karnataka, Haryana, and Sikkim observed improvements of 19 pp, 15 pp, and 14 pp respectively, marking the highest improvements in total gender gap (Figure 1). In urban areas, West Bengal, Uttar Pradesh, and Jharkhand made the biggest gains of 22 pp, 19 pp, and 18 pp respectively (Figure 3). States with historically low HDI, high levels of poverty and disparaging gender inequality such as Uttar Pradesh and Madhya Pradesh also observed improvements of 11.43 pp and 13.93 pp (Figure 1).

Using a two-pair mean comparison test, the mean digital gender gap fell from 51% in 2015 to 36.3% in 2020, making the difference in the digital gender gaps statistically significant. Outside of the impact to the gender gap, on an absolute basis, women saw a nation-wide 28.28 pp increase in access to mobile internet, up from 5.01% in 2015 (Figures 4 and 5), representing 185M women accessing the internet through their mobiles. Developed states like Kerala and Goa observed improvements of 59.88 pp and 49.67 pp respectively, leveraging access to better infrastructure and high government expenditure (Kefala, 2011) (Figures 4 and 5).

Nationally, there is convincing evidence that women have made progress in leaps and bounds in both urban and rural areas (Figure 2, 3). However, the digital gender gap measures the improvement in women's access as a proportion of men's access. Hence, it is important to note that men have had noteworthy increases in access, with a national average of 47.25 pp (Appendix C). In the same time period, women averaged a 28.29 pp increase in access (Figures 4 and 5), leading to the conclusion that both external socio-economic factors, culture, as well as affordability in mobile benefitted men at 167% the rate that it benefitted women. In other words, while women improved with millions of new connections, the improvement for men, at the very worst, was on par with women (Sikkim). At the very best, men were becoming digital citizens at more than twice the rate of women (Appendix C).

Telangana provides a useful example of this formulaic bias manifesting. In 2015, it had been a year since the new state was carved out of Andhra Pradesh and rural internet access for women was at a national low of 0.24% (Figure 8) while urban access for women was 8.13% (Figure 12). In 2020, after a 33.26% penetration of Jio, those figures were 15.8% (Figure 9) and 43.9% respectively (Figure 13). Parallel to that, Men increased from 0.6% in rural and 12.4% urban to 46.7% rural and 72.3% urban. The improvements for women were overshadowed by improvements among men, worsening the gender gap from 43% to 48% in urban areas (Figures 14 and 15). This disparity in rates of diffusion can also be attributed to Telangana's nationwide low GII of 0.41, making the digital divide more reflective of offline indicators. Averaged over all states, men were making 160% of the gains made by women. For this reason, the advancement and empowerment of women is not reflected in the digital gender gap — and while a gender-balanced ratio should always be the goal, an absolute increase for both genders also represent progress in digital inclusion.

Interestingly, analyzing the relationship between the improvement in digital gender gap in urban areas with Jio's penetration shows a negative relationship (Figure 18). Andhra Pradesh had an overall 32% penetration of Jio but observed a deterioration in gender gap by 4% (Figures 14 and 15). This can be explained by the limitations in the formula mentioned previously, or by the additional challenges faced by urban women, such as higher costs of living, and different gender roles in cities.

Linear Regression 1 – No Control Variables

Table 2 presents the results of the first regression, assessing the impact of subnational Jio penetration on the improvement in the digital gender gap. Using robust standard errors, the effect of Jio penetration as a percentage of the population gap had a negative correlation with the digital gender gap, as hypothesized. One could logically posit that cheaper mobile internet would improve access for women. On average, Jio had a 30% penetration rate for all unique subscribers (defined as the ratio of Jio subscribers to the population of a given state) – of those, the state of Karnataka saw the highest improvement in the digital gender gap, at 18%, with over 12 million women coming online for the first time (Figure 1). The state of Punjab had the highest penetration of Jio, and even with historically low HDI and GII indices, saw an improvement of 12% in the digital gender gap overall and an 18% improvement in rural areas (Figures 10 and 11). In a notable exception, four states experienced a deteriorated gender gap — namely Kerala, Telangana, Manipur, and Himachal Pradesh (Figure 1).

The resulting model with the independent variable without controls demonstrated an Adjusted R^2 of 0.048. This suggests that the penetration from Jio only explains 4.8% of the state-level variation in the digital gender gap. The coefficient is negative, with a value of -0.1 which suggests that the increase in Jio subscribers lowered the digital gender gap. With the addition of every 13.7M subscribers, the national digital gender gap fell by 1% (Figure 16).

Table 2: Linear Regression (OLS) with no controls

	Coefficient	Std. error	t.value	p.value
(Intercept)	0.085	0.028	3.043	<0.001
Jio	-0.103	0.008	-1.213	0.234

Linear Regression 2 – with Control Variables

Adding the control variables, however, explain a greater proportion of the digital gender gap with an adjusted R^2 of 0.74. Of the variables, the human development index and Gender Inequality Index were statistically significant, with negative correlations. The introduction of the control variables did not change Jio's effect, but it was not statistically sigsnificant. All variables had inverse relationships with the digital gender gap, as hypothesized and covered in the literature review. Consumer expenditure on telecom services depends on disposable income, but that is controlled for by the poverty estimates. A more gender-balanced sex ratio at birth, better female participation in labor force and equal opportunity for education would also contribute toward improving the digital gender gap. Employing stepwise selection computed the HDI, and GII as the key variables while discarding the GDI, Sex Ratio at Birth, Jio Penetration, and Tendulkar Poverty Estimates, in that order. The results suggest that many factors influence the gender gap, but that price and affordability has an important role to play alongside those other factors.

Unsurprisingly, socio-economic development variables at the state level are statistically significant variables in the model. A better standard of living and healthier lives are overall metrics of development that positively affect dynamics beyond internet connection, such as financial inclusion and access to capital (GSMA). Confounding the original hypothesis, however, is that the availability of affordable internet did not significantly impact the digital gender gap. The prevalence of macro variables over individual purchasing power was not anticipated.

Table 3: Linear Regression (OLS) with controls

	Coefficient	Std. error	t.value	p.value
(Intercept)	2.168	0.447	4.841	<0.001***
Jio	-0.10175	0.104	0.969	0.342
HDI	-1.527	0.356	-4.286	<0.001***
GDI	-0.167	0.242	-0.691	0.496
GII	-0.583	0.104	-5.607	<0.001***
Sex	-0.003	0.004	-0.775	0.44
Poverty	-0.001	0.001	-1.248	0.224

There are a few explanations as to why the internet penetration through Jio is not significant in comparison to gender-based indicators such as GII. First, the dataset itself comprises 30 observations (29 states and 1 Union Territory) which is a small enough dataset to cause high standard errors. Moreover, there is significant disparity within states to mark improvements at a subnational level. Second, while Jio's penetration was highly varied in terms of absolute numbers —with Uttar Pradesh, Madhya Pradesh, and Rajasthan gaining 45M, 30M, and 24M subscribers over the 5 years respectively — the variation in penetration rate was low (Figure 16). Most states fell in the range of 25-40% with some outliers. Without the variance in penetration rate, the performance of Jio was too tight to discern. More variance in the data, through additional observations and a potential district-level analysis, could yield nuanced results. At the subnational level, however, socio-economic indicators took precedence as the more significant explanatory factors.

Socio-Economic Indicators

The significance of the HDI to indicators of growth such as internet access is not unprecedented. However, in light of assessing the impact on the digital gender gap, the absence of any significance of the GDI (the female to male proportion of HDI) signifies a need for a closer look at the impact of the HDI. The range for GDI is smaller than HDI, thereby making the same conclusion tougher to draw, however the difference in both impact and significance leaves room for further analysis.

The state of Karnataka, for example, saw the best improvement in digital gender gap – 18.76% with a 30.17% penetration of Jio (Figure 1). As represented by the regression, HDI and GII had the most explanatory power on the digital gender gap — but Karnataka, per the Tendulkar Poverty estimates, is one of the wealthiest states, has a top quintile HDI and GII, and only a sex ratio of 939. Given the high standards of social and economic conditions, it still observed a big impact on the gap.

Splitting the dataset by the median HDI illustrated the explanatory power of both high and low HDI alike. In line with the previous reasoning, states with higher HDIs saw a positive relation with the digital gender gap — with a coefficient of 0.157 (Appendix E). It follows those stable external conditions such as health, education and labour force participation could create a favourable environment for improvements in digital inclusion. The states with lower HDIs (Bihar, Uttar Pradesh, Jharkhand) saw a negative relation with the gender gap with a coefficient of -0.128 (Appendix D). Lower HDIs diminish the effect of Jio penetration, either by benefitting the men more through institutional gender structures and cultural norms or by being impeded by governmental gender inequalities. It is interesting to note that the positive effect of states with higher HDIs is of a higher magnitude than the negative effect of states with lower HDIs. Either way, while the sample of the split is small (15 observations each), development and growth from government bodies can pave the way for consumer-level interventions to bear fruit.

The dominance of subnational indicators such as HDI and GII also point toward another theory of development and economic growth — the underwhelming impact of the transfer approach (Prahalad, 2010). While giving subsidies, in turn creating environments for higher individual consumer purchasing power, does drive upward mobility, it eventually stagnates at a level beyond which only improving institutional and grassroot factors such as health and education can improve overall prospects. A co-creation approach such as local entrepreneurship to generate region-specific mobile internet solutions, and community campaigns to increase awareness can shed light on and aid the research of other barriers to a gender-balanced internet world such as literacy, and security.

Beyond the scope of the regression model, other subjective factors such as culture may prevent women from gaining independent internet access. The internet enables women to participate in the public sphere, and access to it may be controlled by men in patriarchal contexts (Antonio, 2010). Safety and security are another area of further research. These concerns could be especially prevalent in areas with lower HDI, and thereby fewer accomodations and allowances for women in public life. According to GSMA, women may also choose not to go online for fears of harassment, or due to lack of self-belief stemming from awareness. The indirect transaction costs may be large drivers of the digital gender gap, despite the newly available affordability of mobile internet. These factors could explain why states with higher HDI (an offline indicator) have more gender-balanced online presence (Figure 5).

