DISSERTATION

THREE ESSAYS ON LABOR, GENDER AND DEVELOPMENT

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ABSTRACT

THREE ESSAYS ON LABOR, GENDER AND DEVELOPMENT

In my PhD dissertation, I write three research essays on labor, gender and development in India. These essays are based on applied economic research and use longitudinal data estimation techniques. These essays relate to my overall interest in topics surrounding inadequate access to basic infrastructures–electricity, water and credit–and their impact on gender inequities, development opportunities, health, education and labor force participation in India. The first essay focuses on informal finance and women empowerment from an economic and non-economic standpoint. The second essay examines reliable electrification and gender differences in employment, health and household decision making. The third chapter discusses access to piped water and gender differences in employment, health, education and household decision making.

The first essay titled, *Friends and Benefits? Rotating Savings and Credit Associations as Alternative for Women's Empowerment in India*, co-authored with Ramaa Vasudevan and Anita Alves Pena, builds on a theoretical model of Rotating Savings and Credit Associations (ROSCAs). In informal social and financial organizations like ROSCAs, members contribute to a common pot of money that is awarded to a different member at each meeting randomly or through a bid. This study examines the effects of ROSCA on women's socio-economic freedom and autonomy at the national level in India. We compare ROSCAs to agency based micro-credit schemes and analyze their effects using nationally representative longitudinal gender-disaggregated data from 2005-2012. Building on a theoretical model of household savings and spousal bargaining power, we use individual fixed effects and instrumental variable regressions to test the theoretical predictions. Among others, results show that ROSCA membership increases the likelihood of women's cash in hand for expenditure by 1.7 percentage points, say in major purchase decisions by 3.9 percentage points and fertility choice by 4.7 percentage points. These margins exceed those for exogenous

micro-credit schemes and are robust to sensitivity tests. This study is the first to contrast ROSCAs with other micro-credit schemes at the national level. We propose scaling up and associating long-standing ROSCAs with self-help groups for more inclusive development.

The second essay titled, *Does Reliable Electrification Reduce Gender Differences: Evidence from India*, co-authored with Ramaa Vasudevan, Anita Alves Pena and Ray Miller, looks at the issue of the lack of reliable electrification in India despite massive improvements in electricity access in the past decade. We argue that reliable electricity could reduce the time allocated to home production thereby increasing labor market participation, more for women than men. This essay is purely empirical in nature and revolves around the issue of electrification and gender differences in India. We analyze the effect of quality of electricity on gender differences using a comprehensive set of labor and non-labor market outcomes in India viz. labor force participation (usual status and usual principal status of employment), fuel and water collection, decision making for women and choices of fuel and energy for the household. Using the temporal variation in household electricity hours from the India Human Development Survey (2005-2012), we use individual fixed effects and instrumental variables regressions. Our analysis reveals contrasting trends with significant progress at the extensive margin of electricity access, but little progress at the intensive margin of quality, hours of electricity. We find that reliable electrification improves socio-economic status of women relative to men through increased employment opportunities and reduced time allocation to home production. For instance, 10 more hours of electricity increases the likelihood of employment in the 'usual status' by 2.1 pp for men, and 3.9 pp for women. The study recommends considering electricity as a right, and as part of the broader strategy for reducing gender disparities in India.

The third essay titled, *Who Benefits from Piped Water? Evidence from a Gendered Analysis in India* looks at the effect of access to piped water on employment in farm work, wage/salary work, work days, earnings, health and education outcomes by gender in India. Developing countries, including India, have made impressive progress in providing households with piped water in the last two decades. Yet, access and quality of water available for daily use remains very low. Given the disproportionate burden of home production, the 'hidden' agricultural labor of women,

and the fact that India has inadequate access to clean water for daily use, intra-household labor and health inequality could be larger in the absence of piped water access. The disproportionate burden on women of water collection and distribution in the household in developing economies calls for a study on the relationship between piped water supply and gender differences in employment, women's health, child health and education. I use spatiotemporal data from the largest gender disaggregated human development survey in India, 2005–2012, and carry out econometric analyses using individual fixed effects, village fixed effects and instrumental variable regressions to evaluate the effects. Results show that household access to piped water increases the likelihood of wage/salary employment by 11 percent, and annual earnings increase by 14 percent for women, comparatively higher than men, but only in rural areas. In urban areas, there is no effect of pipe water on women's employment. With piped water, women's self-reported health improves; child's health and education outcomes also improve. The study recommends evaluating the social demand curve for piped water supply, and the consideration of piped water supply as necessity, as part of a broader strategy to reduce gender differences and minimize poverty.

Overall, these essays are motivated by the lack of emphasis and policy action on micro-credit and basic infrastructures for the poor and the disadvantaged, especially in rural India. Therefore, all three papers in this dissertation provide policy recommendations to problems of India's economic development relating to gender inequity, marginalization, unemployment, education and health, which thread the three essays together.

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Thank you to everyone who supported my endeavor to work on economic issues facing historically marginalized communities. I wish to thank all women who spared time to have a conversation about ROSCAs in Manipur. This work is influenced by the struggles of all those who start their journeys from a disadvantaged position. It is these lived realities that I seek to make visible and hope that it influences policy making towards a just future and an equitable society. I hope this dissertation honors the histories of the struggles, and that it is used to serve the people to whom it may concern.

DEDICATION

I would like to dedicate this thesis to all first generation students.

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Chapter 1

Friends and Benefits? Rotating Savings and Credit Associations as Alternative for Women's Empowerment in India

1.1 Introduction

Women's financial inclusion has been widely promoted as a key driver of the Sustainable Development Goals (SDG) (Fukuda-Parr, 2018).[1] It has been linked with faster and more inclusive economic growth in developing economies (Hendriks, 2019; Hossein, 2018), underscoring the financial role of women in poor households as they tend to spend more for the collective good of the family, and save more than their husbands (Anderson and Baland, 2002; Ashraf, 2009). In this context, there is widespread debate on the performance of micro-credit programs toward enhancing women's agency, access and control over economic resources and participation in household, social and political decision-making processes (Ngo and Wahhaj, 2012; World Bank, 2013). However, contrary to expectations, the history of agency led micro-credit has been disappointing. Explosive global growth in commercially driven micro-credit schemes pushed by central and state governments, especially in South Asia have been found to be exploitative and profit driven (Fultz and Francis, 2013).

In this context, faults in the existing structures of agency-based micro-credit schemes in developing economies cannot sidestep the significance of micro-credit for women. Exogenous agency and state based micro-credit structures understate the micro evidence of successful informal credit associations, and the potential impacts endogenous savings and credit association have on women (Ardener, 1964; Mayoux, 2002; Hossein, 2018). Hence, there is an pertinent need to explore

[1] This article has been published in the World Development Journal as a co-authored work with Ramaa Vasudevan and Anita Alves Pena.

endogenous savings and credit systems formed within a community (Mayoux, 2005), where the source of finance comes from members and not from outside, volumes involved are manageable and the rents of financial intermediation remain in the hands of the members (Rutherford, 2014). The crisis of micro-credit schemes highlight the importance of savings and credit systems that need to be self-sustaining, bottom-up and localized, bypassing the vulnerabilities of exogenous micro-credit structures (Acquah and Dahal, 2018; Rutherford, 2014). There is evidence that women in developing economies have formed and relied on a myriad of informal endogeneous financial institutions and structures to address their financial exclusion (Ardener and Burman, 1995; Ksoll et al., 2016).

One of the most well-known is perhaps the category of Rotating Savings and Credit Associations (ROSCAs)[2]. Many researchers have highlighted the positive impact of these associations on women's autonomy (Mayoux, 2005; Anderson and Baland, 2002; Rammohan and Johar, 2009; Rutherford, 2014). In many contexts, they are considered to be the optimal saving strategy for unbanked women (Anderson and Baland, 2002), but have received very little policy attention (Rutherford, 2014). In others, ROSCAs have aided in economic reconstruction after financial crisis in Indonesia in 1998 (Acquah and Dahal, 2018), natural disasters such as the Tsunami in India in 2004 (Czura and Klonner, 2018), and could be useful during a pandemic, such as COVID-19 in 2020, when banking facilities are restrained by the lack of knowledge and awareness of internet banking facilities and physical access to the bank, especially for the vulnerable population.

Despite the micro evidence of the benefits women derive through ROSCAs, an examination of the impact of ROSCAs and its comparison with other micro-credit schemes from a policy perspective has remained elusive due to the lack of a nationally representative study. Earlier studies

[2]ROSCAs worldwide have over 1 billion members (Bisrat et al., 2012). In China, they are called Hui. In India, they are broadly called Chit Funds or *Kamethis* (Ardener and Burman, 1995). In Latin America, they are called Tanda. In Mexico, they are called Cundina (Hossein, 2018). In Ethiopia they are called Equb, Stovkel in South Africa, Osusu or Adashi in Nigeria and Liberia, Jangi in Cameroon, Sanduk ou gameya in Sudan, Tontine in Congo Kinshasa, Hui in Vietnam, Kye in Korea, Bisi in Pakistan, Tontines in much of francophone Africa, Gamias in Egypt, Susu in Ghana, Njangis in Cameroon, Upatu in Tanzania, Chilemba in East Africa, Arisan in Indonesia, Pia Huey in Thailand, Ko in Japan and Kye in Korea. Bolivians know them as Pasanakus. They also are prevalent in North America, Germany and Austria (Reito, 2019).

in developing countries have documented both positive and negative effects of ROSCAs; however, most of the studies have been qualitative in nature or geographically limited and have largely ignored socio-cultural variations in the country that might influence the effectiveness of ROSCA programs. To test the effectiveness of ROSCAs at the national level and to gain deeper understanding of women empowerment through micro-credit, this study posits a 'within community endogenous' ROSCA model and its effects on women's socio-economic freedom, agency, mobility and decision making ability (Calomiris and Rajaraman, 1998; Singh and Cready, 2015; Smets, 2000). The objective is to study the impact of ROSCAs using the novel framework laid down by Kabeer (2001) in defining a woman's autonomy: (i) economic freedom, referring to women's ownership, control and decision making ability over economic resources, allocation and labor supply, (ii) agency in household decision making ability and reproductive freedom, (iii) mobility, in terms of freedom to travel alone.

We use India Human Development Survey (IHDS), and focus on the 2012 data of women's membership in ROSCAs with 41,255 household observations. The study uses Ordinary Least Squares, Two Stage Least Squares instrumental variables and panel instrumental variable regressions with geographic instrumental variables (Fang, 2003), average village level[3] level membership in ROSCAs as an instrument along with regional and cultural controls. We use principal component analyses of nineteen empowerment variables to aggregate into five focal empowerment indices. The effect of ROSCA participation is assessed and compared to membership in NGOs, loans from NGOs, membership in Self Help Groups (SHGs) and loans from group lending. We examine the differences in the magnitude of the effect of the endogenous (ROSCAs) and the exogenous (all others) micro-credit schemes. We find strong positive effect of ROSCAs on all women empowerment indices at the national level with differing magnitudes. ROSCAs are more effective than other micro-credit schemes and provide stronger intra household bargaining opportunities for

[3]The data used in the study has observations from both rural and urban areas. We denote the regional aggregation of participation through villages in rural areas and through Primary Sampling Units (PSUs) in urban areas (Desai and Vanneman, 2018).

women in terms of economic decision making, economic freedom, mobility, agency and household decision making processes.

Section 2 outlines the structural differences between endogenous and exogenous models of credit. Section 3 discusses micro-credit models, especially ROSCAs in the context of India, and compares micro-credit models in India using the available literature. Section 4 presents the methodology with theoretical and empirical model of ROSCA membership and its effect on women's bargaining power. Section 5 presents the empirical results. Section 6 concludes.

1.2 Endogenous and Exogenous Micro-Credit Schemes

Existing literature suggests that exogenous agency-led group liability based micro-credit schemes in developing economies, are complex in structure (Goetz and Gupta, 1996) and impulsive in credit delivery (Fultz and Francis, 2013) driven by profit motives (Mayoux, 2002), and lack dynamism to continuously include women into a network of sustainable finance (Mayoux, 2005). The famous Grameen loan model and the cash transfer programmes lack the essence of individual self-selection based on member's knowledge of trust and credit worthiness of other members (Ngo and Wahhaj, 2012). This deficiency enhances default, makes loans unprofitable, unaffordable and prone to corruption (Goetz and Gupta, 1996). It also presents a one-sided supply viewpoint of women empowerment without considering the intra-household resource bargaining power of women (Ahmed, 2008). On the other hand, endogenous dynamic lending such as in ROSCAs help overcome adverse selection when lenders do not know borrowers well initially (Ahlin and Waters, 2016). Repeated lending through ROSCAs allows the lender to gather information on the borrower over time (Reito, 2019). Use of this information allows the lender to tailor contract terms to fit initially unobserved borrower risk characteristics (Ahlin and Waters, 2016; Besley et al., 1993; Rutherford, 2014).[4]

There were early recommendations of public private partnerships (PPP) in the delivery of micro-credit through the donors (banks) and the distributors (NGOs and SHGs) (Roy and Chowdhury, 2009; Deininger and Liu, 2013), but these structures have been criticized for quickly turning

[4]See appendix Table A1 for a hypothetical fixed interest based ROSCA with 5 members.

into a for-profit initiative from both the donors and the distributors (Ngo and Wahhaj, 2012; World Bank, 2013). The top-down approach with individual instead of group liability (De Quidt et al., 2016) presents a hurdle to the effective, equitable and rational distribution of credit to women in developing countries, especially for those women who do not have productive projects and are reliant on returns from financial intermediation (Mayoux, 2005). Although, the argument for adding dynamism and individual liability of repayment through exogenous schemes has been proposed (Ksoll et al., 2016; Ahlin and Waters, 2016; De Quidt et al., 2016), the objective is distributional improvements rather than returns through the circulation of finance and financial intermeditaion. Agency induced micro-credit lacks individual willingness to participate and the mechanism to control adverse selection and moral hazard. On the other hand, members self-select into ROSCAs based on their social and economic credibility. In many contexts, ROSCAs offer a secure dynamic model of investment as the returns from circulation of credit and financial intermediation are shared by women themselves and are not cornered by banks or NGOs (Anderson and Baland, 2002). Research in the previous decade on women empowerment through micro-credit schemes has been critical of the existing schemes with women micro-credit loanees (Ahmed, 2008). Strategies for using the programs, contextual opportunities, program constraints and policies have created complexities and differential outcomes for women empowerment through exogenous micro-credit (Duflo, 2012).

A more recent theory behind compliance in endogenous and dynamic micro-credit models with individual liability (Ahlin and Waters, 2016) and no sanctions (Reito, 2019) argues that ROSCAs and other SHG-based associations outperform one-time group lending by pricing safe and poor borrowers who tend to fall out of the market (Ahlin and Waters, 2016). These strategies allow the lender to vary interest rates more freely based on publicly known information, reduces defaults and increases the net returns to participation in the long run. As a matter of strategy, an optimal lending contract in a two-period adverse selection model with limited commitment on the borrower side have been implemented through SHGs in India (Deininger and Liu, 2013). Endogenous micro-credit attracts safe borrowers most of the time i.e., initially and after success – in cases where group

lending would exclude safe borrowers altogether (Ahlin and Waters, 2016). These characteristics are crucial for the financial inclusion of women as they are most likely the safe borrowers who fall out of the market (Anderson and Baland, 2002; Ardener and Burman, 1995; Duflo, 2012).

1.3 Micro-credit for Women in India

1.3.1 ROSCAs in India

Following the Travancore Chitties Act of 1918, and the Cochin Kuris Act of 1931, the earliest report on ROSCAs in India dates back to 1931, when the report of the Central Banking Enquiry Committee (Government of India) described 'chitties' as ROSCAs with loose organization of a small number of people, mostly women, originally confined to villages where periodic contributions were made both cash and kind[5] (Ardener and Burman, 1995; Srinivasan, 1995; Mohini Sethi et al., 1995). One common aspect among most ROSCAs in South India is that they are primarily driven by women (Ardener and Burman, 1995; Mohini Sethi et al., 1995). The framework of ROSCAs in India are universal as described in the introduction with periodic deposits in a collective fund and allocation as per a lottery or a bid (Mayoux and Anand, 1995).

Figure 1.1 shows the district level variation in ROSCA participation among women in India in 2012 (370 districts, IHDS). South Indian women have higher participation in ROSCAs, which is in consonance with previous researches showing prevalence of ROSCAs in south Indian states of Andhra Pradesh, Tamil Nadu and Kerela (Mohini Sethi et al., 1995; Srinivasan, 1995; Klonner, 2008; Mayoux and Anand, 1995). In some districts, participation is as high as 20% for the women population in Kerala and Andhra Pradesh and as low as 2% in Rajasthan[6]. States with higher ROSCA participation appear to be more progressive for women with higher literacy rates, employment and better health outcomes (Kishor and Gupta, 2004).

[5]They are patronized as Kitties by the middle and the upper class in the North, called Kamethi by the Northern Muslims in India and Pakistan, Kuri and Chitty in Kerala, Marup in Manipur, Chit Funds, Sahaya or Thatha in other parts of South India.

[6]Authors calculation from IHDS (2012).

Based on the report of the Agricultural Credit Review Committee, Reserve Bank of India (1991), 51% of the ROSCA funds were invested for productive purposes. 13% were spent on social and religious ceremonies and 36% was spent for consumption purposes (Ardener and Burman, 1995). In Tamil Nadu alone, the turnover in registered ROSCAs, which are mostly of the bidding variety, equaled 100 billion Rupees, about 2.5 billion US dollars, in 2000, compared to aggregate bank deposits of 66 billion Rupees, Reserve Bank of India, 2000 (Klonner, 2008). These statistics however underestimate the significance of ROSCAs as they are extremely popular and act as a substantial socio-economic instrument for the women, but are almost never registered in rural areas (Klonner, 2008; Mohini Sethi et al., 1995; Mayoux, 2005). According to Mohini Sethi et al. (1995), ROSCAs helped women to become skilled entrepreneurs and achieve self-esteem by providing the seed money for investment in small scale ventures.

1.4 Theoretical Model

Our theoretical model builds on the Nash bargaining model by Anderson and Baland (2002) with an objective to maximize a two-period time separable utility function of a household comprised of a husband and wife. The household has two options to save for the good D, either in autarky, S, or through ROSCAs, S^R. Our bargaining model relaxes restrictive assumptions on relative preference for the good being higher for the wife, incorporates returns from bidding ROSCAs and models the rate of default. Based on the predominance of women as household representatives in ROSCA membership (Besley et al., 1993; Anderson and Baland, 2002; Anderson et al., 2009; Hossein, 2018), we assume that the socio-economic effects of ROSCA membership are disproportionately experienced by women.

If the household saves S^R in ROSCAs in the first period and acquires the good D in the second period, the household acquires a return on savings τS^R for being willing to wait to get the good in the second period, which for expositional purposes is realized by the wife only[7]. We assume that

[7]In a two player random ROSCA, there is a probability of 1/2 of the household receiving the good in the first period and 1/2 probability of receiving the good in the second period. In case of a bidding ROSCAs, the second member

the husband is indifferent to savings in ROSCA and autarky, as long as the rate of default $(1-P)$ is zero.

The good to be acquired through savings, D is a choice variable for which the preference for the wife is given by δ and the preference of the husband is given by $(1-\delta)$.[8] We incorporate the structural characteristic of default in bidding ROSCAs which is extendable to random ROSCAs and analyze its effect on women's bargaining power. We assume in bidding ROSCAs that the household waits for the second period to acquire the good, thus the possibility of default is $(1-P)$ in period 2. Incorporating default allows a holistic analysis of gain and loss of bargaining power for women with ROSCA membership.

We begin with the baseline two period model of savings in autarky and savings in a two member ROSCA. In the first period, the household expresses demand for household good D. To acquire the good D, the household could either save S by itself (autarky) for the two periods, or save in a two member ROSCA S^R, wherein the household is one of the members. For simplicity, we assume the household earns the same income in both periods, that is, the combined income of husband and wife is fixed in both periods with $Y = Y^h + Y^w$. Both the husband and the wife are risk averse and have utility functions that exhibit Constant Relative Risk Aversion (CRRA) over the household's primary consumption C_1 and C_2, with θ as the relative risk aversion parameter.

1.4.1 Two period Savings in ROSCA and Autarky

We begin with a two member ROSCA model where the wife and husband collectively as a household are one of the members of the ROSCA. Their utility function are given as a linear sum of consumption in two periods with their preferences (value) δ and $1-\delta$ for the good D,

taking the pay-out receives a dividend for being a patient member, see Kovsted and Lyk-Jensen (1999) for a detailed analysis of outcomes of random and bidding ROSCAs.

[8]The bargaining model by Anderson and Baland (2002) assumes that the husband has no preference for the good and that the wife's preferences for it are always stronger than the husband's. Our model relaxes the assumption of no preference for the husband and that the wife's preference is always higher than the husband's in case of random ROSCAs, allowing for a more robust co-operative Nash bargaining solution, as argued by Katz (1997).

respectively. The household decides whether it wants to save by itself or save in a ROSCA to purchase the good [9].