Impact on Rural Subscribers

The impact of Jio, while substantial nationwide, has been bolstered by its specific impact on rural subscribers, without ever extensively targeting those customers (Kapoor, 2018). Rural subscribers increased steadily, with 100M in the first year alone (Figures 19 and 20). The subscriber count climbed steadily until September 2021, the first month with a decline, attributable to mobile phone discharge “due to financial difficulties from the pandemic” (Indiatimes, 2021). From the 30 observations in the study, 75% of them demonstrated a more substantial improvement in rural areas than urban areas. Some states such as Arunachal Pradesh and Jammu & Kashmir demonstrated an improvement in digital gender gap in rural regions while urban areas observed worse digital gender gaps. Assam strongly embodies that effect, with a 17% improvement in rural areas while urban gender gaps fell by 1% (Figures 2 and 3).

Rural women saw the highest improvement nationwide. States like Andhra Pradesh, Telangana, and Gujarat had less than 1% internet access for women in rural areas, now 15.4, 15.8, and 17.5% respectively (Figures 8 and 9). Most states have seen double-digit improvements in gender gaps after 5 years. 6 states now boast more than 50% internet access for rural women, with several states inching toward that landmark. The state of Punjab, with one of the highest poverty rates in the country, had the overall highest penetration of Jio — 45.71% — and observed an improvement of 17.26% in the gender gap in rural areas (Figure 2),

As alluded to in the literature review, concerns for rural subscribers do not end with affordability. The problems of coverage and literacy plague these regions at a higher rate than urban areas. Many alternative solutions are being explored in the start-up space, including the use of satellite and aerial platforms, community networking through GSM white spaces and the concept of Google balloons (Khalil et al, 2017). As discussed, since telecom operators are hesitant to expand into rural areas, the viability of these proposals under a larger business model is yet to be assessed.

A silver lining for rural adoption in internet access will be the rollout of 6G (Yaacoub, 2022). The spike in internet and mobile access after the rollout of every telecom grid since 3G is notable. While much attention is given to the challenge of affordability of mobile internet, the implementation of 5G and 6G in developing countries presents new opportunities to study awareness, infrastructure and coverage, and the external environmental factors that affect access for women and rural subscribers. Unfortunately, a single, path driven, and empirical answer cannot be given to the problem of internet access --- multiple systems and solutions need to be analyzed independently and in tandem to realize inclusive, cost-effective interventions by government and private players alike.

Assumptions and Limitations

A correlation (and not causation) is the strongest relationship that can be demonstrated between the price and connectivity because of the data-sparse, gender-blind nature of the available information. Most significantly, every single internet user cannot be directly attributed to Jio. While socio-economic indicators are used to control for external conditions, incomplete data points stop the conclusions short of a causality.

An additional limitation is that many Indians use dual SIM cards to reap the benefits of free internet packs from multiple providers. According to Nielsen, "Multi-SIM use is among the latest trends that Indian consumers are taking advantage of, allowing them to switch carriers on the fly with the simple switch of a SIM card. Instead of just carrying one SIM, many mobile users are dual SIM users. This allows them to switch between providers to capitalize on varying price, data and service offer from industry operators." This trend has been on the rise since 2015 (Nielsen), which means that not all new wireless subscribers are first-time subscribers. This dilutes the Jio Effect by a margin, but not significantly (Fatehkia et al., 2018).

The methodology leveraging the National Family Health Survey also includes a limitation through the questions asked in the survey. While in 2020, questions directly about mobile internet usage were asked, corresponding questions in 2015 were about mobile phone usage. Proxies were made based on the availability of that question in tandem with information about household availability of internet attributed to male head of households. This limiting calculation of the dependent variable in 2015 leaves room for error in measurement. Further research could leverage the permanence of internet usage questions by both GSMA and the NFHS, as governments prioritize the survey and inclusion of digital activity.

The lack of high variance among the penetration of Jio in the states as a percentage of the population (2.16%) creates cohorts of states with similar penetrations of Jio but varying digital gender gaps – making the effect of Jio hard to parse between without additional information on calculating the penetration rate. The constraint of performing the regression on a state level (and not a district level) restricts the number of observations to 30 (the number of states) which gives a higher a margin of error. Given the two static sets of gender gap data, further inferences cannot be made. In future research, performing the analysis at a district level or having information about the percentage of the state who are within the reach of penetration could produce a more a accurate figure for penetration.

Conclusion and Future Research

The findings provide support for the narrative that the increased and robust diffusion of affordable internet through Jio is indeed moving the digital gender gap in the right direction. Strong conclusions on the correlation and the explanatory power of Jio on the digital gender gap cannot be drawn based on this dataset alone. However, the significance of socio-economic indicators such as the HDI and the GII are hard to overlook. Particularly, the positive relationship between affordable internet and the digital gender gap in high HDI states, with the opposite effect in low HDI states, suggests the greater potential for affordable internet in driving outcomes above a certain baseline and reinforces the need for different methods of intervention and diffusion. Further, the impact of Jio is demonstrated more drastically in rural subscriber, who exhibit some of the biggest gains of any group under consideration. Further, it points toward barriers outside of affordability, such as awareness, literacy, and safety and security — which exist in the same quality of life realm that metrics like the HDI interrogate — to be strongly considered as factors exerting an influence on the digital gender gap.

Through Jio alone, astronomical and unprecedented numbers of subscribers have reached connectivity in rural areas (190M as of August 2021) (Figure 19). Leveraging the TRAI's coverage on a month-to-month frequency can be a rich source of understanding in state-wise uptake, particularly given the palpable effects of the pandemic. Many national events, such as migrant exoduses, long periods of lockdown, and social isolation could have impacts on spikes and ebbs of internet usage — all intriguing effects to track.

This thesis included the control of state-wise indicators such as human development, gender inequality and poverty levels — but as much as it is part of the analysis, it also should be part of tackling the problem. Region-specific solutions need to be seamlessly stitched together to make ubiquitous internet access — as well as quality of life interventions that provide the ability to reap the benefits thereof — a reality. To that end, the involvement of strong nation-wide operators like Jio is a step in the right direction by providing the necessary coverage in every part of the country. Some promising initiatives are being taken to spread literacy on the benefits of internet usage, The Internet Saathi initiative, supported by Google and Tata Trust's partnership, aims to facilitate rural women's engagement with the internet by training them in rudimentary internet skills and providing them with an internet enabled device. Accordingly, policies aimed at empowering women by eliminating these traditional restrictions will also promote their digital inclusion. (Sorgner et al, 2020)

A new and increasingly popular method of calculating the digital gender gap is the women-centric approach where increase in access for women is not a proportion of access for men. This thesis was in line with the standardized GSMA approach of using male access as a reference, but newer approaches advocate a women-centric approach. Such pivots in future surveying and research can successfully flip the narrative and leader to richer insights.

The original methodology of this thesis included the usage of Audience estimates provided by the Facebook Marketing API giving much more granular, monthly data on online presence for men and women, under the key assumption that activity on Facebook indicates the usage of mobile internet. During the course of this study, Facebook changed its policy to ban access to archival data. Pursuant to new policies, richer insights may be found by querying the server monthly in real time to gather data over several years, creating a standardized method of measuring women's presence on the internet.

Although Jio's consumer base continues to grow and encompass millions of rural and women subscribers in India, more exhaustive coverage of the population is needed. As India continues to see more people online than ever before, it must continue to tackle formidable challenges from spreading awareness to removing institutional barriers while continuing its progress. In quantifying the impact of affordable internet, especially amid varying levels of state development, this thesis appends empirical momentum to the broader narrative of digital inclusion in India. This method can be applied to other developing countries and even other demographic groups within India, as efforts are made to bring more people online and improve outcomes worldwide.

Figures

Note: Geographic maps of India have been generated using Tableau, notably including NCR of Delhi and excluding all Union Territories including Ladakh

Figure 1: Improvement in Digital Gender Gap – Total

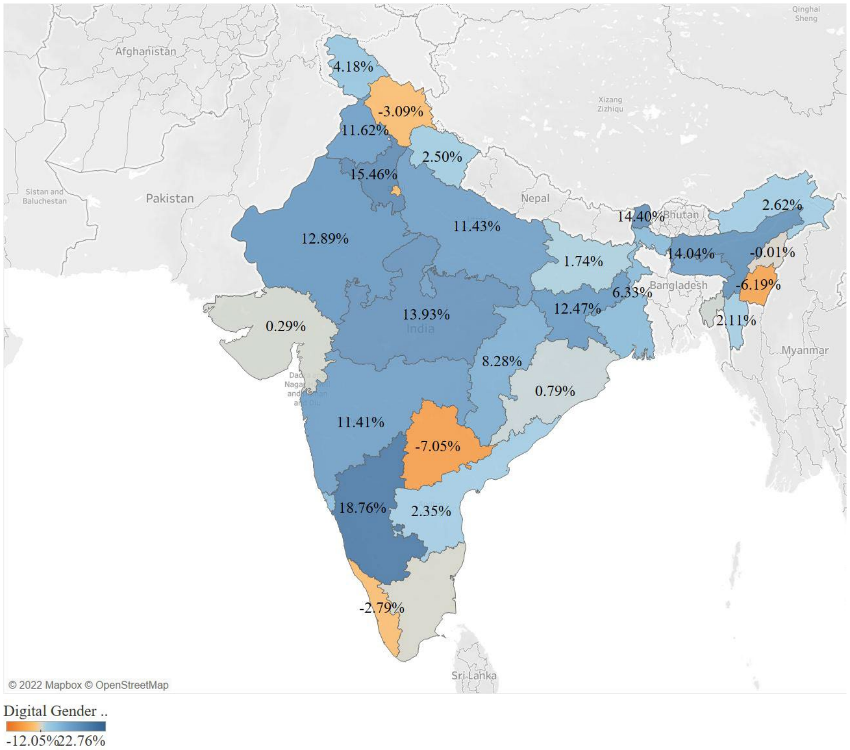


Figure 2: Rural Improvement in Digital Gender Gap

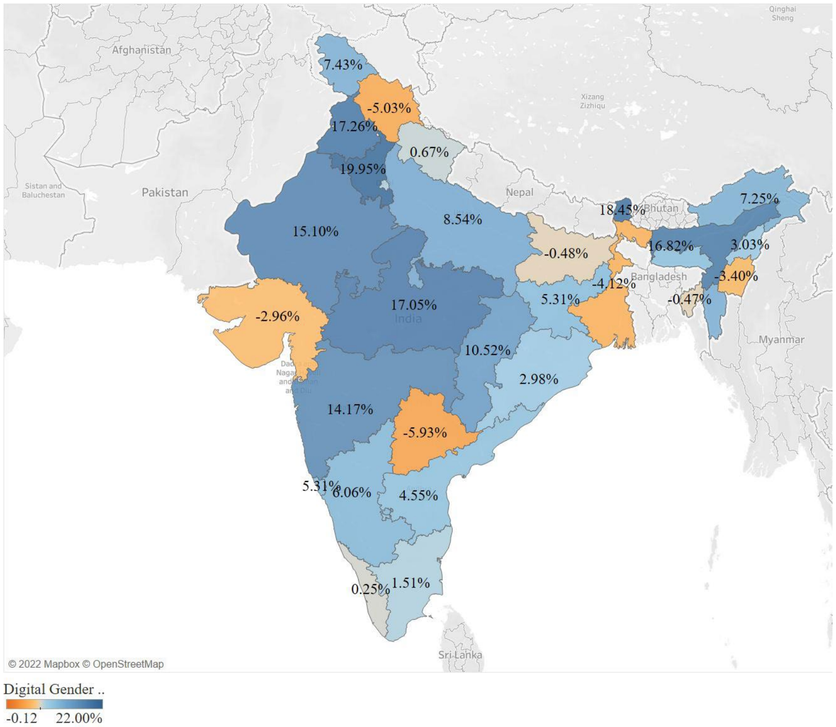


Figure 3: Urban Improvement in Digital Gender Gap

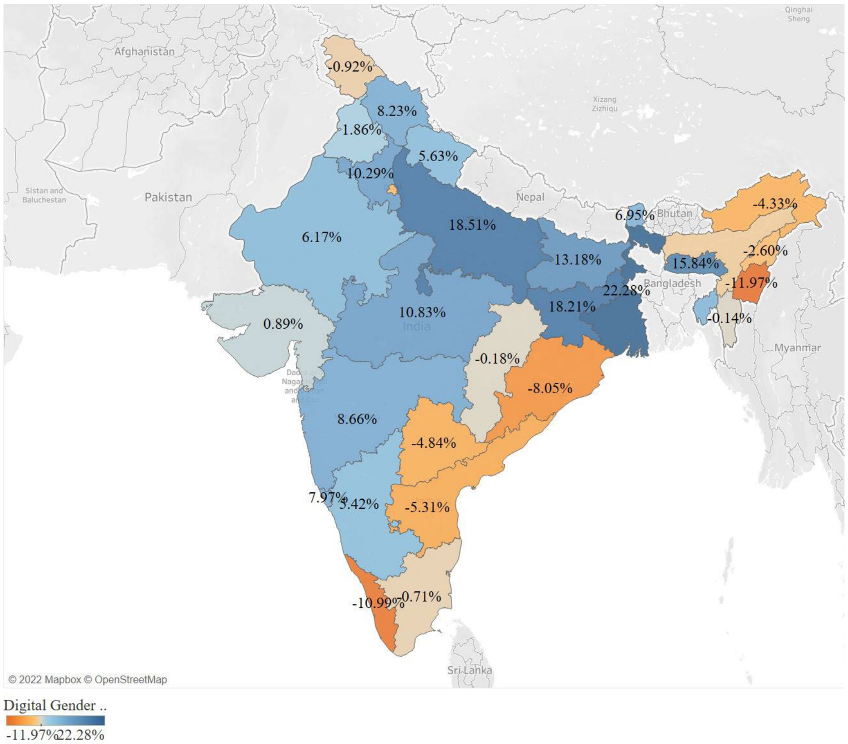


Figure 4: % of Women with access to Mobile Internet in 2015 – Total

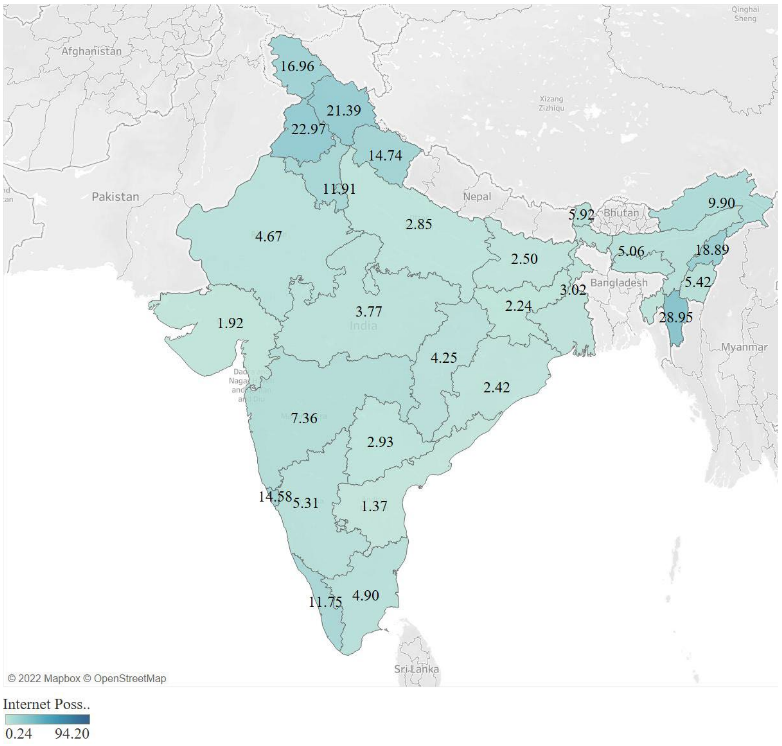


Figure 5: % of Women with access to Mobile Internet in 2020 – Total

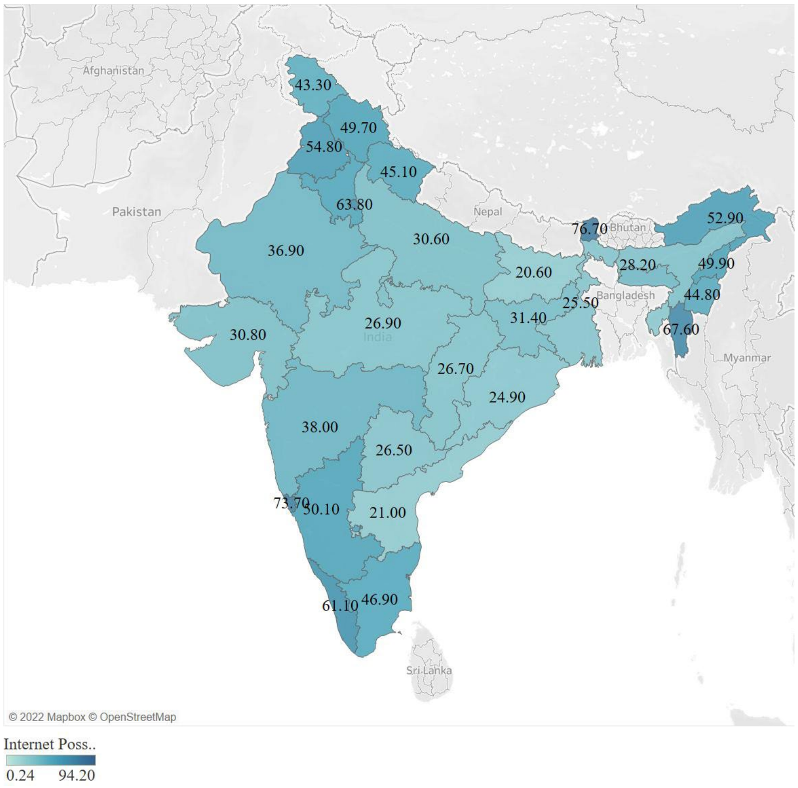