Utilities associated with savings in autarky (by the household itself) for the husband and the wife are given as

$$U_W = U(C_1) + U(C_2) + \delta D \tag{1.1}$$

$$U_H = U(C_1) + U(C_2) + (1-\delta) D \tag{1.2}$$

Utilities with saving in ROSCA are

$$U_W = U(C_1) + \tau S^R + U(C_2) + \delta P D - \delta(1-P) D \tag{1.3}$$

$$U_H = U(C_1) + U(C_2) + (1-\delta) P D - (1-\delta)(1-P) D \tag{1.4}$$

In both the autarky and ROSCA models, $U(C_1) = C_1^{(1-\theta)}/(1-\theta)$ and $U(C_2) = C_2^{(1-\theta)}/(1-\theta)$; C_1 and C_2 are household consumption in period 1 and 2, respectively.[10] The husband has $(1-\delta)$ preference (value) for the household good and wife's preference for the good is δ. Here, $\delta > 0.5$ implies wife's preferences are stronger for the good compared to the husband. In the ROSCA model: $(1-P)$ is the probability of default in the second period.

In equation 1.3, the wife's utility is increased by τS^R compared to the autarky condition in equation 1. In case of a bidding or random ROSCA, τS^R is the gain in utility derived by the wife in the first period from the household being a ROSCA member. For model simplification, we assume that τS^R is a utility gain derived by the wife only, and is a private non-monetary benefit such that C_1 is the same for the husband and the wife in period 1. It does not enter into the wife's consumption in period 1. This is realistic in the sense of how Anderson and Baland (2002) describe ROSCAs to be secretive earnings for women. To incorporate the element of this private benefit,

[9] Available literature suggests that people join random ROSCAs even in the presence of formal financial means as the transaction costs for obtaining loans from formal channels are high where money circulations are for shorter periods, and the purpose of the loan is informal such as for the household good (Bisrat et al., 2012).

[10] We assume the good D is additively separable in the utility for mathematical simplicity.

we treat τS^R as separate from wife's consumption in period 1. This private benefit is used for collective purposes of the household, as discussed by Anderson and Baland (2002), to be the case in Africa.

We assume that if the household agrees to save for the good than it will be acquired in the second period. The household joint utility function is then derived from the co-operative Nash bargaining model (Manser and Brown, 1980) stated as

$$U_{HH} = (U_W)^{\gamma}(U_H)^{(1-\gamma)} \tag{1.5}$$

Where U_{HH} is the joint household utility. In our model, γ is the relative bargaining power of the wife and $(1-\gamma)$ is the relative bargaining power of the husband. Following Iyigun and Walsh (2007) and Lancaster et al. (2006), we assume that bargaining power is a function of the relative incomes Y_i, exogenous factors X_i, and the idiosyncrasies across space and time v_{it} such that $\gamma = \gamma(X_i, Y_i) + v_{it}$. Bargaining power of the spouses has been found to be both linear and non-linear in India by Lancaster et al. (2006), and as such we do not assume any particular functional form, and let $\gamma\epsilon(0,1)$. Our model following Iyigun and Walsh (2007) model assumes that marital bargaining power is determined endogenously through income and savings with no strong preferences of the spouses, that is no assumptions on the parameter δ. Bargaining power takes into account how income and exogenous factors affect their marital decision making power and the share partners extract from household resources.

1.4.2 Two period savings in ROSCA

In case the household chooses to join a random ROSCA, the maximization problem with choice of savings S^R and purchase of the household good D is given by the household utility with the constraints as under:

$$Log(U_{HH}) = (1-\gamma)[(U(Y - S^R)) + (U(Y + S^R - D) + (1-\delta)PD - (1-P)(1-\delta)D)]$$

$+\gamma[(U(Y-S^R))+\tau S+(U(Y+S^R-D)+\delta PD+\delta(1-P)D)]$

subject to

$S^R \geq 0$

$Y \geq C_1 + S^R$

$Y + S^R \geq C_2 + D$(1.6)

The household faces the following constraints: (i) $S^R \geq 0$, savings in the first period has to be positive to acquire the household good D, (ii) $Y \geq C_1 + S^R$, income in the first period should be equal to consumption in period 1 and savings in period 1, (iii) $Y + S^R \geq C_2 + D$, income and savings from the first period must be greater than or equal to consumption in period 2 and the expenditure on the purchase of household good D.

By the first order optimality condition given the choice variable of savings in ROSCAs, we have

$$\partial Log(U_{HH})/\partial S^R = 0 \tag{1.7}$$

By CRRA condition

$$\partial Log(U_{HH})/\partial S^R = U'(C_1) = U'(C_2) + \gamma\tau \tag{1.8}$$

$$U'(C_1) = (C_1)^{-\theta} = (Y - S^R)^{-\theta} \tag{1.9}$$

From equation 1.8 and 1.9, we have:

$$U'(C_2) = (C_2)^{-\theta} = (Y + S^R - D)^{-\theta} + \gamma\tau = (Y - S^R)^{-\theta} \tag{1.10}$$

Equation 1.9 yields the neccessary first order condition to derive equilibrium savings. To solve for the equilibrium values of S^R, we take the derivative of the utility function with the second-choice variable D. The first derivative of the log utility function with respect to the second choice variable D, that is $\partial Log(U_{HH})/\partial D = 0$ yields the marginal effect of purchasing the household good on savings in ROSCA.[11]

[11]See appendix A6: derivation of equilibrium savings rate in ROSCAs and autarky.

$$S^{R^*} = Y - ((2P(1-\gamma-\delta+\gamma\delta) - (1-\gamma-\delta) + \gamma\delta)^{-1/\theta} \tag{1.11}$$

With no default in ROSCAs, that is, if $P = 1$, then:

$$S^{R^*} = Y - \frac{1}{[(2\gamma\delta + 1 - \delta - \gamma + \gamma\tau)]^{1/\theta}} \tag{1.12}$$

Equation 1.11 and 1.12 show the equilibrium saving rate in ROSCAs with and without default.

1.4.3 Two period savings in autarky

In case the household chooses to save in autarky, the maximization problem with choice of savings S, and purchase of the household good D, is given by the household's collective utility with the constraints as under:

$$Log(U_{HH}) = \gamma[(U(Y-S)+(U(Y+S-D)+\delta D]+(1-\gamma)[(U(Y-S)+(U(Y+S-D)+(1-\delta)D)]$$

subject to

S ≥ 0

$Y \geq C_1 + S$

$Y + S \geq C_2 + D$(1.13)

The first order partial derivative of equation 1.4.3 with respect to savings, i.e., $\partial Log(U_{HH})/\partial S = 0$, yields savings in period one, $S = D/2$. Further, the first derivative of the log utility function with respect to the second choice variable D, i.e., $\partial Log(U_{HH})/\partial D = 0$ gives the equilibrium savings in S^* in autarky as under:

$$S^* = Y - \frac{1}{[2\delta\gamma + (1-\gamma) - \delta]^{1/\theta}} \tag{1.14}$$

Proposition 1: Given, constant income shares, if the value of the good for the wife is higher or equal to the husband's, i.e., $\delta \geq 0.5$, and if there is no default in the ROSCA, i.e. $P = 1$, the

household would have to save less in ROSCAs as compared to autarky to acquire the good, D, that is, $S^{R*} \leq S^*$, this implies a lower burden of savings for the wife in the first period. By the same analogy, the household as a collective would be more willing to save in ROSCAs as compared to autarky.

Figure 1.3 shows the relationship between household savings and bargaining power of the women as implied by equations 1.12 and 1.14 in the model. Equilibrium savings in both autarky and ROSCAs increase with higher levels of wife's bargaining power if the preference for the good, $\delta > 1 - \delta$. In this case, the figure shows that the households would save more in ROSCAs as compared to autarky, also when $\delta < 1 - \delta$, that is the man's preference are stronger than the woman's, the decline in savings for the good, D, is lower in ROSCAs as compared to autarky. The gap between the two savings curve increases as we increase the value of τ, private benefit to the wife, and reduces with higher levels of bargaining power of the wife, γ (see appendix figure A7). At very high levels of wife's bargaining power γ, the household does not save for the good and buys it in the first period. These relationships confirm the existence of a negative self-selection in ROSCAs where very high and very low bargaining power of women curtails ROSCA membership (Anderson and Baland, 2002).

1.4.4 Bargaining power in ROSCA and autarky

To arrive at the empirically testable hypothesis, we rearrange equation 1.12 to show woman's bargaining power, γ, on the left-hand side, and everything else on the right hand of the equation (see appendix A6). We then totally differentiate γ with respect to S, savings in case of autarky. The first and second derivative of wife's bargaining power, γ with S yields:

$$\partial\gamma/\partial S = \frac{\theta(Y-S)^{-\theta-1}}{(2\delta-1)} \tag{1.15}$$

$$\partial^2\gamma/\partial S^2 = \frac{(1+\theta)\theta(Y-S)^{-\theta-2}}{(2\delta-1)} \tag{1.16}$$

Analogously, with $P = 1$, the first and second derivative of wife's bargaining power, γ with savings in ROSCAs, S^R (see appendix A6) yields:

$$\partial\gamma/\partial S^R = \frac{\theta(Y-S)^{-\theta-1}}{(2\delta P + \tau - 1)} \tag{1.17}$$

$$\partial^2\gamma/\partial S^{R^2} = \frac{(1+\theta)\theta(Y-S)^{-\theta-2}}{(2\delta P + \tau - 1)} \tag{1.18}$$

As shown by equations 1.15 and 1.16, in autarky, an increase in the household savings increases wife's bargaining power only if wife's preference for the good, D, is stronger than the husband's, that is if $\delta > 1 - \delta$. Equation 1.17 and 1.18 show that the same is not true for savings in ROSCAs, even when $\delta = 1 - \delta$, at which point savings in autarky does not affect women's bargaining power, ROSCAs still have a positive effect on wife's bargaining power. Equation 1.18 in comparison to equation 1.16 shows that savings in ROSCAs yields a higher increase in wife's bargaining power compared to savings in autarky. Higher bargaining power with savings in ROSCAs is due to the private benefit derived by the wife, τS^R, of being a patient member in the ROSCA.

Proposition 2: ROSCAs improve women's bargaining power even in the absence of strong preferences. For all $\delta \geq 0.5$, ROSCAs increase women's bargaining power more than the savings in autarky. For all $\delta \leq 0.5$, the decline in women's bargaining power in ROSCAs is lower than that of autarky.

Figure 1.4 shows the comparative static effect of savings in autarky and savings with ROSCAs. The figure shows that for the same level of preferences, $\delta \geq 0.5$, savings in ROSCAs yields a higher increase in wife's bargaining power as compared to autarky. When both husband and wife's preference for the good are equal, that is $\delta = 0.5$, then savings in autarky has no effect on women's bargaining power, but ROSCAs still have a positive effect on wife's bargaining power. When $\delta < 0.5$, then the decline in wife's bargaining power is slower in ROSCAs as compared to autarky. Therefore, given no default $P = 1$, ROSCAs increase the bargaining power of the wife more than

the increase through savings in autarky, even when the preferences are equal between the husband and the wife, ceteris paribus.

1.4.5 Exogenous Micro-Credit and Women's Bargaining Power

We use a two period exogenous micro-credit model where through an external agency (government programs or agency based credit), credit is provided to the household in the first period. We assume a repayment rate τ for the loan from the micro-credit agency to be paid in the second period at the rate τD. The household is farsighted and saves S^{MF} in the first period as it knows that it will have to pay back the credit in the second period. In the second period, the household has to pay the micro-credit agency the full amount of credit, which is D in this model along with an interest τ on D.

Given the context, the household joint utility maximization problem using a Nash bargaining model is given by equation 1.4.5:

$$Log(U_{HH}) = (1-\gamma)[(U(Y+D-S^{MF}) + (1-\delta)D) + U(Y+S^{MF}-D(1+\tau)]$$

$$+ \gamma[(U(Y+D-S^{MF}) + \delta D) + U(Y+S^{MF}-D(1+\tau)] \quad (1.19)$$

The household chooses S^{MF} and D. The first order condition for maximization $\partial U_{HH}/\partial S^{MF}$ yields equation 1.20:

$$(Y+D-S^{MF})^{-\theta} = (Y+S^{MF}-(1+\tau)D)^{-\theta} \quad (1.20)$$

A similar analysis as in the previous section yields the following equation:

$$\partial S^{MF}/\partial\gamma = \frac{1}{\theta}\left(\frac{1}{\tau}[2\delta\gamma+1-\gamma-\delta)]\right)^{-(1+\theta)/\theta}\left(\frac{1}{\tau}(2\delta-1)\right) \quad (1.21)$$

$$\partial\gamma/\partial S^{MF} = \frac{\theta(Y+D-S^{MF})\tau^{-(\theta+1)}}{(2\delta-1)} \quad (1.22)$$

$$\partial^2\gamma/\partial S^{MF^2} = \frac{(1+\theta)\theta(Y+D-S^{MF})\tau^{-(\theta+2)}}{(2\delta-1)} \tag{1.23}$$

The effect of savings in exogenous micro-finance on the bargaining power depends on the relative value of τ and the good D, and is expectedly positive for $\delta > 0.5$ as shown by equation 1.23. If the preference for the good is higher for the husband, that is if $\delta < 0.5$, then an increase in savings with the agency based micro-credit reduces wife's bargaining power.

In figure 1.5 we plot equations 1.18 and 1.23 under a variety of simulated values of parameters for illustration. Given $D = 6$,$\tau = 0.4$, $\theta = 0.1$, no default in the ROSCA, $P = 1$, then under various values of δ, we see that ROSCAs increase women's bargaining power in a more sustained manner compared to exogenous micro-credit. Figure 1.5 shows that when the woman's preferences are equal to the man's $\delta = 0.5$, savings in exogenous agency-based savings does not yield any increase in the bargaining power, $\gamma = 0$, however, savings in ROSCAs increases woman's bargaining power, due to the private benefits in the first period.[12] This distinctive feature of socio-economic returns through participation in ROSCAs is the key to increase in women's bargaining power.

Given the prediction of the theoretical model of savings in autarky, ROSCA and exogenous micro-credit, and their effects on women's bargaining power, we wish to empirically examine if these predictions hold at the macro level in India.

1.5 Data and Empirical Model

1.5.1 Data

The data used to test the predictions of the theoretical model are derived from the panel data set by combining the second and the third wave of survey of the Indian Human Development Survey, 2005-2012, (Desai and Vanneman, 2018). IHDS is a nation-wide sample survey covering all states based on the population density, except for Meghalaya and Union Territories of Andaman and Nicobar Islands and Lakshadweep. The surveys are jointly carried out by researchers from the

[12]More calibrations of the theoretical model are shown in appendix A7.

University of Maryland and the National Council of Applied Economic Research in New Delhi. IHDS have individual, household and gender disaggregated responses, and cover wide-ranging topics on demographics based socio-economic characteristics of households and individuals, useful for our survey.

The dataset has 13,706 households from urban areas and 28,446 households from rural areas. Since the IHDS has an 83 percent match of survey households in between the waves, we balance our sample (track same individuals in both years) for the fixed effects analysis. In doing so, we lose some observations for individuals who were not tracked in the third wave of the IHDS. Our sample is restricted to individuals over 15 years of age and we exclude observations reporting missing values for ROSCA membership. We then have 98,704 individuals above 15 years tracked in both the surveys. Out of the individual sample size, 27 percent answered the eligible women's questionnaire. Overall, we have 26,784 women respondents who are tracked in both the surveys, plus an additional 3 percent (29,800) of the panel sample size, as more women answered the eligible women's questionnaire in the third round, 2012.[13] The sample is balanced at the individual level, in that we track 25400 individual responses on ROSCA memberships in both rounds by eligible women, however, regression analyses may not reflect the same number of observations due to missing observational information on outcomes and controls. The variable "is your name on a bank account" has few observations in the first wave because of missing data. The variable, household electricity hours, is conditional on electricity access (0/1) and therefore, some of the women in the questionnaire may not have household's electricity access, thus the fewer observations. We use this strongly balanced sample for the analysis. One advantage of taking the observations at the eligible women's level is that the effects of ROSCA are now conditional on the eligible woman knowing if the household is a ROSCA member or not.

A majority of our analysis is carried out using the panel data set, 2005-2012, using the household's membership in ROSCA as the average treatment effect. Since household's membership is

[13]The cross-sectional analysis of women's ROSCA membership which we use as a robustness check confirms the 83% match across the IHDS waves. In the cross-sectional analysis, we have approximately 31,500 eligible women respondents.

a good proxy for women's membership in India as also noted in Ardener and Burman (1995) for India, and by Anderson and Baland (2002) in Kenya. Our objective is to analyze the effect of household's ROSCA membership on women's empowerment, hence, we use the IHDS eligible women's questionnaire as our main data source for the outcomes of our interest, along with the income and social capital questionnaire on employment and collective household goods. The variables derived from the eligible women's questionnaire are shown in appendix Table A2, and the remaining outcome variables as well as the covariates are shown in table 1. For women's employment, we create binary variables for (i) any employment ($\geq$ 240 hours in a year), and (ii) business activity ($\geq$ 240 hours in a year).

Even though, the data on membership of ROSCAs at the household level is available for both IHDS waves, the 2005 wave does not have data on women's membership of ROSCAs, and also has fewer dependent variables. As a robustness analysis, we also look at the effects of women's participation in ROSCA which is only available in the third wave of the IHDS, 2012. We create indices using principal component analysis (PCA) of five focal empowerment variables and run an OLS regression with district and caste dummies to examine the effect of women's membership in ROSCAs on a larger set of empowerment variables. All variables and their relative factor weights in the PCA analysis are shown in appendix Table A3.

Table 1.6 shows the descriptive statistics between the two survey waves conditional on response from the women whose empowerment we are concerned with.[14] Household ROSCA participation increased by 5.2 percent (7.6 to 12.8 percent). Household's membership in NGOs declined marginally, while, household participation in SHG increased substantially, many of which now act as Village Savings and Loans Associations in developing countries (Ksoll et al., 2016; Ngo and Wahhaj, 2012). Loans from informal money lenders declined by 3.8 percent, while loans from bank increased by 7.4 percent. Loans from ROSCAs increased by a small margin, while loans from government remained constant and low.

[14]Descriptive statistics unconditional on filling the eligible women's questionnaire is shown in appendix Table A4.

In terms of economic freedom for women: the likelihood of cash in hand for expenditure increased from 82 to 93 percent. Women's property ownership increased from 15 to 19 percent, and the likelihood of having a bank account increased substantially (46 to 59 percent). Women's employment in any activity ($\geq$240 hours in a year) increased from 56 to 59 percent, while business activity increased from 3.6 to 5 percent. In terms of economic decision making: women's say in major purchases increased from 71 to 81 percent. Women's likelihood of shopping for the household increased from 56 to 64 percent. In terms of access to basic amenities: household's likelihood of having indoor piped water increased from 27 to 31 percent, and the likelihood of having a toilet increased from 41 to 55 percent. In terms of mobility, the need to ask permission to visit health center and grocery increased marginally, while the permission to visit friends decreased. In terms of household decision making, women's say in child's marriage increased, say in child's illness increased marginally, and their say over the number of children increased by 12 percent.

1.5.2 Panel fixed effects regression

We are interested in estimating the effect of household ROSCA membership on women's empowerment, and also comparing ROSCAs with exogenous micro-credit schemes in terms of their effect on empowerment. Given the panel structure of the data set, we use fixed effects—average treatment effect model—controlling for observable socio-economic factors that could influence the outcome. The individual fixed effects regression model is as follows:

$$Y_{it} = \delta Rosca_{it} + X_{it}^{'}\beta + \alpha_i + d_t + \epsilon_{it} \tag{1.24}$$

Equation 1.24 shows the individual fixed effects model, where, Y_{it} represents the outcome of interest, mainly the categorical variables of empowerment for woman i at time i. $Rosca_{it}$ is the woman's response (Yes or No) about the household's membership in ROSCA for the i^{th} household, at time t. The observable vector $X_{it}^{'}$ includes socioeconomic and demographic characteristics which are likely to affect variables of women's empowerment: natural log of the real income of the household, household head education, woman's education, age, status of poverty, marital

status and household size. The unobserved α_i is modeled as a fixed effect with no restriction on the correlation with other model regressors, and d_t is the survey wave intercept. The error term ϵ_{it} (clustered at the individual level) is assumed to be randomly distributed. We are interested in estimating the effect of household's ROSCA membership, measured by the coefficients δ.

Using panel fixed effects model controls for the time invariant unobserved heterogeneity through the individual specific effect α_i. In terms of household's ROSCA membership, capturing this time invariant unobserved heterogeneity is critical, as available literature has found that ROSCA membership is dependent on individual member's trust worthiness and social collateral (Ardener and Burman, 1995; Hossein, 2018). These attributes of an individual could be a factor of multitude of unobservable characteristics of the individual which may not change overtime, and could be their personal traits. For instance, the respect or reputation that the individual has in the society, or the punctuality of periodic ROSCA payments, these are hard to account for through observable socio-economic characteristics. In some instances, the need to protect savings from husbands explains the importance of confidentiality and secrecy that groups insist upon (Anderson and Baland, 2002). These attributes are unobservable in the data, but are captured through the individual specific effects in our analysis.