Figure 6: Digital Gender Gap Total 2015

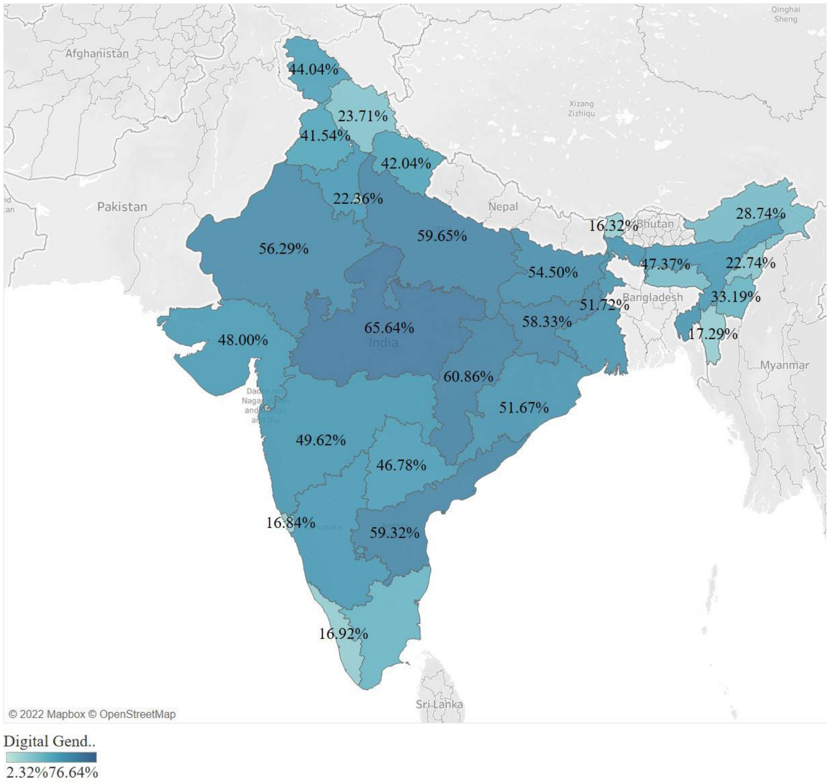


Figure 7: Digital Gender Gap Total 2020

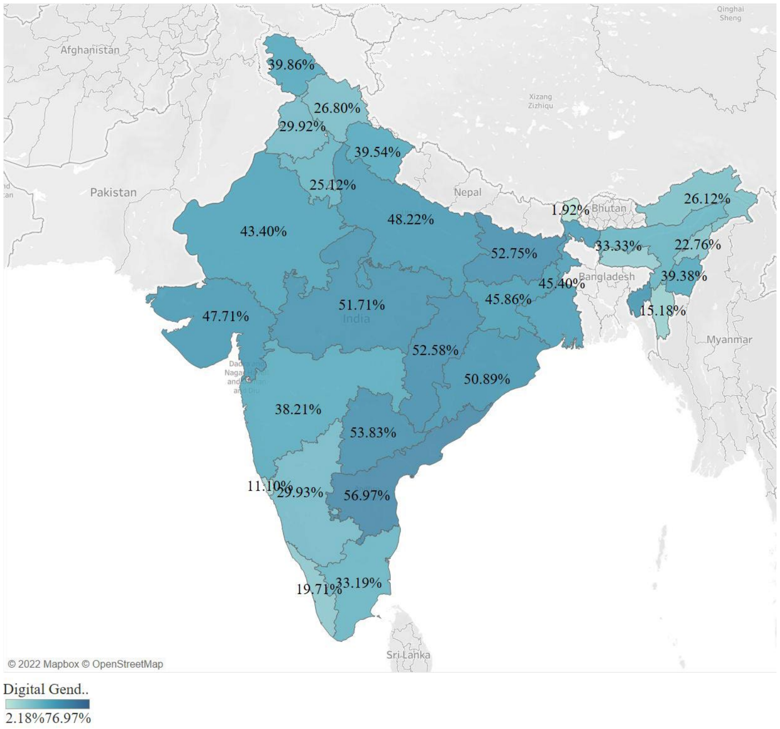


Figure 8: % of Women with access to Mobile Internet in 2015 – Rural

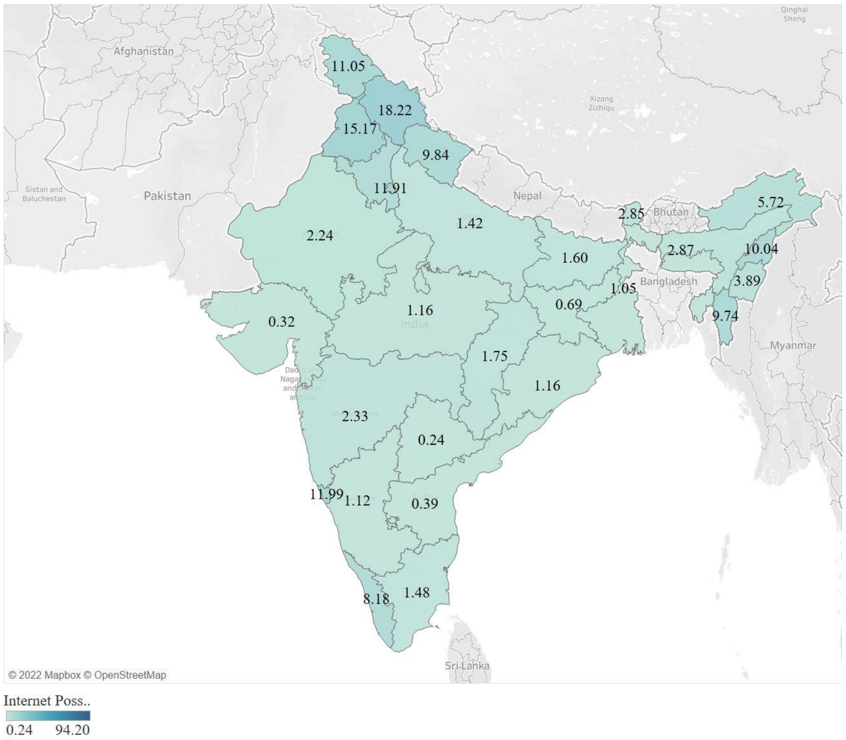


Figure 9: % of Women with access to Mobile Internet in 2020 – Rural

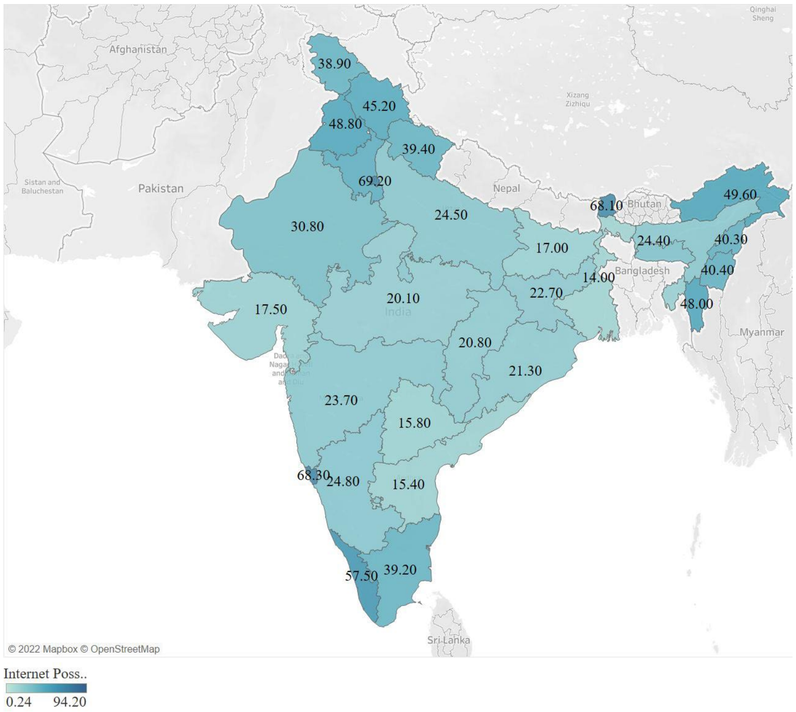


Figure 10: Digital Gender Gap in Rural Areas 2015

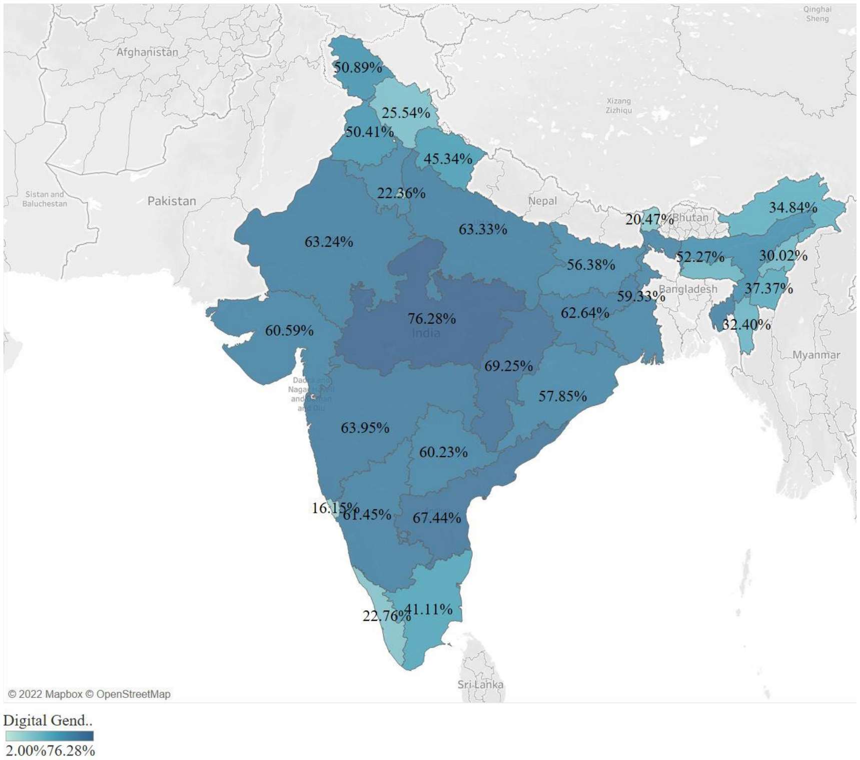


Figure 11: Digital Gender Gap in Rural Areas 2020

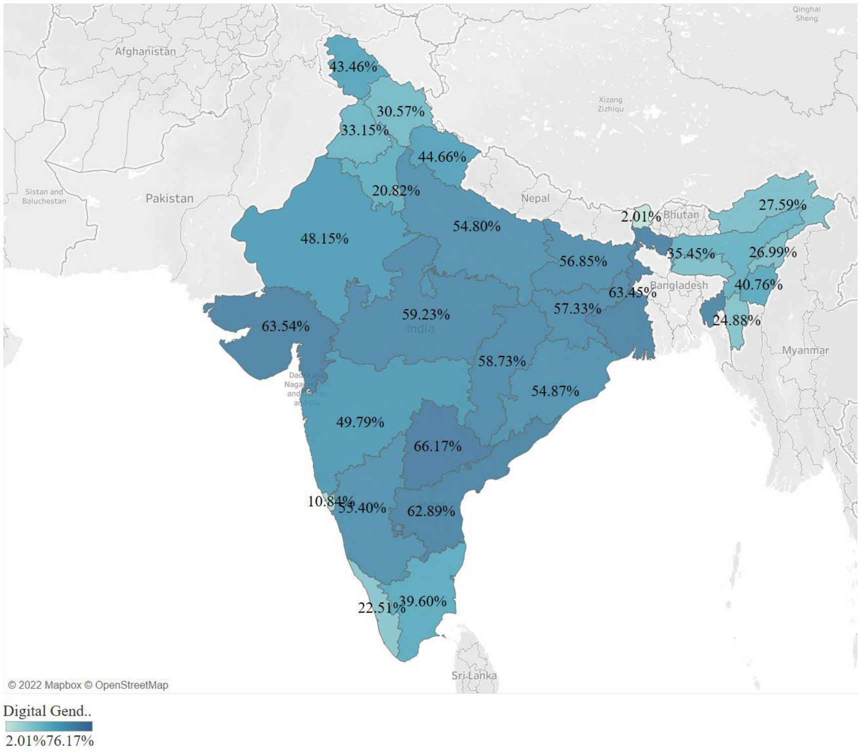


Figure 12: % of Women with access to Mobile Internet in 2015 – Urban

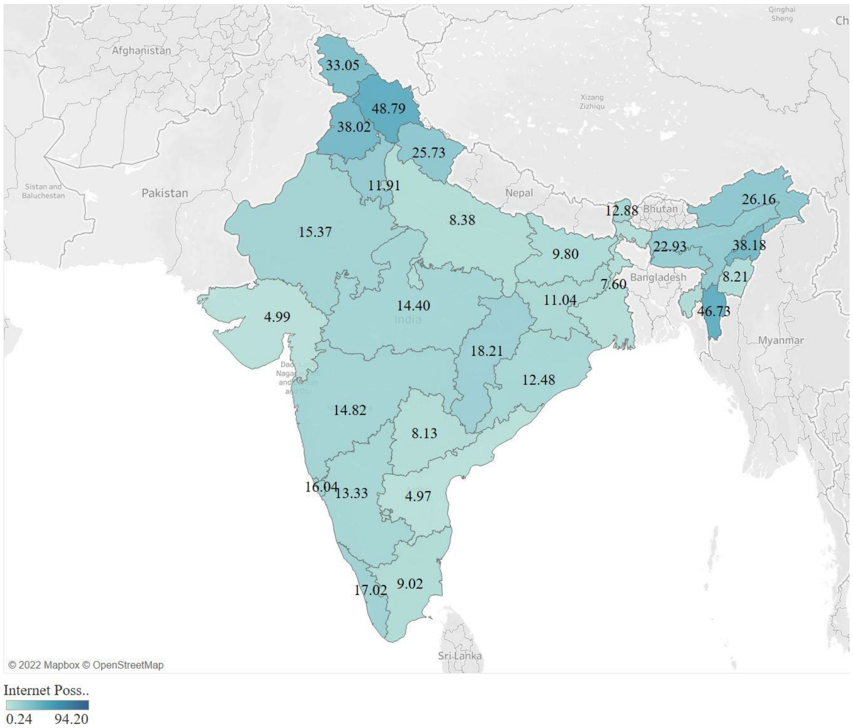


Figure 13: % of Women with access to Mobile Internet in 2020 – Urban

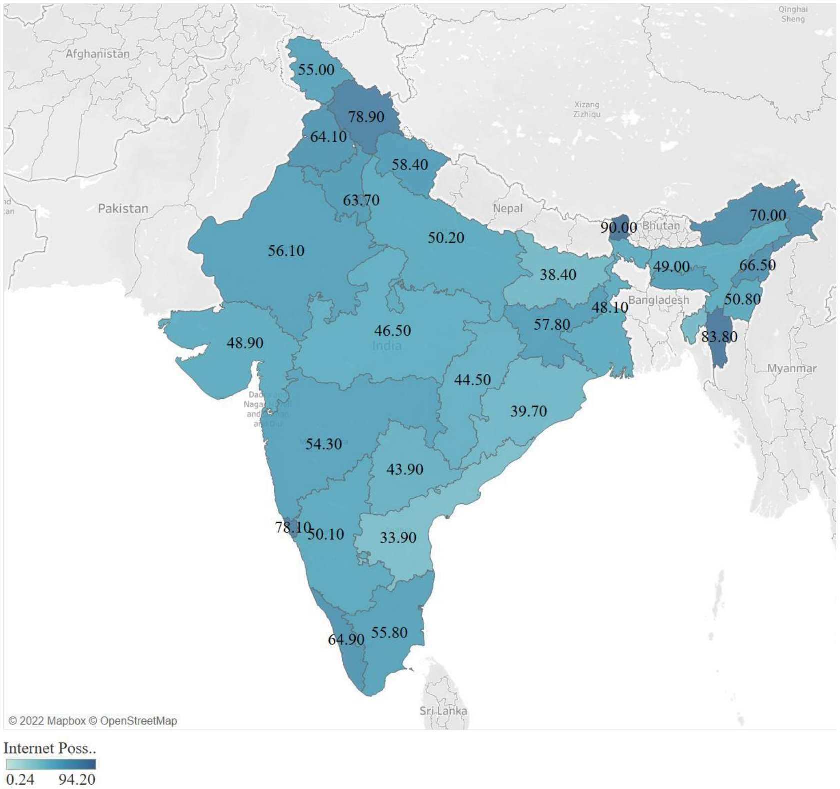


Figure 14: Digital Gender Gap in Urban Areas 2015

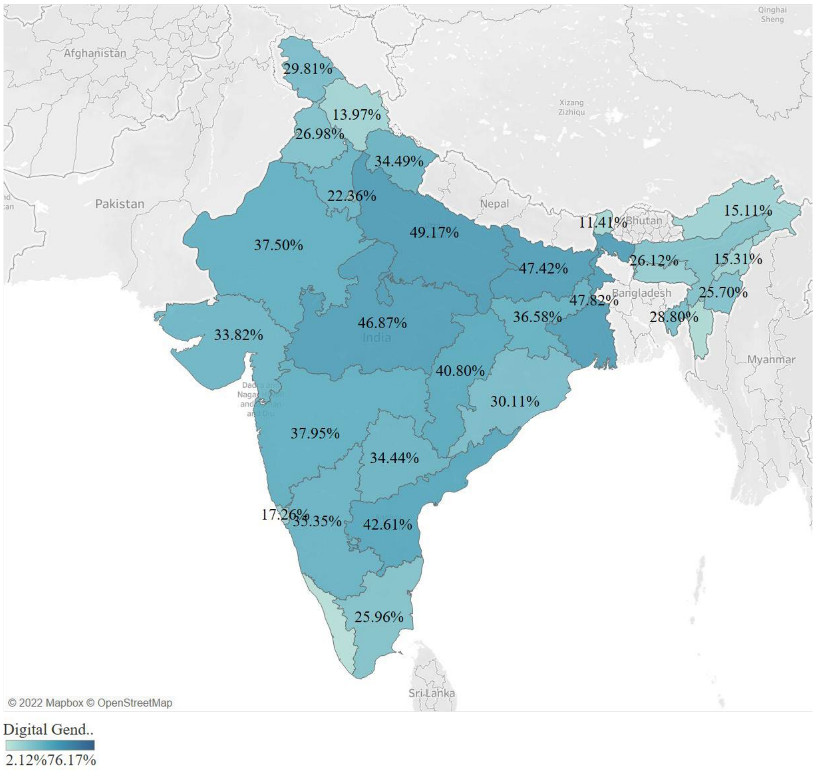


Figure 15: Digital Gender Gap in Urban Areas 2020

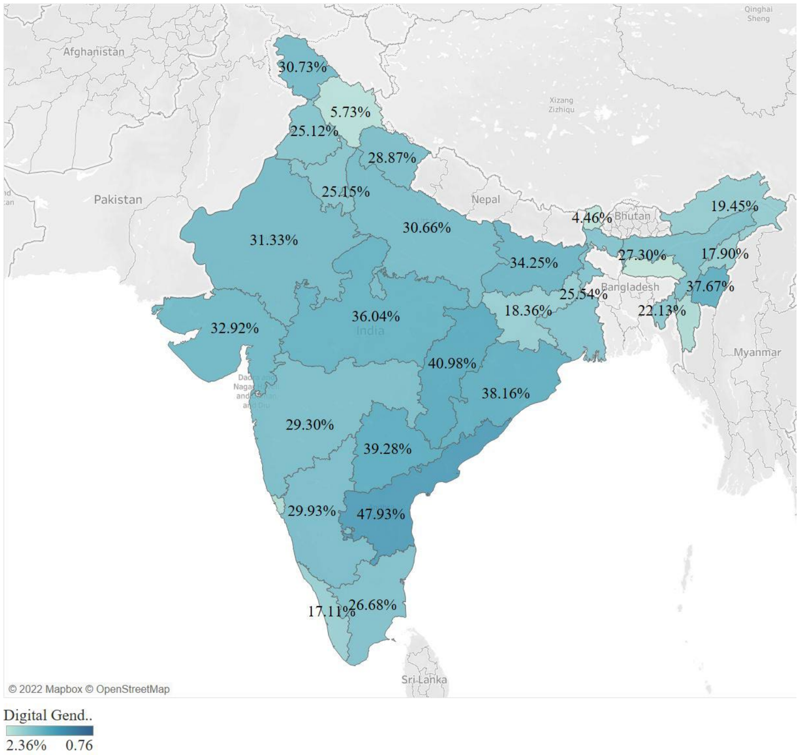


Figure 16: Trend of X: Improvement in Total Gender Gap Y: Jio Penetration