In terms of the observable time-invariant characteristics, specific to the context of India where caste, language and religion form the basis of social structure (Thorat and Neuman, 2012), the structure of social organization has been argued to influence membership in ROSCAs (Srinivasan, 1995). In addition, as noted by Mohini Sethi et al. (1995) and Klonner (2008) in contemporary south India, ROSCA membership is dependent upon caste, sex, language and religion, among others, these time-invariant variables are accounted for in the fixed effects model.

In terms of the comparison of endogenous and exogenous micro-credit, we use individual fixed effects model as described above, and by changing the model regressor, we compare the effect of ROSCA, NGOs, SHGs, bank loans, and loans from government programs on variables of women's

empowerment. The fixed effects model is given by the following equation:

$$Y_{it} = \delta Mcredit_{it} + X_{it}^{'}\beta + \alpha_i + d_t + \epsilon_{it} \tag{1.25}$$

In equation 1.25, $Mcredit_{it}$ indicates self-reported status of household $i's$ membership in ROSCA, NGO, SHG, or if the household i has acquired loan from ROSCAs, money lender, bank or government program at time t. All other variables are as previously defined.

Even though we control for the critical time invariant unobservables that affect ROSCA memberships, the coefficients derived from the fixed effects are not causal point estimates, as the unobserved correlation between the error term and the time variant unobserved heterogeneity could bias the estimates. For instance, uncertainty about one's productivity, or the ability to perceive risk, among others, could significantly affect ROSCA membership. Sudden micro or macro shocks, such as an employment shock, or a climate shock, such as the Tsunami, may affect the demand for ROSCA memberships, as has been noted by Czura and Klonner (2018) and Besley et al. (1993).

Anderson and Baland (2002) through an intra-household resource bargaining model, argue for a negative selection bias with the proposition that it is optimal for the women not to join a ROSCA for very high values of her relative weight in household decision making. Therefore, women could exit ROSCAs once their household reaches a certain threshold of income. Following the literature on declining ROSCA membership with rising living standards (Kedir and Ibrahim, 2011; Besley et al., 1993; Anderson and Baland, 2002), we assume the existence of a negative self-selection bias in the fixed effects estimate. To this effect, we expect the baseline fixed effects estimate to underestimate the coefficients. Therefore, as a robustness analysis, we instrument the household's decision to join ROSCAs using the average level of membership at the village/Primary Sampling Unit level, and expect to correct the underestimation of coefficients as a robustness measure.

1.5.3 Panel Instrumental Variables

We use popularity of ROSCAs as an instrument and proxy it by the average household membership in ROSCAs at the Village/PSU level. Popularity of ROSCAs is a major driver of participation

as it creates a base of potential members, which is critical as ROSCAs are mostly localized in India (Klonner, 2008). Higher membership in ROSCAs at the local level helps build social network among members (Anderson and Baland, 2002) and trust among the people in a locality, which furthers participation through peer and demonstration effects (Acquah and Dahal, 2018). The first stage estimate of instrumental variables (IVs) regression is obtained by estimating the following equation:

$$Rosca_{ijt} = \alpha + \lambda I_{jt} + X_{ijt}^{'}\beta + \theta_i + \pi_t + \epsilon_{ijt} \tag{1.26}$$

In equation 1.26, I_{jt} is the instrumental variable: average village level ROSCA membership in village/PSU j of household i at time t.[15] λ is the coefficient of the effect of average village level ROSCA membership in village j, on the likelihood of ROSCA membership of household i in village j at time t. All other covariates are as discussed above. Popularity of ROSCAs affects household's membership through peer and demonstration effects (Anderson and Baland, 2002; Mayoux and Anand, 1995). If neighbors become ROSCA members and realize economic and social gain as a collective, then the status of non-membership may signal lower socioeconomic standing, a case, which we expect women would avoid. In terms of the exclusion restriction, figure 1 and 2 of ROSCA memberships of the household and women do not provide any clear indication of women empowerment in areas with higher average ROSCA participation rate.

1.5.4 Sensitivity test using OLS Model

Due to the lack of data on women's ROSCA membership, and some potential empowerment variables in the 2005 wave of the survey, we use the cross section of the 2012 survey wave as a sensitivity test, and examine the relationship between women's ROSCA membership and their

[15]There are 1,503 villages in the IHDS, (2012), with 42,152 household level observations, hence there is sufficient variation of approximately 28 observations at the village/PSU level. Also, as a first pass, we check for the correlation between economic empowerment index and ROSCA membership at the village level, the correlation is 0.006, therefore we assume weak association between the IV and the outcome variables. Economic empowerment index is created using Principal Component Analysis of economic empowerment variables. We collapse the average value of the categorical variables at the village level, and create an economic empowerment index following the PCA factor load technique discussed by Fang (2003).

empowerment.[16] We then compare the effect of women's membership in ROSCA to exogenous micro credit agencies as carried out in the panel analysis. The baseline estimate for this analysis is as follows:

$$Y_i = \alpha_i + \delta wrosca_i + X_i^{'}\beta + \gamma c_i + \theta d_i + \epsilon_i \tag{1.27}$$

$$Y_i = \alpha_i + \delta Mcredit_i + X_i^{'}\beta + \gamma c_i + \theta d_i + \epsilon_i \tag{1.28}$$

In equation 1.27 and 1.28, Y_i represents the outcome of interest, five indices and categorical variables of empowerment for women i of caste $c_i = 1, .., 4$ in district $d_i = 1, 2, ..., 370$. $wrosca_i$ is the membership in ROSCA of the i^{th} woman.[17] We control for geographic and cultural characteristics at the district and caste levels with district and caste dummy variables. $X_i^{'}$ is a vector of individual and household observable socioeconomic and demographic characteristics: log real income of the household, household head education, sex, age, adult women's education, and household size. The error term ϵ_i is assumed to be randomly distributed. We are interested in estimating the effect of women's ROSCA membership, measured by the coefficients δ. In addition to testing the sensitivity of our results, using only the 2012 survey waves allows us to have more observations, and to look at more empowerment variables, as shown in Table A3 in the appendix.

1.6 Results

1.6.1 ROSCA and Women Empowerment

For the majority of our analysis on empowerment, we use individual fixed effects as our main model with standard error clustered at the village/PSU[18] level to show the effects of household's ROSCA membership on women's economic freedom, economic decision making, agency and access to collective goods of the household, mobility and household decision making ability. Table

[16] Summary statistics of the 2012 cross-sectional data by ROSCA membership is shown in appendix Table A5.

[17] Five focal empowerment indices are created using table A3. The empowerment variables reflect women's: economic freedom, economic decision making, agency, mobility and household decision making.

[18] PSU implies primary sampling unit, which is the identifier of a village in rural area or a block/Tehsil in urban area.

1.2 shows the effect of ROSCA membership on women's economic freedom defined by women's access to: cash in hand for day to day expenditures, having their name on property papers of the house, having a bank account with their name on it, employment in any activity for over a month in a year, and similarly, employment in a business activity. The rationale for using employment in a business activity as an outcome is to examine the effect of ROSCA and women's entrepreneurial activity, which has been found to be positive in qualitative studies in developing countries (Ardener and Burman, 1995; Hossein, 2018; Besley et al., 1993).

Table 1.2 shows that household's ROSCA membership increases women's access to cash in hand for day to day expenditures by 1.7 percentage points (pp), significant at 5 percent. ROSCA membership increases women's likelihood of having their name on property papers of the house by 3.3 pp, significant at 1 percent. ROSCA membership increases the likelihood of having a bank account for women by 7.8 pp, significant at 1 percent. In terms of employment opportunities, ROSCA membership has similar effects on women's employment in any activity (wage, salary, farm and business) and business activity. ROSCA membership increases the likelihood of employment activity by 1.4 pp, for any activity, significant at 1 percent. Similarly, for business activity, the coefficient 1.4 pp is significant at 1 percent.

For expositional purpose, we show the coefficients of all model regressors only in Table 1.2. Log of real household income has a positive effect on all economic freedom variables, the effects vary for different economic outcomes. One log point increase in household income increases women's cash in hand by 0.5 percent, property ownership by 0.6 percent, likelihood of having a bank account by 1.6 percent, any employment by 1.2 percent, and business activity by 1.3 percent. As shown in table 1, there have been significant improvements in a number of economic freedom variables overtime, therefore, controlling for the time trend through the wave dummy is critical to our analysis to capture any trend effect which might bias the coefficients of ROSCA membership. The wave dummy in table 2 shows significant improvements in major economic outcomes for women overtime. Household head's education (one-unit increase is one more year of education), majority of whom are male, has no effect on cash in hand for women, no effect on women's

property ownership, reduces the likelihood of women having a bank account by 1 pp, reduces the likelihood of women's employment and entrepreneurial activity by 0.5 and 0.1 pp, respectively.

In terms of significant effects, one more year of women's education increases the likelihood of having cash in hand for expenditure, and also increases the likelihood of having bank account. Women's age in years increases their likelihood of having cash in hand and reduces the likelihood of an employment activity. Increasing household size, one more member in the household significantly reduces women's economic freedom, in all variables except for their employment activity. Being poor also reduces the likelihood of having cash in hand for women. Being married reduces the likelihood of having cash in hand by 3.3 pp, and also reduces the likelihood of having a bank account by 5.4 pp. Being a widow increases the likelihood of having property ownership and bank account by 16 and 9 pp, respectively. Being separated from their husband increases women's employment activity by 13 pp.

According to Kabeer (1999) and Jayachandran (2019), access to credit is a significant determinant of women's bargaining power, and their economic contributions to the household. Supportive of the above argument and micro evidences in developing economies, results in Table 1.3 show that ROSCA membership has a strong influence on women's economic decision-making abilities. Table 3 shows the individual fixed effects estimates of household's ROSCA membership on women's economic decision-making ability viz. women's say in major economic purchases of the household (such as a TV or a refrigerator), likelihood of women having the most say in major purchases of the household, women's ability to do grocery shopping for the household, likelihood of their partner discussing work and expenditure related issues with them. The rationale for using the variable "most say in purchasing decision" is to examine if the inequality in decision making (as shown in table 1) within the household can be reduced through ROSCA membership.

Table 1.3 shows that household's ROSCA membership increases women's say in major purchase decisions of the household by 3.9 pp, significant at 1 percent. ROSCA membership increases women's most say in major purchases by 1 pp, significant at 10 percent, increases women's likelihood of grocery shopping for the household by 2.7 pp, significant at 1 percent. ROSCA mem-

bership also has a significant positive effect, 3.8 pp, on the likelihood of men discussing their work-related activities with the women, while the likelihood of discussing household expenditures is positive, the effect is not significant. Higher household income reduces women's economic decision making in the household. These results are supportive of the de-feminization argument (Abraham, 2013)—higher income of a household blocks labor supply of women, especially in rural India, hence, lower economic decision-making ability.

In Table 1.4, we examine the effect of ROSCA on women's agency in terms of membership in social groups, and the likelihood of access to collective goods and assets in the household. We find that ROSCA membership significantly increases women's participation in Mahila Mandals. In terms of amenities, ROSCA membership increases the likelihood of having indoor piped drinking water by 1.6 percent, significant at 5 percent. The coefficient although small in magnitude, is large relative to the trend effect (progress overtime).

ROSCA membership increases the likelihood of having either a pit or a flush latrine (toilet) by 1.9 percent, significant at 5 percent. The coefficient is small yet meaningful, given that only 55 percent of the sample had a toilet in 2012. Having a separate kitchen reduces air pollution and promotes hygiene (Singh and Sundria, 2017); the side effects of air pollution could be disproportionately borne by women in the household. To this effect, results show that ROSCA membership increases the likelihood of having a separate kitchen by 3.7 pp. Collective goods like electricity and water have improved women's bargaining power in India (Sedai et al., 2021b, 2020a,b), to this effect, this study shows that ROSCA membership increases household's electricity hours on a typical day by 0.60 hours.

Traditions, safety and family-imposed restrictions forbid women from leaving the family compound or may regulate when, where, and with whom they travel (Jayachandran, 2019). Restricted mobility imposed by the Indian patriarchal system has hindered women's social, psychological, physical and economic progress (Singh and Cready, 2015). Given the impetus on women's mobility through micro-credit and the likelihood of mobility being higher for women who have taken a microloan, estimates from Table 1.5 confirm a strong positive effect of ROSCA membership on

women's mobility. ROSCA membership reduces the need to ask permission from household members to visit health center, friends, and for short distance travel by 3.2, 6.7 and 6.1 pp, respectively. ROSCAs increase women's autonomy (freedom to go alone) in visiting health center, friends, or travelling short distances by 3.9, 7.9 and 1.8 pp, respectively.

Women's individual and joint decision-making ability is circumscribed by the Indian patriarchal society where major social and health related decisions are taken by male members of the household (Jayachandran, 2019). This is highlighted by the denial of the right to their own body, as shown by the response to "do you have most say over the number of children to have", to this only 26 percent women said yes, as shown in table 1. In this regard, ROSCA membership increases the likelihood of women's say over their reproduction by 4.7 pp. With ROSCA membership, women's ability to have a say in the child's marriage increased by 5.2 pp. Their decision-making ability over the child's illness also increases by 1.9 pp.

1.6.2 ROSCA and Other Micro-credit agencies

With the heterogeneity and myriad forms of informal finance (Fultz and Francis, 2013; Mader, 2013), it is almost implausible to compare ROSCAs with all credit sources available to women. There are many variations and models to account for, but, one thing that is common in the spectrum of targeted micro-credit schemes across developing economies from Grameen loans to cash transfers, group lending to dynamic individual lending through NGOs, SHGs and government programs, is the supply of credit to households, especially women at below market or subsidized rates (Duflo, 2012). Of the many schemes of targeted micro-credit, there are a few micro-credit schemes available in the IHDS panel, which allows for comparison of ROSCAs with targeted or potential sources of micro-credit, and their effects on the economic empowerment of women.

Table 1.7 shows the effect of ROSCAs, SHGs, NGOs, loans from money lender, bank, ROSCA and government programs on the economic empowerment of women. Household ROSCA membership as discussed in Table 1.2 increases women's likelihood of having cash in hand for expenditure by 1.7 pp. While, household's loan from money lender decreases the likelihood of the cash for

expenditure by 1.2 pp. Loan from bank had no effect on the outcome, while loan from ROSCAs have a significant positive impact of 5.3 pp on the likelihood of the outcome. Both NGO and SHG membership did not have a significant effect on women's likelihood of having cash in hand for expenditure. In terms of say in major household purchases, memberships in SHG and ROSCAs have significant positive effects, 3.7 and 3.9 pp, respectively. Loan from ROSCA has a smaller but significant effect on purchase decision, 1.2 pp, while loans from money lender had a negative impact, a 2.2 pp decline in women's say in major household purchases. All other micro-credit systems had little to no effect. Loan from banks had a small but positive effect on women's property ownership and business activity, however, the coefficients are smaller as compared to the effects of ROSCA. Loans from ROSCA also had a significant positive effect on property ownership and business activity, 1.8 and 1 pp, respectively. All other micro-credit systems had little to no effect on women's property ownership and business activity.

1.6.3 Robustness and sensitivity tests

As a robustness exercise, we use panel fixed effects instrumental variables regressions. Although the instrument passes the F-test for weak instruments following the criteria laid down by Staiger and James (1997), we do not assume that the instrument is orthogonal and that it satisfies all the exclusion restrictions. As Anderson and Baland (2002) argued, with high levels of bargaining power women would not need to join ROSCAs, we anticipate the instrumental variable regression to correct for the under-estimation in the individual fixed effects regression.

Results in Table 1.8 show the instrumental variable results on women's economic empowerment through ROSCA membership, the outcome variables are therefore similar to individual fixed effects model in Table 1.2. Column 1 in 1.8 shows that ROSCAs increase women's likelihood of having cash in hand for expenditure by 2.2 pp, as compared to 1.7 pp shown in the individual fixed effects model in Table 1.2. As such, the instrument does control for the under-estimation in the individual fixed effects model. In terms of property ownership, the IV coefficient shows a 4.1 pp increase compared to 3.3 pp in the fixed effects model. Likelihood of having a bank account with

ROSCA membership is 8.2 pp in the IV model as compared to 7.8 pp in the fixed effects. In terms of employment, the IV results show, on average, a 2 pp increase in any employment and business activity compared to 1.4 pp in the individual fixed effects model. Overall, the IV results correct for a small under-estimation bias in the fixed effects model, but in general, the coefficients are strong and show robustness with alternative estimation techniques.

We further conduct robustness checks of the panel fixed effect estimates on women's economic empowerment by interacting the state fixed effects and district fixed effects with the wave dummy. We do this to control for the time-variant location factors that could correlated with both membership and outcomes. We also cluster the standard error differently for state and district fixed effects differently: standard errors of state fixed effects at the village/PSU level and standard errors of district fixed effects at the individual level to check for the robustness of the standard errors.

Panel (a) in Table 1.9 shows the effect of ROSCA membership on women's economic empowerment as in Table 1.2 but with the wave dummy interacted with the state fixed effects. All point estimates on economic empowerment variables are marginally higher than those in Table 1.2, which shows that the results obtained in Table 1.2 are on a conservatively lower bound, and that the time-variant location factors do not significantly alter the point estimates. Panel (b) shows similar analysis with the wave dummy interacted with district fixed effects. Here again, the point estimates are similar to the ones found in Table 1.2.

Given that the 2012 survey wave has women's membership directly as a variable, we anticipate women's ROSCA membership to have a higher effect on women's empowerment as compared to household membership, and for the coefficients to be larger in magnitude.

The sensitivity test using cross sectional data in Table 1.10 confirms the positive impact of ROSCA on women's economic empowerment. For expositional purpose, we show all the covariates used in the analysis, as we control for time invariant observable variables such as the individual's caste and district. Cross-sectional analysis is bound to overestimate the effect of ROSCA membership due to the simultaneity issue. Results show that ROSCA membership increases women's cash in hand for expenditure by 3.7 pp, property ownership by 6.4 pp, decision

making in land purchase (variable only available in 2012 wave) by 3.3 pp, decision on the number of children by 2.8 pp, and likelihood of having a bank account by 10.9 pp.

As a second sensitivity test, we compare ROSCAs to exogenous micro-credit agencies using the cross-sectional data. For this exercise, we create five focal empowerment indices from the empowerment variables available in the 2012 wave using PCA as shown in Table A3. This allows us to examine more variables of empowerment which are not available in the panel analysis. After standardizing the empowerment indices with mean zero and standard deviation as 1, we find that in terms of economic freedom, ROSCA membership increases economic freedom index by 0.23 SD. SHG membership increases economic freedom by 0.22 SD, and loan from ROSCAs increases women's economic freedom by 0.11 SD while membership in NGOs and loan from government programs have no effect on the economic freedom of women. Overall, for all indices, ROSCAs followed by SHG and loans from ROSCAs have strongest effect on women's empowerment.

1.7 Conclusion

Our study motivated by the lack of empirical evidence of ROSCAs on women's empowerment from a policy perspective finds strong positive effects of ROSCAs on women's empowerment. Analysis shows the relevance and prevalence of ROSCAs in India, in myriad forms and functions. We find support for the arguments that ROSCAs can be placed within a broad set of institutions which provide credit (Besley et al., 1993), earning opportunities (Bisrat et al., 2012; Hossein, 2018), social support (Geertz, 1962) and mutual aid (Klonner, 2008). The analysis finds ROSCAs to be better than other micro credit schemes underscoring the significance of saving for financial inclusion (Anderson and Baland, 2002), with an anonymous agreement (Ardener, 1964) that is not reliant on the purchase of a household good and is not supply side determined (Rutherford, 2014).

Our analysis shows that ROSCAs are crucial even in modern times for women's empowerment owing to the development and support ROSCAs endow, especially to women, given the gap in the achievement of financial inclusion (Duflo, 2012; Kabeer, 1999; Goetz and Gupta, 1996). Results support the micro evidence that ROSCAs as an endogenous system provides economic re-

turns (Handa and Kirton, 1999), knowledge of finances (Hossein, 2018), disciplining mechanisms (Anderson and Baland, 2002) and social awareness (Ksoll et al., 2016), which enables women to exercise their agency in making major economic decisions of the household. Providing loans to household through agencies or the government has no effect on women's ability to make economic decisions as also found in India, Bangladesh, Brazil and South Africa (Fultz and Francis, 2013; Mader, 2013; Goetz and Gupta, 1996).

Our results show and confirm the evidence in developing economies of lackluster performance of exogenous micro-credit schemes and transfer programs. On the other hand, ROSCA membership provides a dynamic alternative that could affect the real bargaining power in the decision making without having to revert to the prior situation. There have been suggestions accepted and initiatives taken on considering ROSCAs as a policy tool for women's empowerment, of which some have been successful (Acquah and Dahal, 2018; Rutherford, 2014; Roy and Chowdhury, 2009; Hossein, 2018), and some have backfired, as in the curious case of Nepal (Seibel and Schrader, 1999).

Following Geertz (1962), it could be argued that the process of financial inclusion of women may be likened to climbing a ladder: As women in developing economies reach up with their hands to rungs not previously within their reach, they cannot immediately let go of the lower rungs on which their feet have rested. The process should be something like this: They reach up to a new rung, grasp it tentatively, and only when they are rather sure of its location such as financial returns/strategy of savings, and solidity in terms of security with savings/credit flow do they venture to pull themselves up and let the lower foot finally leave the lowest rung on which they have been supporting themselves. Essentially such a process is not possible if women are in touch with only two adjacent rungs of the ladder – there must be at least three grips through the dynamic movement of the feet such that they are continuously engaged in the realm of finance through savings and credit circulation and intermediation. Otherwise, the uncertainties inherent in securing a grip on the unfamiliar top of the series will not allow them to let go of the bottom one; they must have a dynamic 'middle' basis of security on which they feel they can rely.

1.8 Tables and Figures

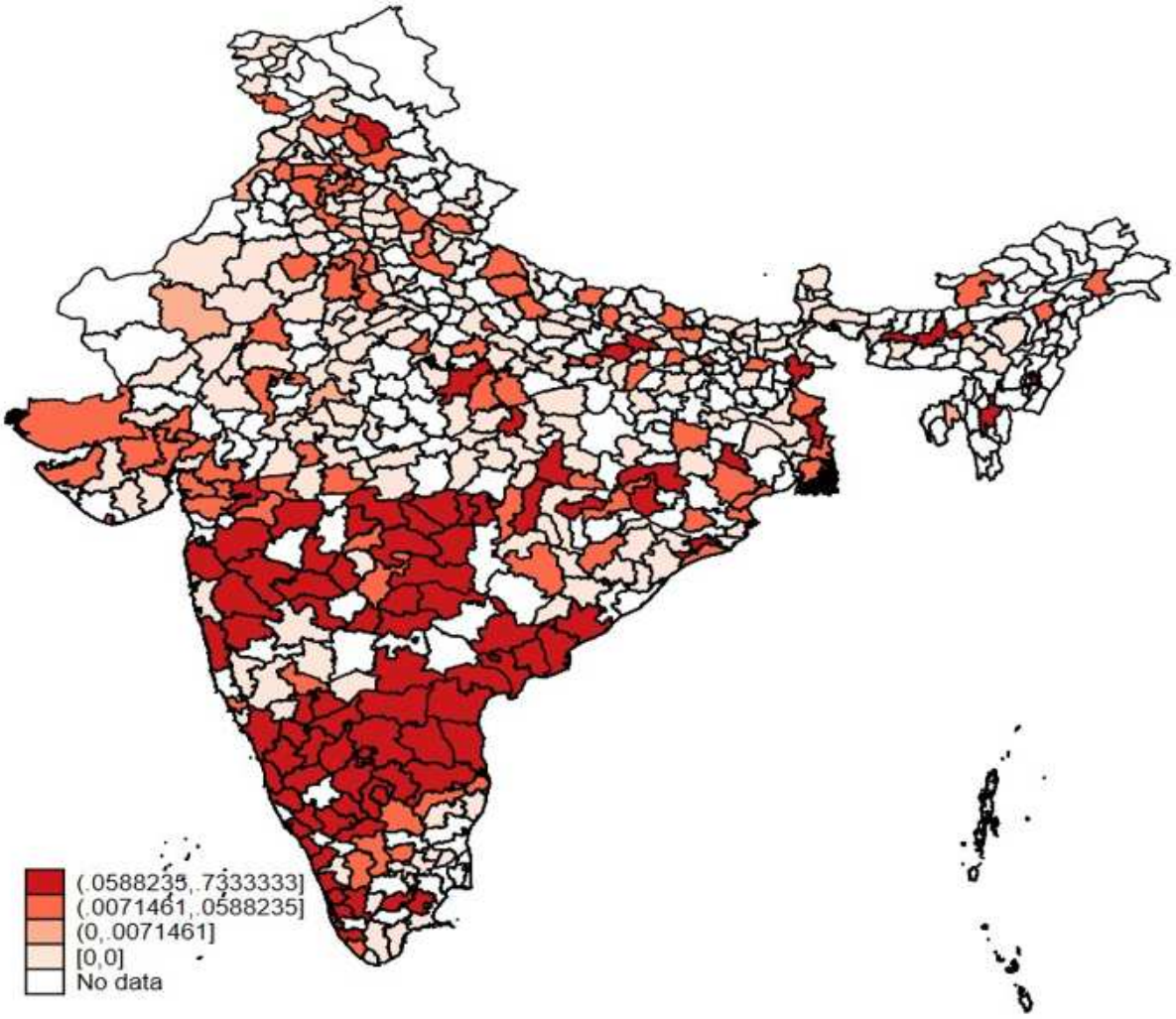

Figure 1.1: ROSCAs Membership, Women, India, District Level, Label: Fraction of membership (0-1), IHDS (2012). Administrative map created by authors using Stata software and matching individual data across districts in India

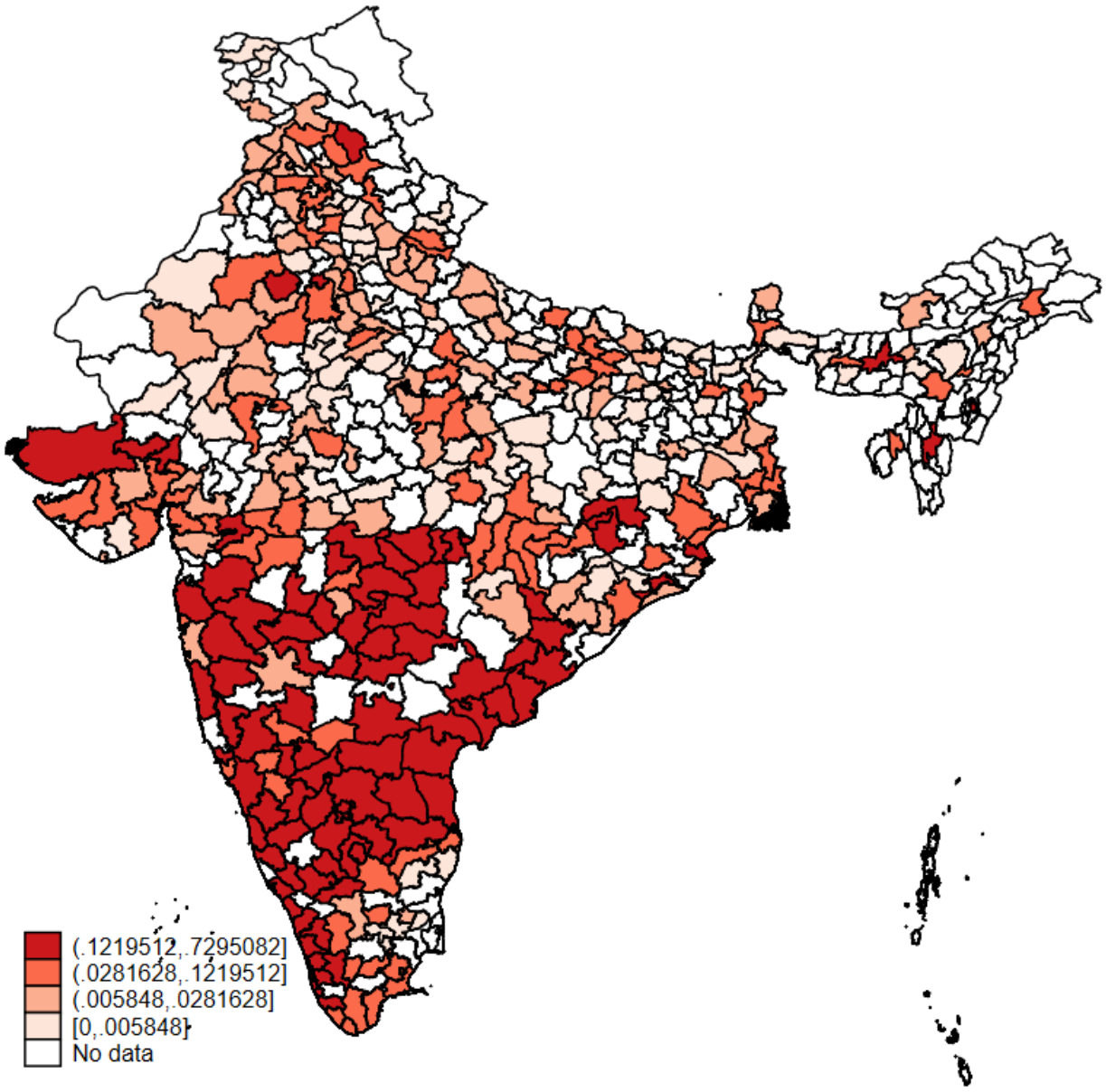

Figure 1.2: ROSCAs Membership, Households, India, States, Label: Fraction of membership (0-1), IHDS (2012). Map created by authors using Stata software and matching household data across districts in India

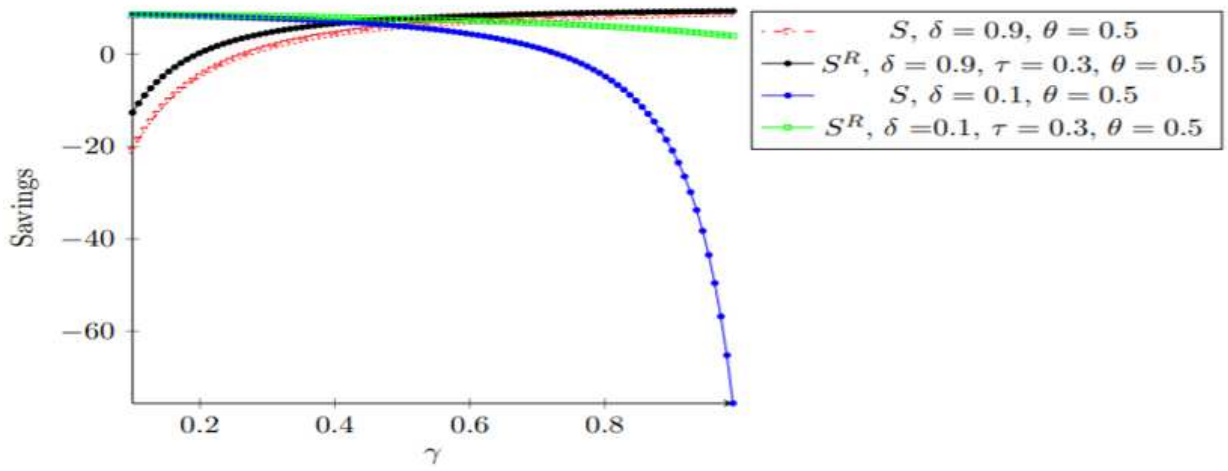

Figure 1.3: Effect of women's bargaining power on household savings at different values of the parameters.

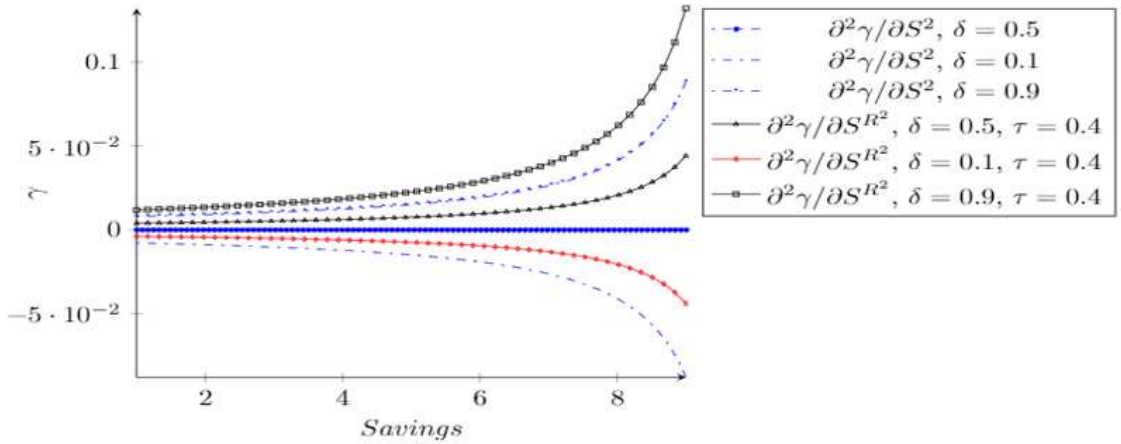

Figure 1.4: Savings in autarky and ROSCAs and its effect on women's bargaining power under different values of the parameters. Here, $\theta = 0.1$ for all cases.

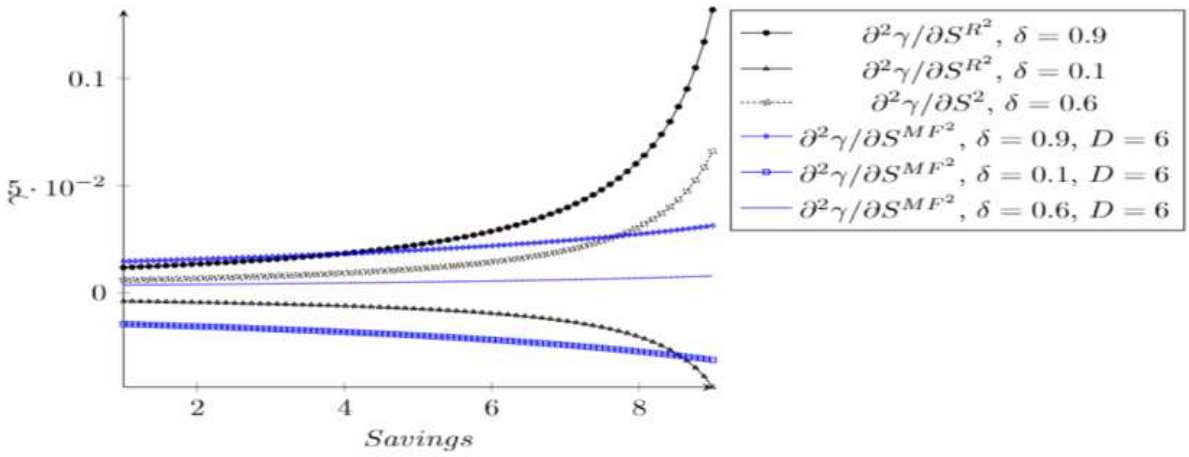

Figure 1.5: Savings in ROSCAs and other micro-finance schemes and its effect on women's bargaining power under different values of the parameters. Here, $\theta = 0.1$, and $\tau = 0.4$ for all cases

Table 1.1: Descriptive Statistics of the IHDS panel, 2005-2012

	2005			2012		
Variables	Obs.	Mean	SD	Obs.	Mean	SD
Independent variables and covariates						
HH. ROSCA member	25400	0.076	0.264	25400	0.128	0.335
HH. NGO member	25391	0.017	0.128	25390	0.012	0.111
HH. SHG member	25397	0.106	0.308	25395	0.223	0.416
Loan from Money Lender	25400	0.146	0.353	25400	0.108	0.310
Loan from Bank	25400	0.119	0.324	25400	0.193	0.395
Loan from ROSCA	25400	0.011	0.103	25400	0.018	0.133
Loan from Government	25400	0.004	0.065	25400	0.004	0.061
Log real HH. Income	25067	11.614	0.970	25096	11.301	0.996
Household Head Education	25370	7.425	4.932	25400	8.408	4.917
Woman's Education	25295	4.535	4.881	25396	5.611	5.156
Age in years	25400	33.219	7.899	25400	40.481	8.346
Household Size	25400	5.643	2.434	25400	5.226	2.277
Poor	25387	0.224	0.417	25396	0.165	0.371
Dependent variables						
Cash for expenditure	25321	0.822	0.382	25358	0.935	0.246
Name in house papers	24362	0.155	0.362	24454	0.194	0.395
Woman's bank account	9276	0.461	0.499	17971	0.596	0.491
Woman's Any Work	26617	0.564	0.496	29713	0.593	0.491
Woman's Work Business	26783	0.036	0.187	29725	0.05	0.218
Woman has a say in major purchases	25391	0.710	0.454	25216	0.817	0.387
Woman has most say in major purchases	25212	0.110	0.313	25171	0.134	0.341
Women does shopping-food and vegetables	25260	0.568	0.495	25358	0.645	0.478
Couple uses contraceptives	23272	0.630	0.483	22918	0.791	0.407
Household member of Mahila Mandal	25390	0.081	0.273	25393	0.109	0.312
Household's electricity hours in a day	19425	16.068	6.708	22352	15.104	6.889
Woman need permission to visit health center	25377	0.751	0.433	25192	0.767	0.423
Women can visit health center alone	24466	0.696	0.460	25091	0.748	0.434
Woman need permission to visit friends/relatives	25028	0.760	0.427	25258	0.683	0.465
Women can visit friends/relatives alone	24035	0.716	0.451	25024	0.806	0.396
Woman need permission to visit grocery store	20867	0.549	0.498	21759	0.560	0.496
Women can visit grocery store alone	21180	0.752	0.432	24140	0.830	0.375
Woman has a say in child's marriage	23910	0.798	0.402	24738	0.896	0.305
Woman has most say in child's marriage	24351	0.102	0.302	24650	0.157	0.364
Woman has a say in what to do in Child's Illness	24300	0.857	0.351	24852	0.920	0.271
Woman has most say in what to do in Child's Illness	24562	0.307	0.461	24795	0.325	0.469
Woman has a say in the number of children	25393	0.807	0.395	24243	0.925	0.263
Woman has most say in the number of children	24762	0.195	0.396	24180	0.265	0.441

Source: Authors elaboration IHDS, 2005-2012. Note: In the estimations we also include woman's marital status as covariate. Responses are conditional on the participation in the eligible women's questionnaire.

Table 1.2: Panel fixed effects- ROSCAs and Economic Freedom for Women, India, IHDS, 2005-2012

	(1)	(2)	(3)	(4)	(5)
Variables	Cash for expenditure	Name house papers	Bank account	Any employment	Business employment
HH. ROSCA member	0.017**	0.033***	0.078***	0.014*	0.014***
	(0.009)	(0.011)	(0.019)	(0.009)	(0.005)
Log real HH. income	0.005*	0.006	0.015*	0.012***	0.013***
	(0.003)	(0.004)	(0.008)	(0.003)	(0.002)
Wave dummy (2005=0, 2012=1)	0.090***	0.025**	0.137***	0.099***	0.013***
	(0.009)	(0.011)	(0.023)	(0.009)	(0.005)
HH. head education (0-15)	0.000	0.001	-0.009***	-0.005***	-0.001**
	(0.001)	(0.001)	(0.003)	(0.001)	(0.001)
Women's education (0-15)	-0.002*	-0.001	0.003	-0.001	0.000
	(0.001)	(0.001)	(0.002)	(0.001)	(0.001)
Women's age in years	0.003***	0.001	0.003	-0.002**	0.001
	(0.001)	(0.001)	(0.003)	(0.001)	(0.001)
Household Size	-0.011***	-0.002	-0.012***	-0.000	-0.002**
	(0.001)	(0.002)	(0.004)	(0.002)	(0.001)
Poor (0/1)	-0.022***	0.007	0.007	-0.011	0.001
	(0.007)	(0.007)	(0.023)	(0.007)	(0.004)
Marital Status (Base: Spouse absent)					
Married	-0.037***	-0.008	-0.055	0.003	0.001
	(0.014)	(0.016)	(0.034)	(0.016)	(0.008)
Widowed	-0.034*	0.160***	0.093*	0.038*	-0.010
	(0.018)	(0.025)	(0.049)	(0.023)	(0.012)
Separated	-0.022	0.041	0.030	0.136***	0.043
	(0.037)	(0.053)	(0.091)	(0.042)	(0.030)
Observations	49,927	48,088	15,037	49,801	49,969
Number of individuals	25,358	24,299	7,606	25,373	25,373

Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1, clustered at the village/PSU/level. The base category of marital status is no spouse or spouse absent. Poor is defined by the Tendulkar cut-off for poverty, 2012 (Desai and Vanneman, 2018).

Table 1.3: Panel fixed effects- ROSCAs and economic decision making for women, India, IHDS, 2005-2012

	(1)	(2)	(3)	(4)	(5)
Variables	Say in Major purchase	Most say in major purchase	Grocery shopping for family	Husband discusses Expenditures	Work
HH. ROSCA member	0.039***	0.010*	0.027**	0.011	0.038***
	(0.012)	(0.007)	(0.012)	(0.008)	(0.011)
Log real HH. income	-0.011**	-0.013***	-0.003	-0.001	-0.006
	(0.005)	(0.003)	(0.005)	(0.003)	(0.004)
Wave dummy	0.099***	0.007	0.073***	0.037***	0.020*
	(0.013)	(0.008)	(0.012)	(0.008)	(0.011)
HH and individual controls	Y	Y	Y	Y	Y
Observations	49,856	49,636	49,869	48,533	48,483
Number of individuals	25,391	25,212	25,260	24,848	24,920

Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1, clustered at the village/PSU level. Additional independent variables in all regressions as in Table 1.2.