Figure 17: Trend of X: Improvement in Rural Gender Gap Y: Jio Penetration

Figure 18: Trend of X: Improvement in Urban Gender Gap Y: Jio Penetration

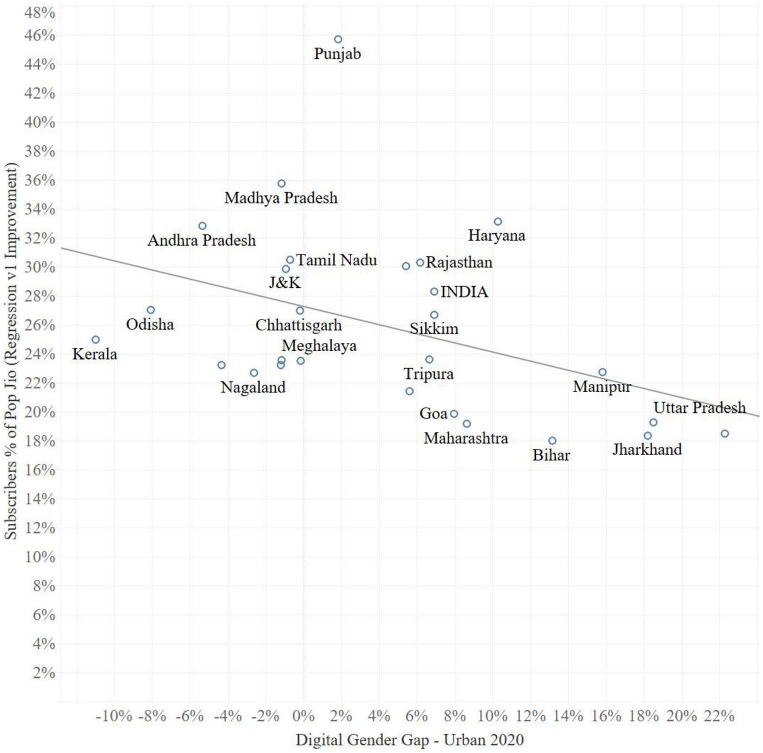
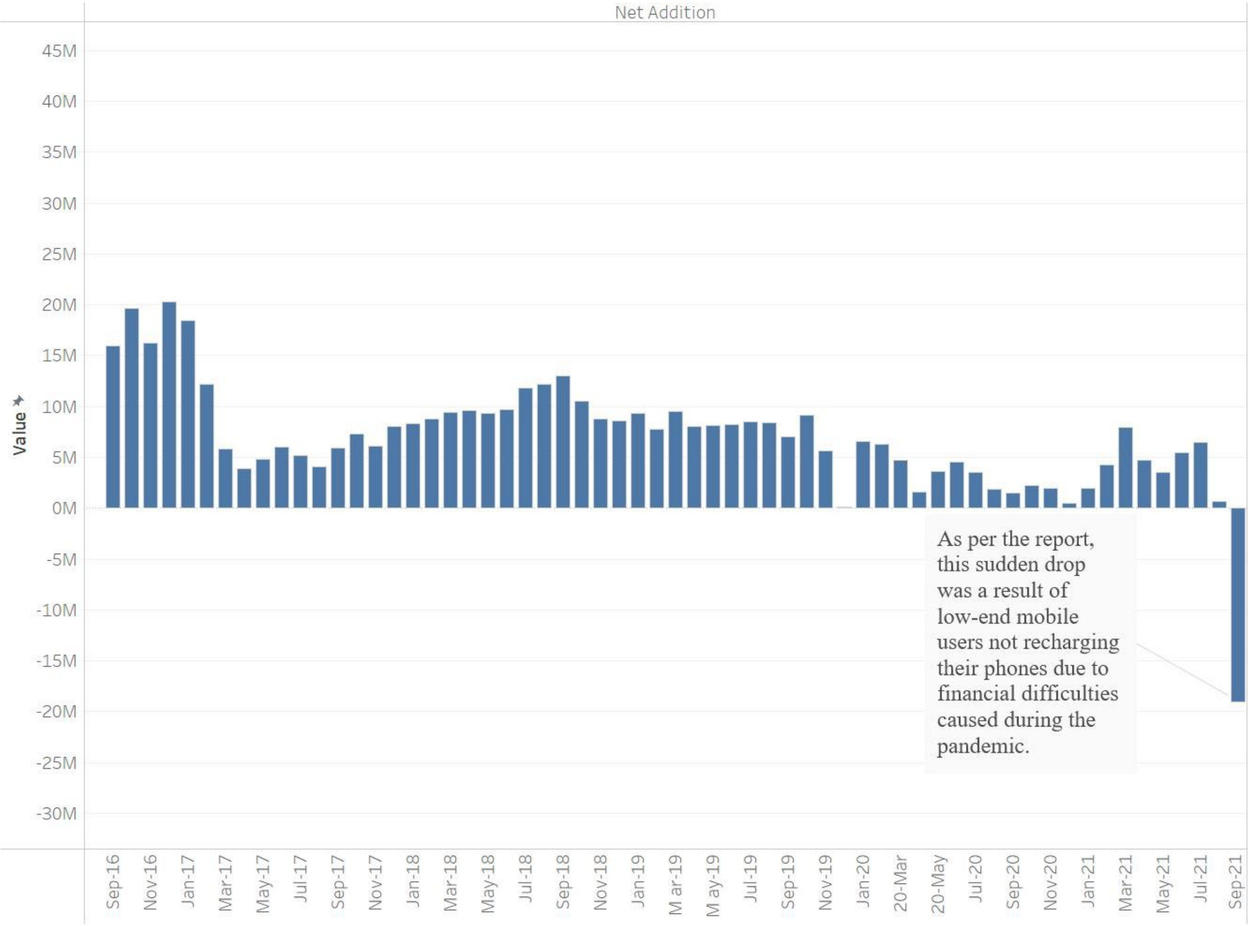
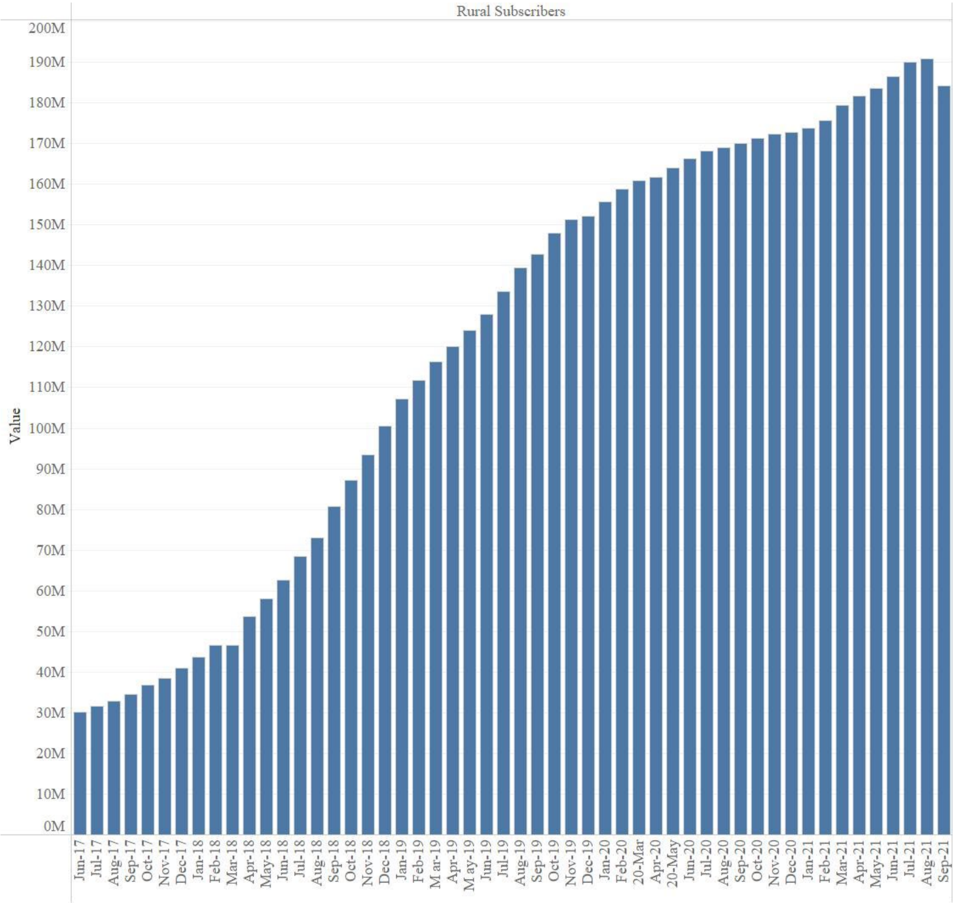


Figure 19: Net Additions to Jio's Rural Subscribers



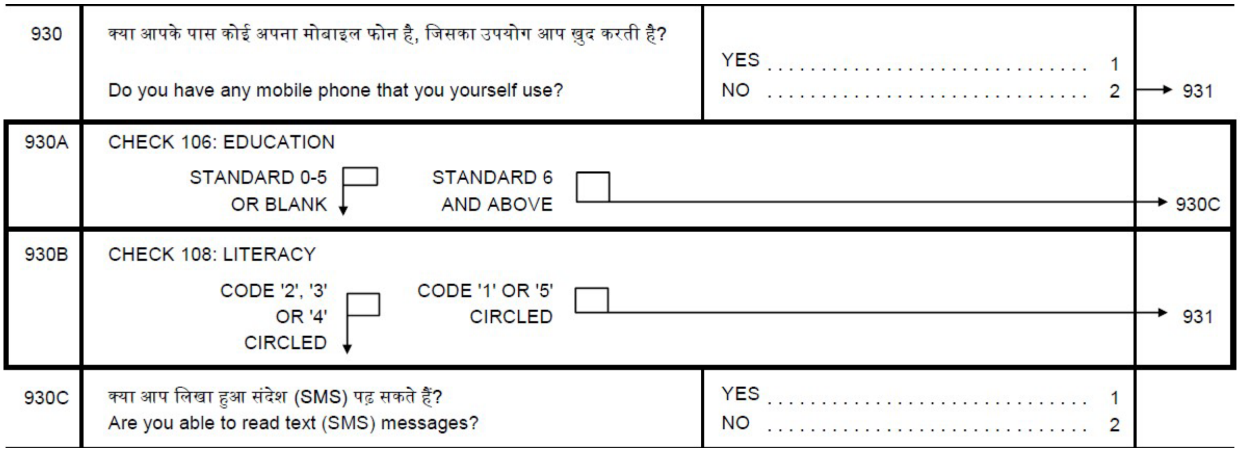
As per the report, this sudden drop was a result of low-end mobile users not recharging their phones due to financial difficulties caused during the pandemic.