Table 1.4: Panel fixed effects- ROSCAs, agency and collective goods in households, India, IHDS, 2005-2012

	(1)	(2)	(3)	(4)	(5)	(6)
Variables	Contraceptive Use	Membership Mahila Mandal	Indoor Pipe Water	Toilet	Separate Kitchen	Electricity Hours
HH. ROSCA member	0.049***	0.179***	0.016**	0.019**	0.037***	0.606***
	(0.011)	(0.013)	(0.010)	(0.009)	(0.011)	(0.212)
Log real HH. income	-0.011**	-0.001	0.012***	0.011***	0.018***	-0.069
	(0.004)	(0.003)	(0.004)	(0.003)	(0.004)	(0.074)
Wave dummy	0.221***	0.019***	0.024***	0.125***	0.001	-1.363***
	(0.012)	(0.007)	(0.009)	(0.009)	(0.011)	(0.207)
HH. and individual controls	Y	Y	Y	Y	Y	Y
Observations	45,538	50,020	50,023	49,890	49,978	37,969
Number of individuals	23,272	25,373	25,374	25,265	25,321	19,425

Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1, clustered at the village/PSU level. Additional independent variables in all regressions.

Table 1.5: Panel fixed effects- ROSCAs and women's mobility, India, IHDS, 2005-2012

	(1)	(2)	(3)	(4)	(5)	(6)
	Health Center		Friend's house		Grocery Shopping	
Variables	Ask Permission	Visit Alone	Ask Permission	Visit Alone	Ask Permission	Visit Alone
HH. ROSCA member	-0.032**	0.039***	-0.067***	0.079***	-0.061***	0.018
	(0.013)	(0.011)	(0.014)	(0.012)	(0.018)	(0.011)
Log real HH. income	-0.020***	0.010**	-0.006	0.006	-0.009	0.010**
	(0.004)	(0.004)	(0.005)	(0.004)	(0.006)	(0.005)
Wave dummy	0.069***	0.050***	-0.032**	0.091***	0.067***	0.054***
	(0.012)	(0.012)	(0.013)	(0.013)	(0.017)	(0.012)
HH. and individual controls	Y	Y	Y	Y	Y	Y
Observations	49,817	48,821	49,536	48,329	42,020	44,664
Number of individuals	25,367	24,466	25,361	25,314	24,151	24,996

Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1, clustered at the village/PSU level. Additional independent variables in all regressions.

Table 1.6: Panel fixed effects- ROSCAs and women's household decision making, India, IHDS, 2005-2012

	(1)	(2)	(3)	(4)	(5)	(6)
Variables	Child Wedding Decision	Child Wedding Most Say	Child Ill Decision	Child Ill Most Say	Number of Children Decision	Number of Children Most Say
HH. ROSCA member	0.052***	0.006	0.019**	0.006**	0.047***	0.018
	(0.012)	(0.008)	(0.009)	(0.013)	(0.012)	(0.011)
Log real HH. income	-0.003	-0.007**	-0.003	-0.011**	-0.010**	-0.022***
	(0.004)	(0.003)	(0.004)	(0.005)	(0.004)	(0.004)
Wave dummy	0.078***	0.047***	0.036***	-0.007	0.102***	0.064***
	(0.011)	(0.009)	(0.010)	(0.013)	(0.010)	(0.011)
HH and Individual controls	Y	Y	Y	Y	Y	Y
Observations	47,932	48,279	48,428	48,633	48,898	48,211
Number of individuals	25,231	25,184	25,256	25,199	25,352	25,282

Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1, clustered at the village/PSU level. Additional independent variables in all regressions.

Table 1.7: Panel fixed effects- endogenous-exogenous micro-credit and women's economic empowerment, India, IHDS, 2005-2012

	(1)	(2)	(3)	(4)
Variables	Cash for expenditure	Say in Purchase Decision	Property Ownership	Work Business
HH. ROSCA member	0.016**	0.039***	0.033***	0.014***
	(0.007)	(0.009)	(0.009)	(0.005)
Loan from money lender	-0.012*	-0.022**	-0.010	0.003
	(0.007)	(0.009)	(0.007)	(0.004)
Loan from bank	0.006	-0.010	0.026***	0.012***
	(0.006)	(0.008)	(0.007)	(0.004)
Loan from ROSCA	0.053***	0.012**	0.018*	0.010**
	(0.019)	(0.040)	(0.020)	(0.011)
Loan from govt. program	0.015	-0.036	-0.037	0.025
	(0.031)	(0.022)	(0.037)	(0.016)
HH. NGO member	0.013	-0.004	0.008	-0.003
	(0.017)	(0.022)	(0.020)	(0.012)
HH. SHG member	0.006	0.037***	0.004	0.004
	(0.006)	(0.008)	(0.008)	(0.004)
HH and individual controls	Y	Y	Y	Y
Observations	49,927	49,856	48,088	49,969
Number of individuals	25,374	25,374	25,299	25,373

Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1, clustered at the village/PSU level. Additional independent variables in all regressions.

Table 1.8: Panel fixed effects instrumental variable regression- ROSCAs and economic freedom for women, India, IHDS, 2005-2012

	(1)	(2)	(3)	(4)	(5)
Variables	Cash for expenditure	Name house papers	Bank account	Any employment	Business employment
HH. ROSCA member	0.022**	0.041***	0.082**	0.020*	0.021**
	(0.014)	(0.017)	(0.035)	(0.016)	(0.016)
Log real HH. income	0.005*	0.006*	0.015**	0.012***	0.012***
	(0.003)	(0.003)	(0.007)	(0.003)	(0.003)
Wave dummy	0.089***	0.024***	0.137***	0.101***	0.101***
	(0.007)	(0.009)	(0.022)	(0.008)	(0.008)
HH. and individual controls	Y	Y	Y	Y	Y
F test (instrument)	2115	2088	1294	2136	2167
Observations	49,927	48,088	26,904	49,801	49,779
Number of individuals	25,374	25,299	19,473	25,373	25,373

Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1, clustered at the individual level. Additional independent variables in all regressions. The IV is strong given the F test for excluded instrument given by Staiger and James (1997). The strength of the IV is tested using the "xtoverid, nois" command in STATA.

Table 1.9: State and District Fixed Effect analysis for robustness of impact of ROSCA on women's economic empowerment

	(1)	(2)	(3)	(4)	(5)
Variables	Cash for expenditure	Name house papers	Bank account	Any employment	Business Employment
Panel (a) State FE					
HH. ROSCA Member	0.019**	0.040***	0.082***	0.026***	0.013***
	(0.008)	(0.011)	(0.020)	(0.009)	(0.005)
Wave Dummy*State (year=2005)	33	33	33	33	33
Panel (b) District FE					
HH. ROSCA Member	0.016**	0.032***	0.078***	0.023***	0.012**
	(0.007)	(0.009)	(0.019)	(0.009)	(0.005)
Wave Dummy*District (year=2005)	380	380	380	380	380
Observations	49,927	48,088	15,037	49,801	49,969
Number of individuals	25,374	25,299	7,606	25,373	25,373

Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1, clustered at the village/PSU/level for the State Fixed Effects analysis, and at the individual level for the District Fixed effect analysis. There are 33 states 380 districts covered in the sample from the IHDS. The base category of marital status is no spouse or spouse absent. Poor is defined by the Tendulkar cut-off for poverty, 2012 (Desai and Vanneman, 2018).

Table 1.10: Cross-sectional linear probability regression with district and caste controls: women's ROSCA membership and economic freedom, India, IHDS, 2012

	(1)	(2)	(3)	(4)	(5)
Variables	Cash for expenditure	Name on house papers	Decision making Land purchase	Decision Number of children	Bank account
Women ROSCA member	0.037***	0.064***	0.033***	0.028***	0.109***
	(0.006)	(0.010)	(0.008)	(0.005)	(0.012)
Log real HH. Income (base 2005)	0.004**	0.012***	-0.007***	-0.001	0.015***
	(0.002)	(0.002)	(0.002)	(0.002)	(0.004)
Woman's education	0.004***	0.003***	0.003***	0.002***	0.017***
	(0.000)	(0.001)	(0.001)	(0.000)	(0.001)
Woman's age in years	0.004***	0.006***	0.007***	0.001***	0.009***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Number of children alive	0.011***	-0.000	0.018***	-0.001	0.018***
	(0.001)	(0.002)	(0.002)	(0.001)	(0.003)
Household head sex	0.017***	0.099***	0.060***	0.026***	0.137***
	(0.004)	(0.007)	(0.006)	(0.004)	(0.009)
Household head's age	-0.002***	-0.001***	-0.004***	-0.001***	-0.003***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Household size	-0.008***	-0.003***	-0.016***	-0.001	-0.014***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.002)
Urban	0.011**	0.007	0.004	-0.004	0.023**
	(0.005)	(0.006)	(0.007)	(0.004)	(0.010)
Forward caste (excluding Brahmins)	-0.003	0.020***	0.009	0.003	0.003
	(0.005)	(0.007)	(0.008)	(0.005)	(0.011)
Other Backward Caste	-0.012***	0.017**	-0.001	0.005	-0.036***
	(0.005)	(0.007)	(0.007)	(0.004)	(0.010)
Scheduled Caste/Tribe	-0.001	0.015**	0.008	0.006	-0.014
	(0.005)	(0.007)	(0.008)	(0.005)	(0.011)
Constant	0.814***	-0.254***	0.723***	0.886***	0.008
	(0.019)	(0.026)	(0.027)	(0.018)	(0.039)
District dummies	370	370	370	370	370
Observations	34,055	32,785	33,543	32,826	23,886
R-squared	0.124	0.193	0.273	0.199	0.185

Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1, clustered at the individual level. Brahmins is the base group for caste comparisons.

Table 1.11: Comparison of Exogenous and Endogenous micro-credit- OLS with district and caste dummies, IHDS, 2012

	(1)	(2)	(4)	(5)	(6)
	Economic Freedom	Economic Decision	Household Decision	Agency	Mobility
ROSCA Membership	0.23***	0.20***	0.16***	0.67***	0.18***
	(0.02)	(0.03)	(0.02)	(0.03)	(0.03)
NGO Membership	0.05	0.12*	0.04	0.17***	0.14**
	(0.04)	(0.07)	(0.05)	(0.06)	(0.07)
Loan from Govt. Prog.	-0.03	0.06	-0.10**	0.01	-0.08
	(0.09)	(0.12)	(0.08)	(0.07)	(0.15)
Loan from ROSCA	0.11***	0.02	0.04*	0.17***	0.08***
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
SHG Membership	0.22***	0.12***	0.06***	0.53***	0.19***
	(0.02)	(0.02)	(0.01)	(0.02)	(0.02)
Household Controls	Y	Y	Y	Y	Y
District control	370	370	370	370	370
Caste control	4	4	4	4	4
Observation	32758	27845	32136	20868	31946

Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1, clustered at the individual level. Additional independent variables in all regressions.

Chapter 2

Does reliable electrification reduce gender differences? Evidence from India

2.1 Introduction

Issues of access and provision of household infrastructure and labor-saving technologies are pertinent in developing economies with lower levels of access to clean drinking water, fuel, safe transportation, and electricity (Dinkelman, 2011; Mensah et al., 2014; Klasen, 2019).[19] These issues affect women disproportionately given that they often spend more time than men at home, and are subjected by social norms to bear the major burden of home production (Ferrant and Thim, 2019; Fletcher et al., 2017; Klasen, 2019). One such issue is that of reliable electrification in India (Kennedy et al., 2019; Aklin et al., 2016; Sedai et al., 2020b; Klasen, 2019), to which very little attention has been paid by policy making, especially from a gendered perspective. The issue of household electrification is more than just the presence or absence of grid connections, or other alternatives; its reliability (e.g. hours of electricity per day) is critical to productive activity and social life, especially in developing countries (Klasen, 2019; Aklin et al., 2016; Fletcher et al., 2017; Dinkelman, 2011).[20] Reliability is a significant determinant of household satisfaction with electrification and has been causing social unrest in India (Aklin et al., 2016; Klasen, 2019; Sedai et al., 2020a).[21] In this context, this study examines the hours of electricity available per day as the

[19] This study has been published in the Journal of Economic Behavior and Organization as a co-authored work with Ramaa Vasudevan, Anita Alves Pena and Ray Miller.

[20] Recent studies have shown that increasing electricity connections does not supercharge economic development in developing economies (Lee et al., 2020). In the case of India, a nation-wide act to increase electricity connection from 2005-2014, did not increase household and national income (Burlig and Preonas, 2016).

[21] Aklin et al. (2016) find that an increase of one standard deviation (6.5 h) in duration increases the level of satisfaction with lighting by 0.3 points on a 0–2 scale, corresponding to an increase of about 40% of the standard deviation of satisfaction.

measure of reliability of electrification and analyzes its effects on welfare outcomes stratified by gender.[22]

Studies that have looked at the microeconomic consequences of electrification on women's welfare have focused primarily on electricity connections, and argued that electrification increases female labor force participation (LFP) and empowerment (Rathi and Vermaak, 2018; Samad and Zhang, 2019; Sedai et al., 2020b; Dinkelman, 2011; Winther et al., 2017). However, available literature in developing economies lacks three integral components for a robust understanding of the impact of electrification on women's welfare: (i) addressing endogeneity; self-selection is involved since consumption and supply of electricity are non-random, (ii) reduced form models have used electricity access as the explanatory variables without considering the reliability of electricity, and (iii) existing studies have focused either on the labor force participation, intra-household resource allocations, or women's empowerment instead of a holistic labor and non-labor market analysis. Our study addresses these gaps in the literature through an analysis of the causal effects of reliable electricity on a comprehensive set of labor and non-labor market outcomes for men and women that include both the intensive and extensive margins of work.

Fluctuating voltages, poor maintenance service, frequent power outages, and the appropriation of the limited supply of electricity by elite households have been a norm in India (Rathi and Vermaak, 2018), especially in rural areas (Joseph, 2010; Aklin et al., 2016; Kennedy et al., 2019; Chatterjee and Pal, 2020). Despite tremendous progress at the extensive margin of providing access (Khandker et al., 2014; Rathi and Vermaak, 2018; Samad and Zhang, 2019), as of 2018, six relatively poor states in India have less than 15 hours of electricity on a typical day (Kennedy et al., 2019; Sedai et al., 2020a).[23] Analyses of national and regional household surveys and review of available literature shows little progress in the reliability of electricity (measured by hours

[22]Having said this, we acknowledge that hours of electricity available in a day may not reflect the actual supply quality in terms of ample voltage to run appliances on a day to day basis. To attenuate this issue, we control for the electricity payment per hour and state level percentages of peak load surplus/deficit in mega-watts.

[23]Official reports indicate that the objective of 100% electrification of all households has been achieved (Agrawal et al., 2020), yet, only 16% of electrified rural households receive full six hours of electricity during the peak period between 5 PM and 11 PM (Canares et al., 2017). As of 2018, it was reported that "nearly one-fifth of India's rural households still remain in acute darkness" (Singh and Sundria, 2017).

of electricity available) in the household from 2005-2018 in contrast to the substantial progress in providing connections (Sedai et al., 2020a). For households connected to the grid, limited supply may be caused by lack of capacity and rationing.[24] For households using distributed (off-grid) technology, limited hours may, for instance, be related to the availability and affordability of fuel to run the off-grid technologies (Aklin et al., 2016).

Electricity connection is a neccessary but not a sufficient condition to counter energy poverty (Kennedy et al., 2019). Recent studies by Harish et al. (2014) and Sedai et al. (2020a) criticized the frequently used “binary metric" of whether people have/do not have an electricity connection as it can be misleading. Lack of supply reliability, especially during peak periods, acts as an impediment to post electrification decisions, such as the purchase of domestic appliances (TV, fridge, computer, air-conditioner, washing machine, heater, etc.), which lowers the required time for home production, and restricts the efficient allocation of time into labor and home production (Ferrant and Thim, 2019; Klasen, 2019; Sedai et al., 2020b). These time-saving technologies are critical for women, given the norms-based supply side constraints to their LFP, and demands for home production (Fletcher et al., 2017; Ferrant and Thim, 2019; Klasen, 2019; Sedai et al., 2020b).

We examine electricity supply using two household surveys, the India Human Development Survey (IHDS, 2005-2012) and the Access to Clean Cooking Energy and Electricity Survey (ACCESS, 2015-2018), to substantiate lack of reliable electrification as a persistent issue. We then use the balanced sample of households with electricity connections from IHDS data and carry out panel fixed effects and instrumental variable regressions to estimate the effect of electricity reliability on outcomes of interest.[25] Following Bai et al. (2019); Dang and La (2019) and Sedai et al. (2020b,a), we use a geographic instrumental variable: average hours of household electricity at the

[24]Given the high cost of electricity supply to rural areas and low affordability, electricity utilities serving rural areas resort to the practice of rationing supply by restricting the periods of availability of electricity to match the demand for electricity (Nhalur et al., 2018). Affordability to consumers and the public debt burden due to subsidies to electricity utilities are among other hindrances to complete electrification in India (Venkateswaran et al., 2018).

[25]Dropping the data on households without electricity connections implies our sample is representative of better-off households in terms of income and wealth.

state level, excluding one's own district. The instrument is strong as shown by the F statistic for the test of excluded instruments (Staiger and James, 1997).

We find that increasing the number of electricity hours in the household increases the likelihood of employment in the usual status[26] ($\geq$ 240 hours or $\geq$ 30 days in a year) for both men and women, with a stronger effect on women. A 10 hour increase in household electricity increases the usual employment status by 4.2 pp for women and by 2.8 pp for men. There is no statistical difference in terms of principal employment ($\geq$ 180 days in a year)—the effects are 4.0 pp for men and 3.9 pp for women. We observe an increase in work days for both men and women, and a decrease in work hours (significant for men) with improved electricity reliability. This supports the hypothesis of labor productivity effects, or reduced work hours through time efficient technologies (electric irons, refrigerators, sewing machines), as also found by Rathi and Vermaak (2018) in India and South Africa between 2005-2012 and by Dinkelman (2011) in South Africa between 1996-2001.

We find significant positive effects of reliable electrification on the annual earnings of both men and women, with higher earning potential for women as compared to men. There is a significant reduction in weekly fuel and water collection minutes for both men and women with larger reductions (respite) for women as compared to men. Increasing reliability of electrification reduces household's expenditure on firewood and increases the likelihood of acquiring basic household amenities such as a household toilet and indoor piped water. We also show that reliable electrification is critical in empowering women in socio-economic and reproductive decision making, and has a positive effect on women's general health. Our results are robust to alternate specifications of dependent variables, and are similar to the results obtained by Rathi and Vermaak (2018) and Van de Walle et al. (2017) on the gendered labor market effects of electrification.

[26]The usual status (usual principal plus subsidiary status, UPSS) is applied to a person who pursued some economic activity for 30 days (240 hours) or more during the reference period of 365 days preceding the date of the survey. An individual who has worked for a majority of the 180 days prior to the date of the survey is considered employed by the usual principal activity status (UPS). All those with either UPSS or UPS are considered as being in the labor force through the usual principal plus subsidiary status. We use usual status and at least part-time employment interchangeably, similarly for usual principal status and full-time employment.

2.2 Literature and conceptual review

2.2.1 Gender differences in the labor market and the role of labor saving technologies in India

Recent trends of falling Female Labor Force Participation (FLFP) in India are seen as a challenge that requires immediate policy intervention to protect against deterioration of female well-being and empowerment.[27] Increased FLFP changes the social norms and practices, and introduces a phase where individuals with varying degrees of negotiating power can promote their interests (Winther et al., 2017). Earned income through LFP has been found to have a positive impact on women's bargaining power, and reduce gender disparity in developing economies (Anderson and Eswaran, 2009; Anderson and Baland, 2002). Moreover, it has been estimated that per capita income could be 10 percent higher in 2020, and 20 percent higher by 2030 if India's gender participation gap could be halved from year 2000 levels (Kapsos et al., 2014).

As argued by Sen (1987), in any model of economic development it is crucial to take into account that cooperation and conflict exist simultaneously in gender divisions. These attributes are present not only in the labor market but also within the household and are discussed through the supply and demand side constraints to FLFP. On the supply side, Indian households often require that women prioritize home production, and may even explicitly constrain LFP of married women (Fletcher et al., 2017). Societal expectation of women's role as caregivers and caretakers of the household often mean that women who seek work encounter opposition from their peers and families, leading to lower participation (Kapsos et al., 2014). There is also evidence that these norms are typically more binding among wealthier, educated, upper caste households, suggesting that economic growth alone may not alter their influence (Fletcher et al., 2017; Klasen, 2019). On the demand side, women face legal, normative, and economic constraints to work as they are still

[27] The LFP rate for women aged 15 years and above fell by 10.1 pp, corresponding to 22.6 million fewer women in the labor force in 2010 than in 2005 (Kapsos et al., 2014). The drop was higher in rural areas as compared to urban areas, 11.5 and 5.0 pp, respectively. In comparison, male LFP in India declined by only 3.4 pp over the same period.

subject to laws governing when (i.e. which shifts) and in which industries they can work (Fletcher et al., 2017; Jayachandran, 2019).

The role of labor-saving household technologies in determining LFP of men and women has been understudied in India (Fletcher et al., 2017). This is particularly interesting as there are two contrasting theories of the impact of household technologies in reducing gender inequality. On one hand, labor saving technologies relax time constraints and reduce drudgery. Time saved due to better technology could increase time in paid work, therefore these technologies could increase FLFP (Ferrant and Thim, 2019; Klasen, 2019; Fletcher et al., 2017). On the other hand, as long as the stereotype threats and biases persist, the potential of these technologies in reducing gender inequality will be diminished, even if the technological conditions for an even playing field are met (Kabeer, 1999; Winther et al., 2017; Kapsos et al., 2014). As Klasen (2019) argued, even when the availability of labor-saving technologies is no longer a constraint, the issue of relative bargaining power and distributional equity may still linger.

Household electrification as a labor saving technology has been argued to disproportionately benefit women and increase FLFP (Ferrant and Thim, 2019; Rathi and Vermaak, 2018; Sedai et al., 2020b). However, electrification also increases household and farm income, and the LFP of men in developing countries which has been associated with falling FLFP (Rathi and Vermaak, 2018; Van de Walle et al., 2017; Chakravorty et al., 2014; Sedai et al., 2020a; Fletcher et al., 2017; Kapsos et al., 2014; Klasen, 2019). In this context, it would be critical to examine the net effect of reliable electrification on LFP across gender. This is important from a policy perspective as there is an ongoing debate on the inefficiencies in the current scheme of subsidized electricity distribution in India, and the need to privatize electricity generation and distribution (Burgess et al., 2020). As Duflo (2012) argued, if the relative effect of a public policy[28] is such that it reduces gender differences in the labor market and in the household, then a continued policy commitment

[28]In the context of this study, the public policy is a thrust to improve the reliability of electricity, hours of electricity available to households in a day.

to reliable electrification for its own sake may be needed to bring about more equality between men and women.

2.2.2 Reliable electrification and gender equality

Energy poverty is argued to have various socioeconomic consequences, with implications for social wellbeing, health and productivity, among others (Churchill et al., 2020). Cecelski (2005) used UN gender-related measures, such as the Gender Development Index (GDI) and Gender Empowerment Measure (GEM), to explore if energy consumption is related to gender equity and empowerment. The findings indicate that per capita energy consumption correlates closely with the GDI. The relationship is non-linear (concave), suggesting that even modest increases in energy and electricity consumption could be associated with substantial improvements in gender-related development in terms of women's life expectancy, literacy, and school enrollment.

At the micro level, increasing the reliability of electrification economizes on the time spent in home production, and facilitates the potential reallocation of time from unpaid household labor to paid employment. For example, a study by Kanagawa and Nakata (2008) in Assam, India, showed that the availability of lighting during evening hours extended the effective workday and allowed women to leave certain household chores for the night enabling them to participate in more formal economic activity during the day. In case of erratic power supply, these benefits may fail to materialize. Dinkelman (2011) in a study in South Africa found that the deficiency of electricity led to sub-optimal time allocation to home production hindering the possibilities for paid employment, and increasing the time spent on unpaid home production.

In addition to increased productivity in home production, reliable electrification increases the exposure and social awareness through media (radio, television), which have been found to change gender attitudes[29] and increase women's mobility and autonomy (Sedai et al., 2020b; Jensen and Oster, 2009; Winther et al., 2017). Access to cable television, which is dependent on the reliability

[29]The assumed mechanism is that individuals, especially in rural areas come in contact with outside world through television and radio, and among other, these services allow individuals to gain knowledge about family planning, contraceptive use, pregnancy, latrine building, perception of own-village status and also learn about and adopt alternative gender norms (Winther et al., 2017; Jensen and Oster, 2009).

of electrification, has been associated with significant decreases in the reported acceptability of domestic violence toward women, preference for a son, and fertility, along with having a positive impact on gender norms and how girls are valued compared to boys (Jensen and Oster, 2009; Winther et al., 2017). Reliable electricity could affect fertility and women's decision making directly through knowledge and information systems, or indirectly, by increasing LFP and relative wages of women as compared to men (Galor and Weil, 1993).

Households, especially in rural India, have depended for years on kerosene and biomass for lighting, cooking and reading, however, these sources of fuel contribute to air pollution and are hazardous for health (Parikh, 2011; Aklin et al., 2016). Use of electricity instead of fuel wood for cooking, heating, reading and lighting reduces household air pollution and leads to decreased risk of respiratory disease, particularly among women and young children (Parikh, 2011), along with reductions in low birth weight and neonatal death (Epstein et al., 2013). Less kerosene and firewood usage implies better health outcomes for women which has a direct effect on their labor supply (Epstein et al., 2013; Sedai et al., 2020b).

According to Rathi and Vermaak (2018), although rural electrification has positive welfare impacts, the benefits of electrification do not accrue universally, but instead depend on gender roles, supporting policies, and the labor absorptive capacity of the economy. Their study concludes that electrification raises the annual incomes earned by those who work in paid employment for both men and women in India and South Africa. Results also show that in India, with respect to the number of paid work-hours, both men and women worked fewer hours, suggesting that electrification raises productivity. In contrast, for South Africa, where the labor market had less absorptive capacity, there were no employment benefits of electrification, but women benefited more in terms of increases in earnings as compared to men.[30]

[30]Dinkelman (2011) estimated that rural electrification increased rural female's employment by 9–9.5 percentage points in South Africa. Similarly, Grogan and Sadanand (2013) found the probability of women working outside the home increased by 23 percent in Nicaragua as a result of rural electrification. However, to our knowledge, there is no estimate of the effect of electricity reliability on labor market activity by gender.

In studies most closely related to ours, Sedai et al. (2020a,b) and Samad and Zhang (2019) found strong *positive* effects of additional hours of household electricity on household's income, assets, basic amenities and women's autonomy. Sedai et al. (2020a) used panel fixed effects to analyze the impact of electricity reliability on household welfare (consumption, assets and amenities). Samad and Zhang (2019) conducted a cross-sectional analyses of women's empowerment using the spatial variation in access to electrification.[31] Their results show that an additional hour of electricity increases average household's annual consumption by 0.2 percent, income by 0.3 percent, and women's freedom of movement by 2.3 pp. However, their analysis does not discuss the effects of additional electricity hours on gender differences in the labor market and the household. This paper, in contrast, investigates the effects of reliable electrification on gender disaggregated outcomes in the labor market, fuel collection, women's empowerment and energy choices. In addition, examination of the differences between men and women allows us to infer the relative empowerment of women as compared to men.

2.2.3 The context of electrification in India

In the last few decades, the government of India has focused on access to electrification in its national policies. The government allocated substantial resources to increase electricity and these initiatives are expected to contribute significantly to achieving the United Nations' Sustainable Energy for All initiative, which targets to achieve universal access to modern energy services by 2030. However, providing universal access to electricity has not been complemented with policy measures related to affordability, reliability, and quality of service (Sedai et al., 2020a; Aklin et al., 2016). Major reasons behind the lack of reliable electricity despite the policy impetus are (i) poor infrastructure, (ii) policy focus on free connections, (iii) un-affordability and, (iv) poor financial structure of distribution companies (Joseph, 2010; Allcott et al., 2016; Burgess et al., 2020).

[31] Sedai et al. (2020b) look at the effect of electricity access on household welfare in terms of consumption, assets, amenities, and status of poverty, but do not look at the means to welfare enhancement- which are gains in employment, productivity and business activity for household members due to better electrification.

In 2003, the landmark “Electricity Act" was implemented to consolidate the laws relating to the generation, transmission, distribution, trading, and use of electricity. The Act outlined measures conducive to the development of the electricity sector, promoting competition, protecting the interest of consumers and supply of electricity to all areas, rationalizing electricity tariffs, and ensuring transparent policies related to subsidies, amongst other provisions. The main objective was the electrification of all villages and habitations with more than 100 people, installing small generators and distribution networks where grid extension is not considered cost-effective, and providing free electricity connections to households below the poverty line. The public program, Rajiv Gandhi Grameen Vidyutikaran Yojana (RGGVY), increased the village electrification rate to 74% by the end of 2010 from 59% in 2000 (Rathi and Vermaak, 2018). In recent times, the central government has been supplementing the efforts of the state governments to achieve universal access to electricity by providing insurance to distribution companies against their losses through various schemes.[32] However, despite significant leaps in providing electricity connections, electricity reliability has been dismal (Sedai et al., 2020a,b).[33]

Figure 2.1 and 2.2 show the reliability and the change in distribution of electricity at the household level between 2005-2018. Figure 2.1 highlights the lack of reliability electricity spatially and temporally between 2005-2012 at the national level. The figure shows that some states had better reliability of electrification compared to others, and as such points to electrification being endogenous with the level of development. Figure 2 shows the hours of electricity gained or lost

[32]Namely: Deen Dayal Upadhyay Gram Jyoti Yojana (DDUGJY), Integrated Power Development Scheme (IPDS), Pradhan Mantri Sahaj Bijli Har Ghar Yojana (Saubhagya) and the Ujjwal Discom Assurance Yojana (UDAY).

[33]Government reports indicate 16 to 24 hours of supply in rural areas while consumer surveys and sample measurements report much lower hours. One survey by Smart-Power reports that half of rural households experience eight hours of power cut in a day, and nearly half the rural enterprises use non-grid supply options. The nationwide village survey by the Ministry of Rural Development in 2017, indicates that only half the villages get more than 12 hours of supply (Sreekumar et al., 2019). As per the government reports, India has achieved 100% village electrification (Shrimali and Sen, 2020). However, from 2015-2018 average hours of electricity in a day increased from approximately 13 hours a day to 14.5 hours a day. Electricity during night time was relatively stagnant, changing from 3.4 hours to 3.5 hours a day (Sedai et al., 2020b).

by the household during the period 2005-2018.[34] The figure shows that while some households gained hours of electricity, some household's lost in terms of reliable electrification. These different surveys point to the same re-distributive trend in electricity over time. This is probably because of the policy impetus on increasing the connections without corresponding improvements in the grid infrastructures, which might have put pressure on the grid capacity, and led to rationing of supply, as has been pointed out by Aklin et al. (2016) and Sedai et al. (2020a). Therefore, the well-acknowledged trade-off between extending basic access to more people and enhancing the access of those already served (Marzolf et al., 2019) seems to hold in terms of electricity supply in India.

The main reason behind the persistence of outages in India as argued by Pargal and Banerjee (2014) is the lack of commercial viability of the electricity distribution business. After-tax losses, mainly concentrated in the distribution segment, in 2011 were equivalent to nearly 17 percent of India's gross fiscal deficit and around 0.7 percent of GDP (Pargal and Banerjee, 2014). According to Joseph (2010), electricity utilities are under the ambit of the government authorities, who see electricity users not as consumers but as voters. Hence, under-pricing of electricity is popular for these authorities. As Burgess et al. (2020) argued, it is common to observe electricity costs to be set well below the full recovery cost. This under-recovery is further exacerbated by electricity theft, transmission and distribution losses (Joseph, 2010).[35] Distributional inefficiencies have attracted private players into the electricity market (Joseph, 2010), and there have been arguments for progressive pricing depending on price elasticity (Chindarkar and Goyal, 2019; Harish et al., 2014). However, so far the lack of a gendered understanding of the impact of reliable electrification has overshadowed the true cost-benefit trade-offs within households.

[34]We analyze electricity reliability across all seven regions at the national level between 2005-2012. However, due to data limitations, we analyze electricity reliability only across six relatively poor and populous states between 2015-2018.

[35]There is under-pricing of electricity to the weaker section of society, almost free electricity to farmers, and pricing above the Average Cost of Supply (ACS) to other consumer groups (commercial and Industrial groups) (Jain and Nandan, 2019). The pricing above ACS to the industry further exacerbates the commercial viability of distribution utilities. Higher pricing charged by distribution utilities prompts the large consumers of electricity (industry) to go for self-generation (Jain and Nandan, 2020). Thus in this way, distribution utilities can lose the lucrative consumer group.

2.3 Data and empirical framework

2.3.1 Data

The data used for this analysis is from the second and third wave of the Indian Human Development Survey (2005-2012) (Desai and Vanneman, 2018). IHDS are nation-wide gender-desegregated sample surveys jointly carried out by researchers from the University of Maryland and the National Council of Applied Economic Research (NCAER) in New Delhi (Desai and Vanneman, 2018). IHDS covers wide-ranging topics at the household, individual and village level on demographic and socio-economic characteristics. The survey covers key gender disaggregated labor and non-labor market characteristics such as: employment for over 240 hours in a year (UPSS, usual status), employment for over 180 days in a year (UPS, usual principal status), work days, work hours, annual earnings, weekly fuel and water collection minutes, basic households amenities, choice of fuel, gender relation variables, energy services, and spending on energy.

Our treatment variable 'hours of electricity on a typical day' is derived from the survey item, "Does this house have electricity?", if yes, "How many hours per day do you generally have power?" It is important to highlight that electricity hours in a day may not reflect the supply quality given the high degree of voltage fluctuations, especially in rural areas. Therefore to attenuate the issue of inability to measure electricity quality (in terms of proper voltage, > 220 Volts), we use two variables to control for supply quality. First, we use the data from the Ministry of Power, India on 'peak load surplus/deficit' (%) as a control in the analysis.[36] Second, we control for the electricity payment per hour of electricity available by the household.[37] Due to the inability to accurately quantify the quality of electricity, we restrict our interpretation of the treatment as the effect of reliability of electricity.

[36]PLD is obtained from the annual reports of the Central Electricity Authority, India, Annual Reports (2005 & 2012, https://cea.nic.in/l-g-b-r-report/?lang=en). Peak load surplus/deficit (PLD) data is derived at the state level for 2005 and 2012 and merged with the IHDS panel. It is percentage value which hypothetically ranges from -100 to 100. The variable is derived as: (availability – requirement)/requirement of electricity in mega-watts by state for 2005 and 2012.

[37]Dividing the monthly electricity bill by hour of electricity available controls for the potential quality but does not bias the treatment effect which is the quantity of hours of electricity.

In addition to IHDS data, we also use the ACCESS survey (2015-2018) to examine the recent trends in electricity hours in six states (Uttar Pradesh, Madhya Pradesh, Bihar, Jharkhand, West Bengal and Orissa). The analysis of descriptive statistics from the ACCESS survey provides inferences of the present state of electrification in relatively poor and populous states in India (Mani et al., 2018; Sedai et al., 2020a). Due to the lack of gender disaggregated data in the ACCESS survey, our regression analysis focuses on the variables in the IHDS survey.

We exclude individuals whose household did not have access to electricity in both waves of the IHDS (observations dropped) as the focus of the analysis is on the intensive margin of reliability of electricity supply. After dropping the observations for households without electricity access and individuals below the age of 17 and above 70, we have a time balanced sample of 33,183 men and 32,275 women in each round of the IHDS survey. The sample for the analysis of employment, work hours, work days, fuel and water collection, energy choices and amenities are drawn from the individual based questionnaire, while the empowerment outcomes are drawn from the women's questionnaire of the survey. It is important to note that the comparison of outcomes between men and women is not necessarily for the same household. The inferences drawn and compared are not for couples, or adults in the same household, but for the overall sample.

2.3.2 Empirical model

Baseline model and endogeneity

The baseline individual fixed effect estimation is given as

$$Y_{it} = \beta EH_{it} + X_{it}^{'}\delta + \theta_i + \gamma_t + \alpha D_{jt} + \lambda P_{jt} + \epsilon_{it} \tag{2.1}$$

where Y_{it} represents the outcome of interest for individual i at time t: employment, work hours, work days, annual earnings, fuel and water collection minutes, energy choices, basic household amenities, and women's empowerment. EH_{it} is the hours of electricity available in the household of individual i at time t. In addition to the effect of additional hours, we create survey sample weighted quartiles of electricity hours and analyze a piecewise linear model with 0-9 hours of

electricity in a day as the base category. $X_{it}^{'}$ is a vector of individual and household observable socioeconomic and demographic characteristics: household: wealth, measured by total assets and size, and individual: education, age, and marital status. In addition, in all the analyses, we control for household's payment for electricity per hour available, and percentage of PLD % of electricity at the state level. The unobserved θ_i is modeled as a fixed effect with no restriction on the correlation with other model regressors. γ_t is a survey wave intercept. In addition, we control for geographic time-varying characteristics at the district level through the average district level household income D_{jt}, and average district level household poverty P_{jt}. The error term ϵ_{it} is assumed to be randomly distributed in the fixed effects analysis while any heterogeneity is accounted for in the instrumental variables regression.

The main argument for endogeneity in the baseline model is that the supply, consumption and distribution of electricity in India are non-random, there is self-selection and sorting involved. According to Lee et al. (2020), "electricity grid infrastructure is costly and long-lived, and its planning and construction requires the inputs of multiple stakeholders, therefore, it is rarely randomized, instead it is endogenous to a variety of economic and political factors" (p. 131). From the supply side, energy infrastructure projects target relatively wealthy or quickly-growing regions, as has been found in India by Burlig and Preonas (2016). Selection of this kind would bias econometric estimates of treatment effects. However, Joseph (2010) argued electricity connection through the local grid based transmission infrastructure in India does not distinguish between richer and poorer households in a given area. From the demand side, electrification decisions are dependent on household income, location, and social-cultural factors (Sedai et al., 2020b; Khandker et al., 2014; Dang and La, 2019). Higher employment and income levels could lead to a higher consumption of electricity.[38] Therefore, while remaining agnostic about the nature of the self-selection bias, our empirical analyses seeks to address the possibility of endogeneity.

[38]Time varying characteristics are hard to account for because there could be confounding trends in wealth as well as economic and infrastructural developments in districts which could simultaneously affect electricity variables and household outcomes (Dang and La, 2019).

More specific examples of the general arguments of endogeneity in the Indian context relate to, (i) reliable electrification at the household level being associated with reliable electrification at the regional level, this could increase employment opportunities in the region thus leading to higher LFP and could be the potential cause for reverse causality, as was found by Rao (2013), (ii) if electrification is more cost-effective in areas that already have unmeasured economic advantages, which are correlated with individual labor market outcomes, then household electrification status may suffer from omitted variable bias (Rathi and Vermaak, 2018), (iii) household electrification status may be endogenous to labor market outcomes via the unmeasured political economy motivations rather than customer demand or the cost-effectiveness of grid expansion.[39] Endogeneity could also be due to time-varying omitted variable bias motivated by unobserved factors at the household level: household's perception about potential benefits or costs of electricity (Khandker et al., 2014).

In previous work, Rathi and Vermaak (2018) capture time-invariant unobserved heterogeneity using individual fixed effects to examine the extensive margin of electricity access and labor market outcomes across gender. However, they do not capture the correlation between time-variant unobserved heterogeneity and the error term (such as an employment shock, like the Mahatma Gandhi National Rural Employment Guarantee Program, the global financial crisis, a pandemic, or a medical emergency, among others).[40] The cross-sectional estimation by Sedai et al. (2020b) provides causal estimates of empowerment, but their analysis does not focus on labor market outcomes which is the main outcome of interest in our analysis. Moreover, the study does not take into account the temporal variations which are crucial to the analysis of electrification in India, especially in the time frame of our study (2005-2012) when major strides were made in electrifying households.

[39]Political economy may explain the location and timing of public interventions, such as subsidies and industrial parks, which are likely to affect the chosen labor market indicators directly (Rathi and Vermaak, 2018).

[40]In addition, the sample size used by Rathi and Vermaak (2018) is small (29,614 for men and 9,813 for women) compared to our study (32,288 for men and 31,925 for women). Their sample is skewed towards male respondents potentially leading to biased estimates (Semykina and Wooldridge, 2010). Our sample is more balanced by gender, hence minimizing participation bias.

Instrumental variable

We use average household electricity hours at the state level, excluding one's home district, as an instrument to address the remaining endogeneity.[41] By excluding households from an individual's home district, the instrument takes into account local spill-over effects at the district level (electrification in own district could be correlated with higher LFP through, for example, higher economic activity or price changes).[42] It measures the district level variation temporally which allows us to capture the time-variant unobserved heterogeneity for each wave. The same instrument has been used previously on the effect of electrification on household welfare and empowerment by Dang and La (2019) and Sedai et al. (2020b,a).

The first stage estimation using the instrumental variables approach is given by:

$$EH_{it} = \lambda I_{jt} + X_{it}^{'}\delta + \theta_i + \gamma_t + \alpha D_{jt} + \lambda P_{jt} + \epsilon_{it} \tag{2.2}$$

where I_{jt} is the average household electricity hours in household i's state at time t, excluding their home district. λ is the coefficient of the instrument. All other variables and specifications remain the same as in the baseline estimation.