Figure 20: Total Jio Rural Subscribers



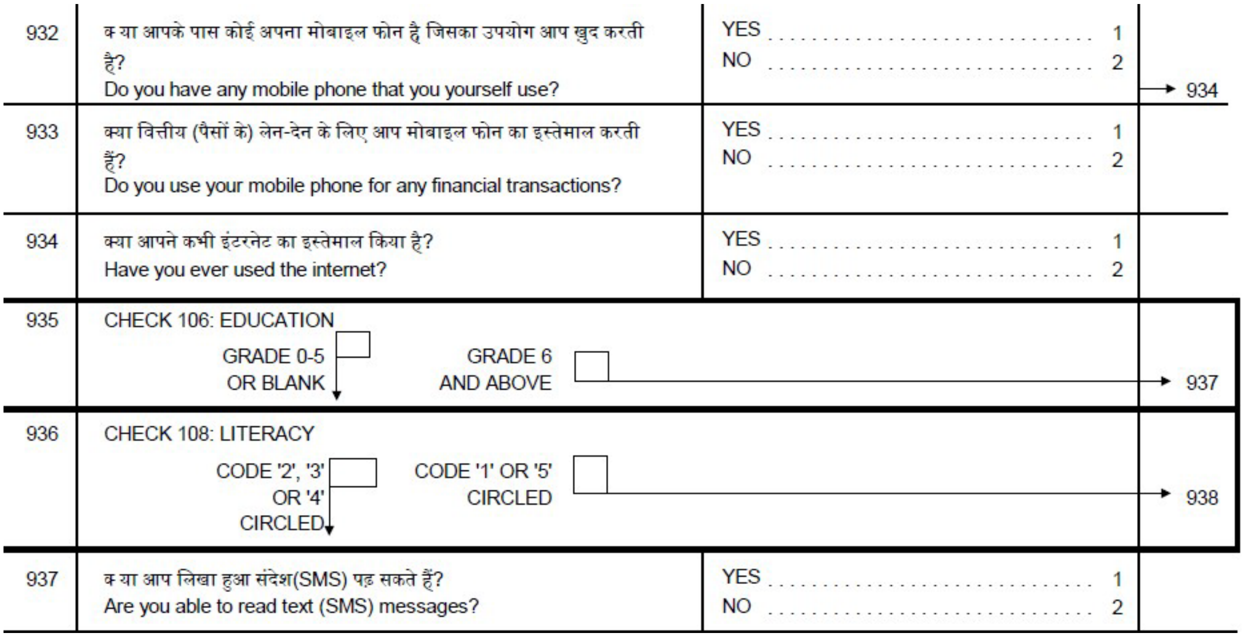
Appendix

Appendix A: NFHS 2015 Survey Women



930	क्या आपके पास कोई अपना मोबाइल फोन है, जिसका उपयोग आप खुद करती है? Do you have any mobile phone that you yourself use?	YES . . . . 1 NO 2	→ 931
930A	CHECK 106: EDUCATION STANDARD 0-5 OR BLANK ☐ STANDARD 6 AND ABOVE ☐		→ 930C
930B	CHECK 108: LITERACY CODE '2', '3' OR '4' CIRCLED ☐ CODE '1' OR '5' CIRCLED ☐		→ 931
930C	क्या आप लिखा हुआ संदेश (SMS) पढ़ सकते हैं? Are you able to read text (SMS) messages?	YES . . . . 1 NO 2	

Appendix B: NFHS 2020 Survey Women

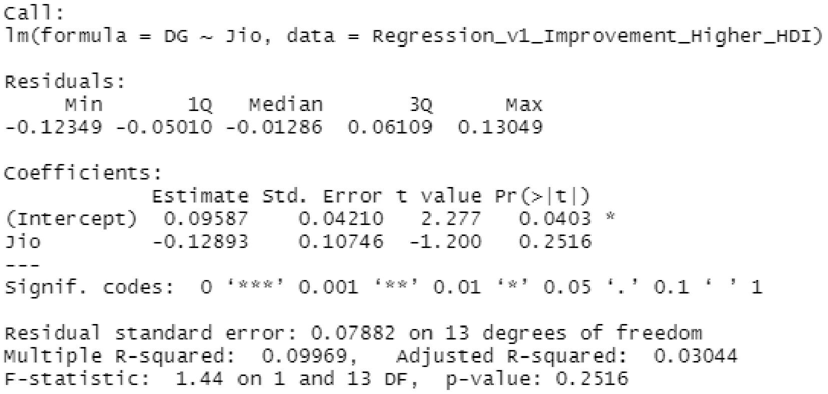


932	क या आपके पास कोई अपना मोबाइल फोन है जिसका उपयोग आप खुद करती है? Do you have any mobile phone that you yourself use?	YES . . . . 1 NO 2	→ 934
933	क्या वित्तीय (पैसों के) लेन-देन के लिए आप मोबाइल फोन का इस्तेमाल करती हैं? Do you use your mobile phone for any financial transactions?	YES . . . . 1 NO 2	
934	क्या आपने कभी इंटरनेट का इस्तेमाल किया है? Have you ever used the internet?	YES . . . . 1 NO 2	
935	CHECK 106: EDUCATION GRADE 0-5 OR BLANK ☐ GRADE 6 AND ABOVE ☐		→ 937
936	CHECK 108: LITERACY CODE '2', '3' OR '4' CIRCLED ☐ CODE '1' OR '5' CIRCLED ☐		→ 938
937	क या आप लिखा हुआ संदेश(SMS) पढ़ सकते हैं? Are you able to read text (SMS) messages?	YES . . . . 1 NO 2	

Appendix C: Women’s Improvement compared to Men’s: Internet Access Frameworks

Improvement in Men’s Access (2015-2020)	Improvement in Women’s Access (2015-2020)	% Improvement of Men/Women
47.25	28.29	167%
45.44	19.63	231%
57.71	43.00	134%
32.69	23.14	141%
38.10	18.10	211%
45.45	22.45	202%
69.85	51.89	135%
65.37	59.12	111%
55.21	28.88	191%
47.30	35.50	133%
39.87	28.31	141%
41.70	26.34	158%
52.62	29.16	180%
61.15	44.79	137%
61.96	49.36	126%
44.73	23.13	193%
46.89	30.64	153%
35.49	29.96	118%
65.79	39.38	167%
44.69	38.65	116%
40.15	31.01	129%
45.70	22.48	203%
38.91	31.83	122%
54.51	32.23	169%
71.13	70.78	100%
62.85	42.00	150%
51.90	23.57	220%
40.38	20.26	199%
52.04	27.75	188%
49.17	30.36	162%
40.44	22.48	180%

Appendix D: HDI Split Regression Results from R

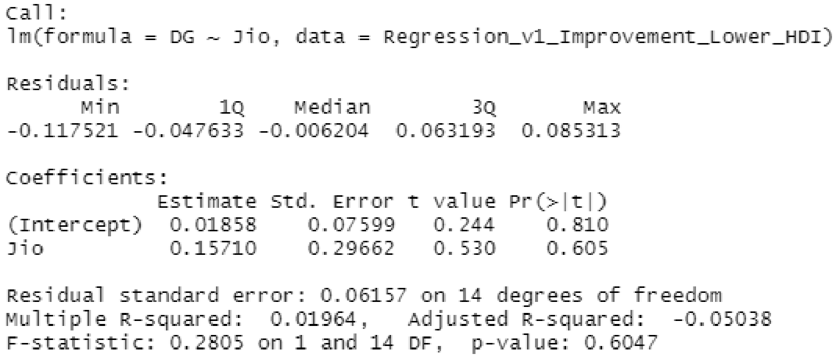


```
Call:
lm(formula = DG ~ Jio, data = Regression_v1_Improvement_Higher_HDI)

Residuals:
     Min       1Q   Median       3Q      Max 
-0.12349 -0.05010 -0.01286  0.06109  0.13049 

Coefficients:
            Estimate Std. Error t value Pr(>|t|)  
(Intercept)  0.09587    0.04210   2.277   0.0403 *
Jio         -0.12893    0.10746  -1.200   0.2516  
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.07882 on 13 degrees of freedom
Multiple R-squared:  0.09969,   Adjusted R-squared:  0.03044 
F-statistic:  1.44 on 1 and 13 DF,  p-value: 0.2516
```



```
Call:
lm(formula = DG ~ Jio, data = Regression_v1_Improvement_Lower_HDI)

Residuals:
      Min        1Q    Median        3Q       Max 
-0.117521 -0.047633 -0.006204  0.063193  0.085313 

Coefficients:
            Estimate Std. Error t value Pr(>|t|)
(Intercept)  0.01858    0.07599   0.244    0.810
Jio          0.15710    0.29662   0.530    0.605

Residual standard error: 0.06157 on 14 degrees of freedom
Multiple R-squared:  0.01964,   Adjusted R-squared:  -0.05038 
F-statistic: 0.2805 on 1 and 14 DF,  p-value: 0.6047
```

References

Agiakloglou and Yannelis—2006—Estimation of Price Elasticities for International.pdf. (n.d.). Retrieved November 19, 2021, from https://link.springer.com/content/pdf/10.1007/s11294-005-2279-3.pdf

Agiakloglou, C., & Yannelis, D. (2006). Estimation of Price Elasticities for International Telecommunications Demand. *International Advances in Economic Research*, *12*(1), 131–137. https://doi.org/10.1007/s11294-005-2279-3

Agiakloglou, C., & Yannelis, D. (2006). Estimation of Price Elasticities for International Telecommunications Demand. *International Advances in Economic Research*, *12*(1), 131–137. https://doi.org/10.1007/s11294-005-2279-3

American Community Survey reports - census.gov. (n.d.). Retrieved November 20, 2021, from https://www.census.gov/content/dam/Census/library/publications/2017/acs/acs-37.pdf?source=post_page---------------------------.

Amy Antonio and David Tuffley. 2014. The Gender Digital Divide in Developing Countries. Future Internet 6, 4 (Oct. 2014), 673–687. https://doi.org/10.3390/fi6040673

Andonova, V. (2006). Mobile phones, the Internet and the institutional environment.

Baliamoune-Lutz, M. (2003). An analysis of the determinants and effects of ICT diffusion in

Barreto, G., & Burga, R. (2014, February 1). The effect of internet and cell phones on employment and agricultural production in rural villages in Peru. Pirhua. Retrieved November 24, 2021, from https://pirhua.udep.edu.pe/handle/11042/1902.

Bhandari, Aarushi. (n.d.). Gender inequality in mobile technology access: the role of economic and social development. *Information, communication & society*. Routledge.