If neighboring districts acquire more hours of electricity and realize the economic and social gains of better reliability of electrification, then the status of fewer electricity hours may signal lower socioeconomic standing, therefore more electricity hours in the neighboring districts is expected to increase one's own electricity hours (Dang and La, 2019). We argue that the exogeneity condition for the instrument also holds because electricity availability in other districts should not directly affect labor market differences across genders in one's home district. Following the ex-

[41] We estimate the instrument using the IHDS data by averaging hours across all households in one's home state, excluding households in one's home district. Therefore, the instrument varies at the district level, by year.

[42] Higher electricity hours at the district level could create an indirect impact on economic activity in the district due to the reaction of prices. Higher electricity hours might imply higher demand for goods and appliances, especially electronic appliances, leading to an increase in prices for those goods, and overall. Therefore, the positive consequences of higher electricity hours through spill-overs in LFP might be off-set by higher prices overall. Bias from these general equilibrium effects is avoided when we exclude the average electricity hours of the household's district in our instrument.

isting literature, we argue that gender differences in the labor market are affected by household's income, relative bargaining power of the individuals, education, age and occupational segregation (Fletcher et al., 2017; Klasen, 2019; Duflo, 2012). As discussed in the potential threats to identification, we do anticipate that household's own district level electrification and the availability of other infrastructures will have an impact on individual LFP, hence excluding one's home district from the instrument is key to the exclusion restriction.

2.3.3 Analysis of descriptive statistics

Table 2.1 shows the descriptive statistics from the two household surveys.[43] There have been huge improvements in access to electricity between 2005-2018. On average, the six relatively poor states used in the ACCESS survey had 66% of the observations having household electricity in 2015, which increased to 85% in 2018. At the national level, between 2005-2012, there was a 11 percent (76% to 87%) increase in total electricity connections at the household level. However, in terms of electricity hours, there was stagnation at the national level between 2005-2012, and an increase of approximately 2.5 hours from a relatively low base of 12.28 hours in the six states between 2015-2018.[44] Overall, at the national level, in 2012, households had electricity supply for 62% of the day. Despite the claims of progress, in 2018, households from the six relatively poor states of the ACCESS survey, had electricity for 61% of the day. Therefore, reliable electricity is still well below the threshold of continuous and complete electrification.

There has been a marginal increase in monthly fuel expenditure (constituting of LPG, firewood and cowdung) and a marginal increase in the use of firewood for cooking, but these differences were not statistically significant across the time period.[45] Significant increases are observed for

[43] Although these surveys have different respondents and are not directly comparable, we can infer about the intensity of electricity supply as these surveys ask the same question about the reliability of electricity in the households, as described in the data section.

[44] 8% of individuals reported using solar and other alternative electricity sources as of 2018. There has been a huge reduction in kerosene lighting as reported in the sample between 2015-2018.The period from 2005-2012 saw a huge increase in households who had subsidized electricity connection (9% in 2005 to 15% in 2012), while there was a decline in subsidized electricity connections 2015-2018 (21% to 17%).

[45] Authors elaboration using T test for statistical differences in the mean.

household toilet facilities given the strong policy impetus during the time period (Kumar, 2015).[46] There was a marginal increase in the availability of indoor pipe drinking water in the household across the survey period.

Table 2.2 shows the access, reliability and payment of electricity for households belonging to different income levels for the raw household sample across the survey period. Poor households have lower access to electricity as compared with economically better off households, and the trend is linear across income groups. Households from all income levels saw an increase in electricity access. However, the same is not true for electricity reliability, all households irrespective of income levels saw a decline in electricity reliability during the survey period. Also, all households irrespective of the income level saw a decline in monthly electricity payment across the survey period.

From an analytical standpoint, our study does not take into account the households who do not have electricity, and therefore the sample could be biased towards higher income households. From a policy standpoint, our results would apply to households with electricity access in both periods and more towards relatively higher income households as compared to the poorest households.[47]

Table 2.3 shows the IHDS survey wave based labor and non-labor market indicators by gender. These statistics are for households with electricity connections, hence they are expected to be higher than the National Sample Survey estimates, as also argued by Rathi and Vermaak (2018). It is known that LFP in the UPSS saw a rebound between 2010-2012, after falling from 2005-2009, termed as the 'rebound effect' (Shaw, 2013), potentially due to increased impetus on employment guarantee program. Therefore, we see some marginal improvements in the LFP for both men and women across the time period. In terms of the usual principal status, IHDS estimates shows similar

[46] Absolute number of households having latrine facility within the household premises rose by 21.2 million (from 30.3 million in 2001 to 51.6 million in 2011), a decadal growth of 70.1% (Kumar, 2015). To account for the policy impact on household toilet construction, we control for any past five years participation or benefit derived from social/insurance schemes to build household toilets.

[47] In this context, Sedai et al. (2020a) have extensively discussed the differences in electricity access and reliability across income levels, and analyzed the impact of electricity reliability on consumption, assets, amenities and debt.

statistics to the NSS, 13.5% workforce participation rate (WPR) for women in rural areas and 4.5% (WPR) in urban areas (Srivastava and Srivastava, 2010).

Between the survey period, hours worked per year in paid employment decreased by 23 hours for men and 39 hours for women, and there was a decrease in real earnings for both men and women.[48] Weekly fuel collection minutes reduced from 127 minutes to 95 minutes per week for men, and from 260 minutes to 215 minutes for women. In terms of women's empowerment, we look at: 'most say in economics decisions, mobility and reproductive freedom'. In all these variables, there have been marginal improvements over time. Women's general health as measured by an index on a scale from 1-5, with 1 being very poor health to 5 being very good health remained relatively constant over the 7 years.

Table 2.4 shows the covariates used in the analysis. Observations from 2005 to 2012 are 87% matched, which is slightly above official match level of the IHDS data set (83%) (Desai and Vanneman, 2018). This is probably because the raw IHDS data is matched unconditionally, while our matching is based on electrified households. During the survey period, there has been no systematic progress in the reliability of electricity. Households either gained some hours of electricity or lost some hours of electricity.[49] There has been a small increase in household's total assets which in our study is used as a proxy of wealth. We use district level household income and district level standard of living measured by average district poverty rate. We do not use household income as a control as it is highly correlated with the LFP and other outcome variables of our analysis.

2.4 Results

All regression specifications have individual and year fixed effects along with additional independent variables as described in the empirical model. Standard deviations of all regressions

[48]The decrease in real earnings for both men and women is attributable to the high level of inflation in 2012 with the base as 2005, as the deflator used in IHDS divides the monetary values in 2012 by 1.81.

[49]So far, to our knowledge there is no study that shows the relative change in electricity hours in the Indian households between 2005-2018. In figure **??**, we show that some households gained more hours of electricity while some households lost. The redistribution in electricity hours seems to be true for both the IHDS and the ACCESS surveys, which indicates that these trends are not due to survey measurement techniques.

are clustered at the individual level. All tables show fixed effects and IV results for all outcome variables. The strength of the instrument is tested using F-statistic (Sanderson-Windmeijer multivariate F test of excluded instruments), and is considered to be strong at 5% level of confidence if the F-statistic is larger than 10 (Staiger and James, 1997). We also present fixed effects results in all tables where electricity hours are divided into four quartiles (0-9 hours is base quartile 1, 10-16 hours is 2, 17-22 hours is 3 and 23-24 hours is 4) based on survey probability weights. Even though time-varying endogeneity could be an issue, these results provide insight into possible non-linearity of effects and serve as robustness check to our main analyses.

2.4.1 Labor market effects of reliable electrification

Table 2.5 shows the linear and piece-wise analyses of the effects of additional hours of electricity on the usual principal and subsidiary status of employment for the whole sample, and across men and women (panel (a) shows outcomes for usual status ($\geq$ 30 days in a year) employment and panel (b) shows full-time employment ($\geq$ 180 days in a year)). The fixed effects results in column 2 and 3 of panel (a) shows that 10 more hours of electricity increases the probability of men's employment in the usual status by 1.1 pp and that of women by 1.2 pp. As the fixed effects estimates without IV do not capture the time varying unobserved heterogeneity, we focus on the causal estimates provided by the IV results. The instrumental variable results in column 9 shows that 10 more hours of electricity leads to 4.2 pp increase in the likelihood of women being in the labor force.[50] In comparison, column 8 shows that 10 more hours of electricity increases men's LFP by 2.8 pp.[51]

The piece-wise analysis across all quartiles in the usual status category shows a stronger and significant effect of additional hours of electrification on women's LFP compared to men. Moving from the base quartile of electricity hours (0-9) to the 2nd or the 3rd quartile does not increase

[50]The coefficient of 4.2 pp when contrasted with the average LFP of women in the usual status ($\geq$ 240 hours) in table 2.3 which is around 49% in 2012, shows that women's LFP in the usual status increases by approximately 9 percent.

[51]The coefficient of 2.8 when contrasted with the average LFP of men in the usual status ($\geq$ 240 hours) in table 2.3 which is around 88% in 2012, shows that men's LFP in the usual status increases by approximately 0.45 percent.

the likelihood of men's employment but it increases women's employment by 2.3 and 1.8 pp, respectively. Moving from the base quartile to the 4th quartile of complete electrification increases men's employment in the usual status category by 2.2 pp and that of women by 2.6 pp. Fixed effect analysis in piece-wise regression shows that gains from additional hours at higher levels of electricity deficiency are stronger for women as compared to men.

In panel (b), we look at full-time employment ($\geq$ 180 days) as the criteria for LFP. Here the coefficients of the IV regression, after correcting for the selection bias, shows that 10 more hours of electricity increases women's LFP by 3.9 pp and men's LFP by 4.0 pp. These coefficients in comparison with panel (a) show that in absolute terms, reliable electrification improves women's employment in the usual status more than men, while there are no significant differences in the impact of reliable electrification on full-time employment between men and women.[52]

Panel (c) shows the intensive margin of annual work days in all employment or business activity, for men and women, conditional on working in both periods. The IV results show that women increased work days more than men—10 more hours of electricity increases women's annual work days by 28 days, while it increases men's annual work days by 17 days. Results at the intensive margin of work days are similar to the extensive margin of LFP for men and women, that is, women gain more in terms of LFP (work days) as compared to men. This is probably because women gain more than men in terms of employment in the usual status and gained equivalent to men in terms of employment in the usual principal status (full-time employment), therefore, the overall effect could be higher work days for women as compared to men.

To underscore the significance of electricity reliability and not just electricity access, we compare our results with studies that have focused solely on electricity access and gendered outcomes. Rathi and Vermaak (2018) looked at the extensive margin of electricity access and found no effect on men's usual status of employment but a positive effect on women. Our study finds a positive effect of additional hours of electricity on LFP for both genders, with a stronger effect on women.

[52]Since panels (a) and (b) are iterations of the categorical variable (extensive margins of employment), both panels have the same observations and statistic for the F test for excluded instrument.

Van de Walle et al. (2017) also looked at electricity access in India and found no significant change in women's full-time employment ($\geq$ 180 days) but an increase in part-time employment ($\geq$ 30 days and $\leq$ 180 days) of 4.6 days per year. For men, they found a 14.6 days increase in full-time employment and 8.9 days reduction in part-time employment. Their study argued that electricity access triggered men to pursue formal work, reducing their part-time work which in part was taken over by women. Results in panel (a) and (c) supports the hypothesis by Van de Walle et al. (2017) that women gain part-time employment and men gain full-time employment.

The differences in these findings could be due to the differences in margins—Van de Walle et al. (2017) and Rathi and Vermaak (2018) looked at the access, while our focus is on reliability. As Aklin et al. (2016) argued, electricity connections with poor reliability may limit individual's time allocations and hinder the efficient redistribution of labor and leisure. The difference in results with Van de Walle et al. (2017) could also be because of the study period. Their study period was between 1982-1999, while ours is more recent (2005-2012), and in between this period, substantial improvements in women's education have taken place (Srivastava and Srivastava, 2010), along with meaningful infrastructural developments (Kumar, 2015), providing a potential foundation to utilize the benefits of reliable electrification in translation to higher LFP. Given that electricity access is not the silver bullet to energy security (Aklin et al., 2016), we argue that our analysis of the intensive margins of deficiency is also important in understanding the gendered effects of electricity as a labor saving technology.

Table 2.6 using IV-FE specifications show the effect of additional hours of electricity on the likelihood of employment in usual subsidiary status ($\geq$ 30 days) and usual principal plus subsidiary status ($\geq$ 180 days) for men and women in rural and urban areas, and for poor and non-poor households. Panel (a) shows that 10 more hours of electricity increases men's likelihood of employment in rural areas by 3.3 pp, and in urban areas by 2.9 pp. Whereas for women, the increase in urban areas is substantially higher than the increase in rural areas, 9.1 and 1.3 pp, respectively. The effects of additional hours of electrification is more pronounced for non-poor households as compared to poor households for both men and women. For non-poor households there is a 2.9 pp and 4.4

pp increase in the likelihood of employment for men and women, respectively.[53] Wile, for poor households, women have a stronger but insignificant effect on usual status employment as compared to men. In panel (b) the same analysis is conducted for the principal plus subsidiary status of employment. With additional hours of electricity, men in rural areas do not gain regular employment while men in urban areas have a significant increase of 10.3 pp. Women in rural areas have a 0.30 pp increase in regular employment while in urban areas the increase is 5.5 pp. Non-poor households tend to gain in terms of regular employment with additional hours of electrification, but only poor men gain regular employment with additional electricity hours.

Table 2.7 shows the effect of additional hours of electricity on the annual work hours for paid work. We use a log-linear specification with the dependent variable being log of annual work hours. Columns 8 and 9 show the instrumental variable results stratified by gender: 10 more hours of electricity in the household significantly reduces annual work hours by 4.5 percent for men, while the effect on women's work hours is positive (4.3 pp) but insignificant. Allowing the functional form to be piece-wise using individual fixed effects shows that moving from 0-9 hours to 17-22 hours (approximately 10 hours of increase) reduces annual work hours by 2.1 percent for men, while it has a positive and significant effect on work hours for women, 5.4 percent. The IV estimations, after controlling for the time varying unobserved heterogeneity shows strong labor productivity effects in reducing work hours for men but not for women. According to Rathi and Vermaak (2018), household electrification might have improved the productivity of home businesses by facilitating time efficient technologies thus reducing the labor supply hours. Given that men work hours are substantially more than that of women (see table 2.3), we expect the effect to be stronger for men as compared to women.

Table 2.8 shows the effect of additional hours of electricity on log of annual earnings from all work activities, after controlling for annual work hours. We control for work hours in order to isolate any productivity gains. The IV-specifications show that 10 more hours of electricity increases

[53]Note our sample consists of only electrified households, hence it does not take in account the majority of poor households, especially in rural areas, that do not have electricity.

the annual earnings of men and women by 15.6 percent and 16.7 percent, respectively. Panel analysis in column 1-6 without accounting for the time varying unobserved heterogeneity shows no significant differences in the effect of additional hours of electricity on the annual earnings between men and women, except in the 4th quartile, where it is significantly higher for women. Rathi and Vermaak (2018) using a panel fixed effects model also found no significant differences in the earnings between men and women with access to electrification.

2.4.2 Reliable electrification, fuel and water collection

Fuel and water collection activity are primarily undertaken by women in India, and elsewhere in developing countries (Fletcher et al., 2017; Dinkelman, 2011; Kapsos et al., 2014; Ferrant and Thim, 2019). The burden of these time consuming activities is disproportionately borne by women (Ferrant and Thim, 2019), as is also shown the table 2.3, where women, on average, spent approximately twice as much time as men in fuel and water collection activities. Time intensity in these activities could be reduced, or the burden could be done away with reliable electrification, as is also argued by Dinkelman (2011); Sedai et al. (2020b) and Ferrant and Thim (2019), the benefits of which would accrue more to women than men.

Table 2.9 shows the effects of additional hours of electricity on weekly fuel collection minutes (panel a) and daily water collection minutes (panel b) for men and women. IV results show that 10 more hours of electricity significantly reduces women's weekly time spent on fuel collection by 37 minutes, and men's weekly fuel collection by 26 minutes. The piece-wise analysis also confirms the disproportionate effects on women. Moving from the base quartile to the 3rd quartile of electricity hours reduces the weekly fuel collection time for women by 66 minutes, and that of men by 37 minutes. Results in the fourth quartile show positive but insignificant effects of reliable electrification on fuel collection minutes for both men and women, this highlights the significance of capturing the time varying unobserved heterogeneity in estimating the effect of electrification on time allocations, and the selection bias in the fixed effect models.

Panel (b) shows the effect on daily water collection minutes. Ten more hours of electricity reduces daily time spent on water collection by 31 minutes for women and 12 minutes for men. The piece-wise analysis corroborates the estimates of the IV-specifications, and shows that at all levels of deficiency, reliable electricity reduces the gender differences in water collection time between men and women. For example, moving from the base quartile to the 4th quartile reduces the daily time spent on water collection by 14 minutes for women and 0.6 minutes for men. Reliable electricity is crucial in reducing fuel and water collection time for both men and women, with stronger reductions for women as compared to men. The time freed up from these activities could be critical in improving the labor market outcomes for both men and women.

Results from the analysis on fuel and water collection highlights a concrete channel by which electrification ameliorates the time constraint on women's participation in paid employment and reduces the burden of unpaid household labor. While this amelioration is by no means an adequate basis for gender empowerment in the absence of complementary policies that directly address norms and institutions that perpetuate gender disparities, it shows a potential avenue to address gender disparities.

2.4.3 Reliable electrification, empowerment and energy choices

We examine the effects of additional hours of electricity on indicators of (i) women's empowerment and (ii) energy choices and household amenities that could affect women's health and well-being. First, we look at empowerment outcomes in terms of economic decision making, mobility, reproductive freedom and health of women, which are viewed to be the key components in agency, resource and achievements of women (Kabeer, 1999). Instead of looking at whether women have a say in major economic decisions, which might be inconsequential if the preferences of other members of the family are stronger, and could be an incomplete representation of women's economic autonomy (Kabeer, 1999), we look into whether women have the most say in major purchase decisions, which highlights their 'agency' more strongly as a 'first order choice' (Kabeer,

1999). Similarly instead of a say on fertility decisions, we look at the 'most say' in deciding the number of children.

To analyze the impact of reliable electrification on women's mobility, we look at effects on electricity hours on women's need to ask permission to visit health center alone. In addition, women's health is considered to reflect 'agency' in the empowerment framework of 'access agency and achievements' (Kabeer, 1999), therefore, we analyze the impact of reliable electrification on health as a measure of women's empowerment. To do so, we create a binary health variable from the discrete variable 'general health', 1-5 (1 very good—5 very poor), by assigning '1' to good and very good health and '0' to poor, very poor and OK.

Between 2005-2012, there were significant improvements in health infrastructure in the country through government's National Rural Health Mission, new construction of heath sub-centres, primary health centres, community health centres, and district hospitals (Agarwal et al., 2019). Public and Private health infrastructure, and knowledge and connections with doctors and health care workers also expanded during the same phase. This could affect women's visitation to health centers alone, and also health in general. Therefore, our analysis accounts for the effect of health care expansion on women's freedom to visit to health center, and self-rated health. We control for the household's acquaintance with doctors and health care workers during the time period.[54] In addition, we control for any health insurance that the household acquired through a public or private source.[55] In addition, results are presented with and without controls for employment and annual earnings to examine the magnitude of indirect effects.

Using a linear probability model, the IV estimates in column 3 of panel (a) in Table 2.10 show that 10 more hour of electricity increases women's agency in major purchase decision of the household by 4.8 pp. Similarly, column 6 shows that 10 more hours of electricity increases women's autonomy over their fertility by 6.6 pp. Moving from the base quartile to the 4th increases the au-

[54]Network with doctor/health-workers variables is derived from the IHDS income and social capital questionnaire. The questionnaire item is "Do you or any members of your household have personal acquaintance with someone who works in any of the following occupation"— (i) Doctors, (2) Health Care Workers.

[55]We observe health insurance at the household level. The likelihood of heath insurance either public or private increased from 3.5 to 11% at the national level, authors elaboration from IHDS, 2005-2012.

tonomy on women's fertility by 5.1 pp. Controlling for employment and earnings, the coefficients are consistent for both outcomes. Our results are consistent to the findings by Samad and Zhang (2019) and Sedai et al. (2020b): electricity access and reliability have positive effects on women's decision making agency.

In terms of mobility, we look at the effect of additional hours of electricity on whether women have to ask for permission to visit health centers. Results in column 3 of panel (b) shows that 10 more hours of electricity reduces the likelihood of women having to ask for permission from family members to visit a health center by 13.3 pp. After controlling for the expansion in health care infrastructure, the effects are stronger on mobility. In terms of general health, the IV estimation shows that 10 more hours of electricity increases the likelihood of reporting good health by 9.2 pp. After controlling for employment and earnings, the effect is reduced to 7.1 pp.