Christos Agiakloglou & Demetrius Yannelis, 2006. "**Estimation of Price Elasticities for International Telecommunications Demand**," International Advances in Economic Research, Springer;International Atlantic Economic Society, vol. 12(1), pages 131-137, February.

Deo, A. (2017). *Telecom Industry in India: Evolution, Current Challenges & Future Road Map*. 14.

developing countries. *Information Technology for Development*, *10*(August 2002), 151–169.

Echávarri, R. A., & Ezcurra, R. (2010). Education and gender bias in the sex ratio at birth: evidence from India. *Demography*, *47*(1), 249–268. https://doi.org/10.1353/dem.0.0089

EIU inclusive internet index. EIU Inclusive Internet Index. (n.d.). Retrieved December 10, 2021, from https://theinclusiveinternet.eiu.com/.

Fatehkia, M., Kashyap, R., & Weber, I. (2018, March 20). *Using facebook ad data to track the global digital gender gap*. World Development. Retrieved November 15, 2021, from https://www.sciencedirect.com/science/article/pii/S0305750X18300883#:~:text=With%20the%20online%20model%20using,lower%20than%20that%20for%20males.

Fusilier, M., & Durlabhji, S. (2008). Fs of student Internet use: Data from three developing countries. *Learning, Media and Technology*, *33*(1), 59–69. https://doi.org/10.1080/17439880701868903

Fusilier, M., & Durlabhji, S. (2008). Predictors of student Internet use: Data from three developing countries. *Learning, Media and Technology*, *33*(1), 59–69. https://doi.org/10.1080/17439880701868903

GDP per capita (current US$) - India. Data. (n.d.). Retrieved November 15, 2021, from https://data.worldbank.org/indicator/NY.GDP.PCAP.CD?end=2020&locations=IN&start=1960&view=chart.

Ghosh, S. (2020, July 14). *How the 'jio effect' brought millions of Indians online and is reshaping Silicon Valley and the internet*. Business Insider. Retrieved November 15, 2021, from https://www.businessinsider.com/reliance-jio-millions-of-indians-online-reshaped-internet-2019-8.

Gulati, G. J., & Yates, D. J. (2012). Different paths to universal access : The impact of policy and

Hanna, N. K. (Ed.). (2016). Mastering digital transformation: Towards a smarter society, economy, city and nation. In Mastering Digital Transformation: Towards a Smarter Society, Economy, City and Nation. Emerald Group Publishing Limited.

Herbert, S. (2017). Digital development and the digital gender gap. K4D Helpdesk Report. Brighton, UK: Institute of Development Studies.

How Asia's richest man won the mobile data price war in India. (2020, July 15). Rest of World. https://restofworld.org/2020/how-india-mobile-data-became-worlds-cheapest/
https://doi.org/10.1002/itdj.1590100303
Jha et al., "Techno-economic assessment of the potential for LTE based 4G mobile services in rural India", *IEEE ANTS*, pp. 1-6, 2015.

Jio Lost 1.1 Crore Users In September 2021 Quarter, First Time In 30 Months. (2021, October 26). IndiaTimes. https://www.indiatimes.com/technology/news/jio-lost-11-million-users-552620.html

Jitmaneeroj, Boonlert. (n.d.). Beyond the equal-weight framework of the Social Progress Index: Identifying causal relationships for policy reforms. *International journal of social economics*. Emerald Group Publishing, Ltd.

Kapoor, A., & Yadav, C. (2018, April 2). *Impact of reliance's entry*. Institute for Competitiveness. Retrieved December 10, 2021, from https://competitiveness.in/impact-of-reliance-entry/.

Kashyap, R., Al Tamime, R., Fatehkia, M., & Weber, I. (2019, October). *Monitoring Digital Gender Inequality using Facebook and Google Advertising Audience Estimates*. Retrieved December 10, 2021, from https://data2x.org/wp-content/uploads/2019/11/Monitoring-Digital-Gender-Inequality_FB-Google.pdf.

Kefela, G. T. (2011). The impact of mobile phone and economic growth in developing countries. *African Journal of Business Management*, *5*(2), 269–275. https://doi.org/10.5897/AJBM09.367

Kefela, G. T. (2011). The impact of mobile phone and economic growth in developing countries. *African Journal of Business Management*, *5*(2), 269–275. https://doi.org/10.5897/AJBM09.367

Kenny, C. J. (2000). Expanding Internet access to the rural poor in Africa. *Information Technology for Development*, *9*(1), 25–31. https://doi.org/10.1080/02681102.2000.9525318

Khalil, M., Qadir, J., Onireti, O., Imran, M. A., & Younis, S. (2017). Feasibility, architecture and cost considerations of using TVWS for rural Internet access in 5G. *2017 20th Conference on Innovations in Clouds, Internet and Networks (ICIN)*, 23–30. https://doi.org/10.1109/ICIN.2017.7899245

Kumar, S. K. A., Ihita, G. V., Chaudhari, S., & Arumugam, P. (2022). A Survey on Rural Internet Connectivity in India. *2022 14th International Conference on COMmunication Systems NETworkS (COMSNETS)*, 911–916. https://doi.org/10.1109/COMSNETS53615.2022.9668358

Lopez-Sintas, Jordi ; Lamberti, Giuseppe ; Sukphan, Jakkapong. (n.d.). The social structuring of the digital gap in a developing country. The impact of computer and internet access opportunities on internet use in Thailand. *Technology in society*. Elsevier Ltd.

More than 3.5 billion left in the dark: Why we’re still fighting to reach U.N. targets for internet access. (2020, November 5). *Access Now*. https://www.accessnow.org/internet-access/

Mukherjee, R. (n.d.). *Jio sparks disruption 2.0: Infrastructural Imaginaries and platform ecosystems in 'Digital India' - rahul mukherjee, 2019*. SAGE Journals. Retrieved December 10, 2021, from https://journals.sagepub.com/doi/full/10.1177/0163443718818383.

Nielsen featured insights. (n.d.). Retrieved November 16, 2021, from https://www.qa.nielsen.com/wp-content/uploads/sites/3/2019/04/FI-Multi-SIM-adoption.pdf.

Norris, P. (2001). Digital divide: Civic engagement, information poverty, and the internet worldwide. Cambridge University Press.

Ovando, C., Pérez, J., Moral, A.: LTE techno-economic assessment: The case of rural areas in Spain. Telecomm. Policy. 39, 269–283 (2015).

Perrigo, B. (2018, September 28). *What to know about Aadhaar, India's biometric identity system*. Time. Retrieved November 15, 2021, from https://time.com/5409604/india-aadhaar-supreme-court/.

Prahalad, C. K. The Fortune at the Bottom of the Pyramid : Eradicating Poverty through Profits. Upper Saddle River, N.J. :Wharton School Pub., 2010.

Published by Statista Research Department, & 10, S. (2021, September 10). *Facebook users by country 2021*. Statista. Retrieved November 16, 2021, from https://www.statista.com/statistics/268136/top-15-countries-based-on-number-of-facebook-users/.

Qiang, C. Z.-W., Clarke, G. R., & Halewood, N. (2006). Information and communications for development: Global trends and policies. Washington, DC:

Rustagi, P. (2004). Significance of Gender-related Development Indicators: An Analysis of Indian States. Indian Journal of Gender Studies, 11(3), 291–343.

Sawadogo, F. (2021). Demand price elasticity of mobile voice communication: A comparative firm level data analysis. *Information Economics and Policy*, 100939. https://doi.org/10.1016/j.infoecopol.2021.100939

Sen A, Anand S. Human Development Index: Methodology and Measurement. New York: Human Development Report Office Occasional Paper 12; 1994.

Sridhar, Kala Seetharam and Sridhar, Varadharajan, Telecommunications Infrastructure and Economic Growth: Evidence from Developing Countries (August 23, 2008). Applied Econometrics and International Development, Vol. 7, No. 2, 2007, Available at SSRN: https://ssrn.com/abstract=1250082

Strahan, R. F., & Hansen, C. J. (1978). Underestimating Correlation from Scatterplots. Applied Psychological Measurement, 2(4), 543–550. https://doi.org/10.1177/014662167800200409

Telecom Industry in India. (n.d.). Retrieved November 14, 2021, from https://www.ibef.org/industry/telecommunications.aspx
Telecommunications Policy, *30*(1), 29–45. https://doi.org/10.1016/j.telpol.2005.06.015
Telecommunications Policy, *36*(9), 749–761. https://doi.org/10.1016/j.telpol.2012.06.013

The rise and fall of Anil Ambani's Reliance Communications https://www.businessinsider.in/business/news/the-rise-and-fall-of-anil-ambanis-reliance-communications/articleshow/74596156.cms

The state of mobile internet connectivity 2021 - gsma.com. (n.d.). Retrieved April 7, 2022, from https://www.gsma.com/r/wp-content/uploads/2021/09/The-State-of-Mobile-Internet-Connectivity-Report-2021.pdf

TRAI. (n.d.). *Measures to Improve Telecom Penetration in Rural India – The next 100 million subscribers*. Retrieved December 16, 2008.

TV white spaces exploration for cognitive radio: Taxonomy and research issues. (n.d.). Springerprofessional.De. Retrieved March 28, 2022, from https://www.springerprofessional.de/en/tv-white-spaces-exploration-for-cognitive-radio-taxonomy-and-res/18094486

Tyers-Chowdhury, A., & Binder, G. (2020, October). *Using big data for insights into the gender digital divide ...* Retrieved December 10, 2021, from

Uidai. (n.d.). *Features of Aadhaar - Unique Identification Authority of India: Government of India*. Unique Identification Authority of India | Government of India. Retrieved November 15, 2021, from https://uidai.gov.in/my-aadhaar/about-your-aadhaar/features-of-aadhaar.html.

Viranch Damani, "5 Challenges for Netflix in India," TechPP, January 7, 2016, accessed September 29, 2016,

World Bank.

Yaacoub, E., & Alouini, M.-S. (2020). A Key 6G Challenge and Opportunity—Connecting the Base of the Pyramid: A Survey on Rural Connectivity. *Proceedings of the IEEE*, *108*(4), 533–582. https://doi.org/10.1109/JPROC.2020.2976703