Table 2.11 shows the effect of electricity reliability on energy choices and basic infrastructure in the household. For this analysis, we restrict the sample to the household head responding for the household, and consequently have fewer observations. First, in panel (a), we look at the effect of additional hours of electricity on the log of the monthly expenditure on fuel-wood. On one hand, common Property Resource (CPR) in India has been reducing at a rate of 1.9 percent every five years due to encroachment, as per the National Sample Survey Organisation (Kaur, 2011), while on the other, the reliance of poor households on CPR for fodder and fuel is higher as compared to richer households in India (Jodha, 1986).[56] Therefore, the use of instrumental variables is critical in capturing the time varying unobserved heterogeneity in the use of fuel-wood in India. The IV analysis shows that 10 hours of electricity reduces the expenditure on fuel-wood by 12.2 percent. Ten more hours of electricity reduces the likelihood of using wood for cooking by 7.3 pp. Similar, but smaller effects of electricity access on fuel use for cooking was found by Dinkelman (2011) and Parikh (2011) in South Africa and India.

[56] Also, Parikh (2011) in a study of Himachal Pradesh, India, found that cooking with firewood was correlated with higher proportion of respiratory symptoms among girls below 5 and females in 30–60 age-groups than males of similar age-groups.

We examine the impact of reliable electrification on collective amenities in the households: household toilet and indoor piped drinking water. These collective household amenities have been argued to have a strong impact on women's empowerment (Fletcher et al., 2017), and could be critical in the Indian context, especially in rural areas. To analyze the effect of reliable electrification, we control for the government programme to improve sanitation and hygiene as there has been tremendous increases in access to toilets during the survey period, owing majorly to the Nirmal Bharat Abhiyan, 2005, (Kumar, 2015).[57] The IV linear probability model in panel (b) shows that 10 hours of electricity increases the likelihood of having a toilet in the house by 1.6 pp. Moving from the base quartile to the 4th quartile increases the likelihood of having a household toilet by 4.1 pp. In terms of indoor piped drinking water, 10 hours of electricity increases the likelihood of having indoor piped drinking water by 1.9 pp. Similarly, moving from the first quartile to the 4th quartile increases the likelihood of having indoor piped drinking water by 3.6 pp.

We further examine the impact of electricity hours on access to a household toilet and indoor piped drinking water in rural/urban areas and poor/non-poor households. Table 2.12 shows that electricity hours have a stronger effect in increasing access to a toilet in rural areas as compared to urban areas, and for non-poor households as compared to poor households. Electricity reliability increases the likelihood of having access to indoor water in rural areas by 4.7 pp, but there is no significant effect in urban areas. Non-poor households have a 2.3 pp likelihood of gaining access to indoor water as compared to 0.007 pp for the poor households.

2.4.4 Analysis of the extensive margin of electricity

As a check of our data and to facilitate comparison to existing literature, we look at the extensive margin of electricity access and examine its effects on employment and earning outcomes. Given our results show that the effect at the intensive margin (reliable electrification) holds, we anticipate similar effects using a binary independent variable. As such we move from a continuous independent variable to a discrete independent variable. Rathi and Vermaak (2018) using the same

[57] In addition, with regards to access to household toilet, we control for household's access to water within the household premises, as these outcomes could be correlated.

panel from IHDS, 2005-2012, look at the effects of electricity access on employment (usual subsidiary status) and earnings (log of annual earnings) for men and women. The sample size used by Rathi and Vermaak (2018) is smaller (29,614 for men and 9,813 for women) compared to our study (69,024 for men and 69,496 for women) and is skewed towards male respondents which could potentially be leading to biased estimates (Semykina and Wooldridge, 2010). Our sample is balanced with nearly equal observations for men and women, which corrects for the potential participation bias. We use the exact same covariates as used by Rathi and Vermaak (2018) as shown in table 2.13.

Coefficients in table 2.13 are similar to the estimates of Rathi and Vermaak (2018). They find a significant positive effect of electricity access on women's employment (UPSS), and so do we. In contrast to their analysis, we find a smaller magnitude of effect on earnings. Their analysis finds a 10 log points increase in annual earnings for women with electricity access, while in our analysis, the coefficient is 7 log points. This could be due to their smaller sample of women (9,813) as compared to our sample, which may have certain characteristics that led to overestimation of the coefficients.

2.5 Discussion and Conclusion

This study contributes to the literature in understanding the gendered effects of reliable electrification. First, we move beyond quantifying electrified households as a policy objective and look at the effects of electricity reliability (hours of electricity supplied) on gender differences in the labor and non-labor outcomes. Second, we tackle the endogeneity between employment and electrification, and arrive at robust point estimates. Third, instead of focusing either on labor market outcomes or empowerment, we seek to provide a holistic picture of the effect of electrification on 'access, agency and achievements' for women following the framework of empowerment by Winther et al. (2017) and Kabeer (1999). Fourth, unlike previous studies which have looked at the effect of reliable electrification on women's outcomes only (Sedai et al., 2020b; Samad and Zhang, 2019), we analyze the gender differences in labor market and fuel collection activities,

which allows us to highlight a significant channel through which electrification helps in reducing gender differences. Through these analyses, we posit that the gender differences in the labor market and in the household reduce with reliable electrification by reducing the the time-burden of labor intensive activities like fuel and water collection.

We analyze two household surveys and posit that there has been redistribution of electricity hours between 2005-2018, with many households gaining access to electricity, while other losing hours of electricity on a typical day. We use the variation in the reliability of electricity between 2005-2012 and study its impact on multi-dimensional framework of labor and household outcomes between men and women to understand the causal effects of reliable electrification in increasing LFP and reducing the burden and drudgery of household labor. We find that reliable electrification reduces the time spent on home production disproportionately more for women than men. Relaxing the time constraint that hinders labor market participation could lead to increased LFP. In addition to labor market outcomes, we examine non-labor market outcomes such as household activities of fuel and water collection, women's economic and reproductive agency, mobility, health, and household's use of amenities (toilet and piped water) and energy choices (fuel-wood expenditure and usage).

We find that the reliability of household electricity is a significant factor in reducing household and labor market differences between men and women. We analyze both the extensive and intensive margins of employment, activities of home production (fuel and water collection), economic and social decision making ability, health related fuel choices and the provisions of basic household amenities and find that reliable electrification generally benefits women more than men. Given our findings, reducing the inefficiency in electricity supply could be a significant policy lever in reducing gender disparities in the labor market and in the household.

This study uses two identification strategies (IV-FE and FE) and examines the empirical evidence on electricity's gendered impacts in India, where electricity provisioning is sub-optimal (Burgess et al., 2020; Chindarkar and Goyal, 2019), and extant gender inequality is a serious concern (Duflo, 2012; Fletcher et al., 2017; Jensen and Oster, 2009). Drawing on the framework of

'access agency and achievements' laid down by Kabeer (1999), and contextualizing it with regards to labor saving technologies, we situate the lack of reliable electrification as a potential obstacle to policies seeking to reduce gender disparities. We measure the direct effects of reliable electrification on gender differences in the labor markets and investigate the mechanisms through which these effects operate. Addressing the endogenous placement of infrastructure and confounding trends, we show that gender differences in employment opportunities and within the household are reduced when households receive additional hours of electricity.

Results from the labor market analysis show that 10 more hours of electricity increases women's likelihood of usual status employment (4.2 pp) more than that of men (2.8 pp), while both women and men gain similar levels of full-time employment, 3.9 pp and 4.0 pp, respectively. This study underscores the role reliable household electrification could play in increasing the employment opportunities for women, and in reducing the gender differences in LFP. In addition, increasing the reliability of electricity supply lowers the time spent on fuel and water collection, more for women than men, reduces unhealthy fuel choices, and increases the likelihood of having basic amenities. It also improves women's general health and increases their say in economic decisions, mobility and reproductive choices.

Additional hours of electricity lowers the annual work hours for both men and women, presumably through the channels of improvements in labor productivity, as argued by Rathi and Vermaak (2018). Relatively better employment opportunities for women with additional electricity hours is reflected in annual earnings. The fact that reliable electrification increased the real annual earnings for both men and women provides evidence that an improvement in the reliability of electricity supply could spark large increases in the demand for labor, primarily through promotion of enterprise and industry.

Given the disproportionate effects electrification has on women's agency, resources and achievements, we argue for considering reliable electrification as a right. In conjunction with other measures, reliable electrification would help relieve the time constraints that ties women to the home and pre-empts their labor force participation, in a context where social norms place the primary re-

sponsibility of unpaid household work on women. Reliable electrification is important for a variety of reasons but one aspect that is less acknowledged in the literature is the gendered impact, which we document in this work. The argument against considering 'electricity as a right' on the grounds of inefficiencies in generation and distribution of electricity (Burgess et al., 2020) can therefore be challenged on the additional basis of its potential role in enabling a reduction in gender disparities.

There is an evident under-provisioning of electricity in India (Sedai et al., 2020a; Aklin et al., 2016) and there are price adjustments that could be optimal (Chindarkar and Goyal, 2019). Policy impetus should be on providing continuous affordable electricity to households, identifying households or localities where willingness to pay exceeds the supply; designing price per units accordingly, with appropriate and timely calculations of costs, surplus and losses. Where neccessary, appropriate public spending should be undertaken to recover the costs of generation and distribution intended to increase household reliable electrification.

2.6 Figures and Tables

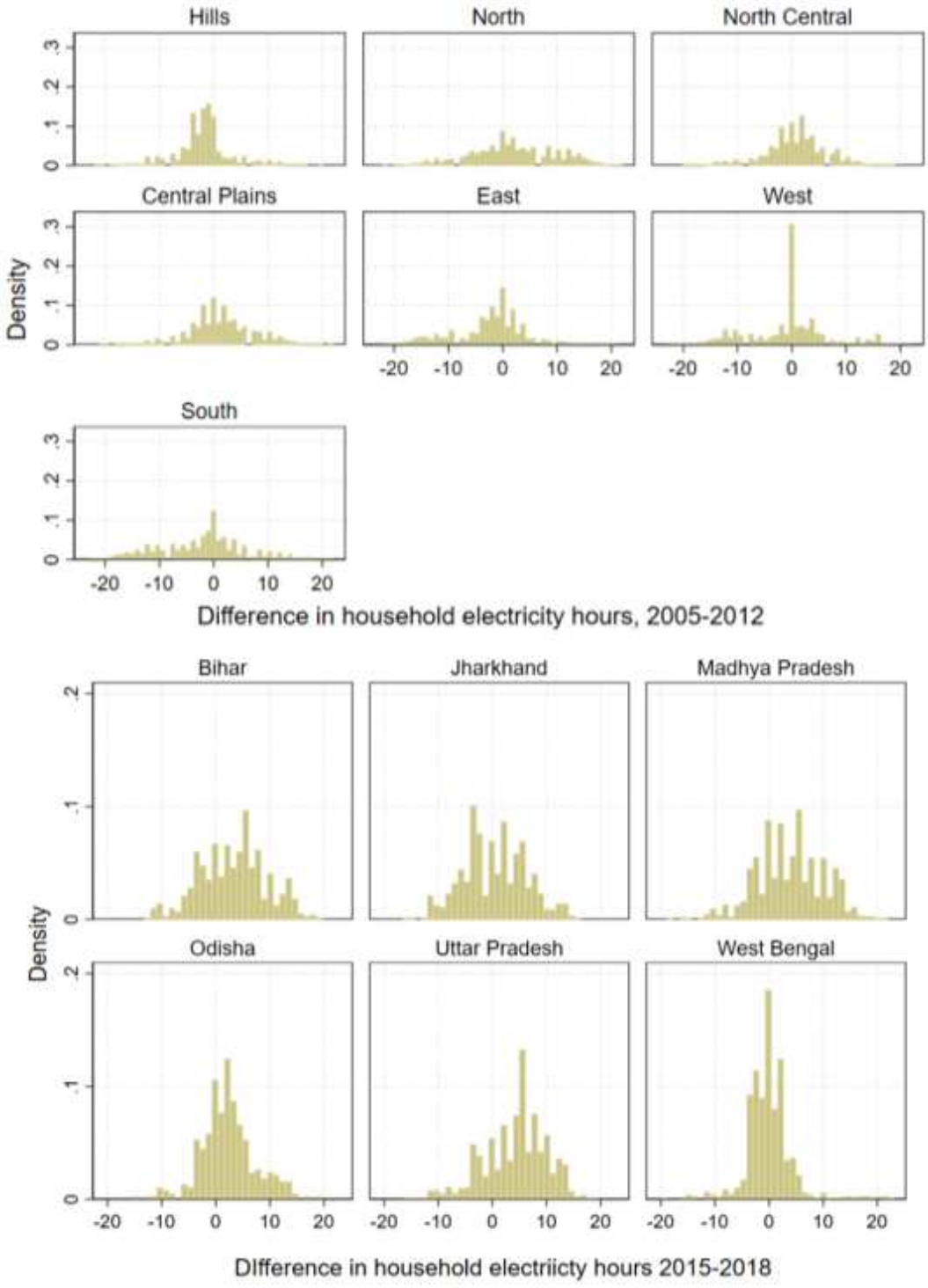

Figure 2.1: Average hours of electricity in India at the district level, 2005-2012, conditional on electricity access.

Source: Authors calculations, IHDS, 2005-2012.

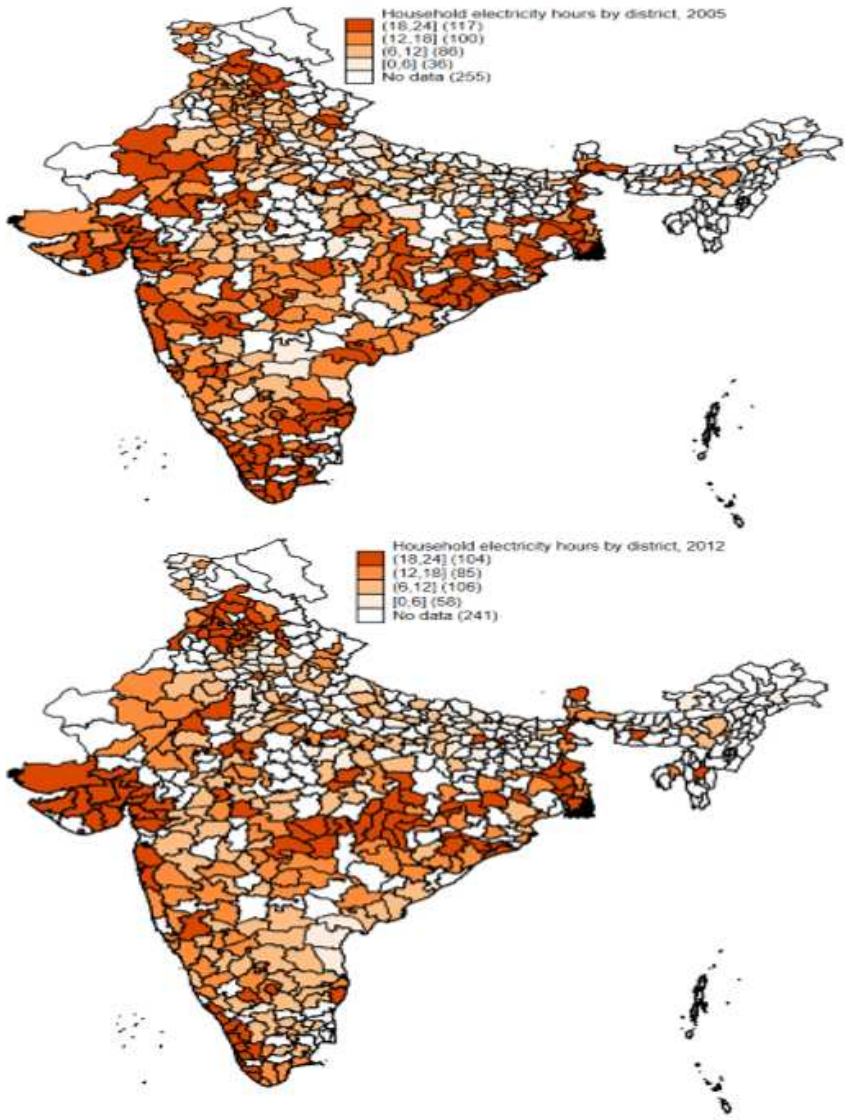

Figure 2.2: Difference in the hours of electricity received by households on a typical day by region between 2005-2012, and by state between 2015-2018, conditional on electricity access.

Source: Authors calculations, IHDS, 2005-2012, ACCESS, 2015-2018.

Table 2.1: Trends in electricity access, reliability, costs, energy choice and household amenities (2005-2018).

	2005		2012		2015		2018	
	Mean	sd	Mean	sd	Mean	sd.	Mean	sd
Access to grid electricity	0.76	0.42	0.87	0.33	0.66	0.47	0.85	0.36
Hours of electricity in a day	15.89	6.74	15.05	6.86	12.28	6.27	14.74	5.48
Sources of Electricity								
Bill company/department	0.84	0.36	0.75	0.43	0.72	0.22	0.69	0.33
Neighbors	0.03	0.17	0.02	0.15	0.02	0.15	0.02	0.14
No bill	0.09	0.16	0.15	0.34	0.21	0.41	0.17	0.37
Own generator	0.01	0.03	0.02	0.05	0.02	0.15	0.07	0.25
Monthly fuel (USD, 2005, PPP).	32.88	37.49	36.34	61.21				
Firewood for cooking (0/1)	0.497	0.499	0.526	0.499				
Household Toilet (0/1)	0.414	0.492	0.534	0.498				
Indoor Water (0/1)	0.266	0.442	0.302	0.459				
Sample size (all adults)	40,018		40,018		7890		7890	

Source: Authors calculations using IHDS (2005-2012) and ACCESS survey (2015-2018). Samples are at the household level. The data from 2005-2012 is the national sample and from 2015-2018 is for six states: Uttar Pradesh, Madhya Pradesh, West Bengal, Orissa, Bihar and Jharkhand. Monthly fuel expenditure is the expenditure on LPG, firewood, and cowdung converted to U.S dollar purchasing power parity equivalent in 2005.

Table 2.2: Electricity Access, Reliability and Monthly Payment by Income levels, India, 2005-2012, IHDS.

	2005	2012	2005	2012	2005	2012	2005	2012	2005	2012
	Poor		Lower Middle Income		Middle Income		Upper Middle Income		Rich	
Electricity Access	0.57	0.72	0.63	0.79	0.73	0.88	0.85	0.93	0.95	0.97
	0.50	0.44	0.48	0.40	0.44	0.32	0.36	0.24	0.21	0.14
Electricity Hours	14.40	13.79	14.79	14.03	15.69	14.59	16.39	15.47	16.94	16.56
	6.78	6.74	6.61	6.73	6.69	6.72	6.68	6.84	6.65	6.84
Monthly Electricity Payment, Rs.	199.37	136.83	221.42	166.05	270.26	207.58	329.36	278.06	512.89	449.95
	344.26	220.15	382.99	319.27	373.89	304.38	397.48	383.51	601.85	551.65

Source: Authors elaboration, IHDS, 2005-2012.

Table 2.3: Descriptive statistic of labor market activity by gender, India, 2005-2012, conditional on electricity access

	Men			Women		
		2005	2012		2005	2012
	Obs.	Mean (sd)	Mean (sd)	Obs.	Mean (sd)	Mean (sd)
Employment UPSS (>240 hours in a year)	32397	0.841	0.886	32028	0.488	0.498
		(0.365)	(0.317		(0.499)	(0.500)
Employment UPS (>180 days in a year)	32397	0.451	0.495	32028	0.077	0.091
		(0.497)	(0.499)		(0.269)	(0.282)
Annual Work Days	27,598	252.92	267.04	13031	180.34	188.54
		(86.07)	(90.40)		(95.92)	(107.66)
Annual Work Hours	27127	2042.84	2065.26	13031	1207.28	1166.06
		(912.00)	(960.54)		(832.29)	(880.83)
Real Earnings p.a (USD, 2005, PPP).	32398	3352	4764	32028	572	984
		(5245)	(9320)		(2141)	(3354)
Fuel Collection Minutes/Week	8196	127.54	95.56	8443	260.315	215.242
		(201)	(253)		(292)	(377)
Water Collection Minutes/Day	9698	37.94	32.46	12883	72.14	49.62
		(54.91)	(36.87)		(71.11)	(46.19)
Most say in: purchase decisions (0/1)				18471	0.111	0.131
					(0.314)	(0.337)
Permission to visit health center (0/1)				18404	0.740	0.768
					(0.438)	(0.422)
Most say in: number of children (0/1)				17739	0.210	0.265
					(0.403)	(0.441)
General Health (1-5)				18446	2.19	2.09
					(0.791)	(0.843)

Source: Authors calculations using IHDS (2005-2012), conditional on electricity access. Standard errors in parentheses. Base, 2011 Indian rupees. General health is coded as 1 being very poor health and 5 being very good health.

Table 2.4: Descriptive statistics of covariates, 2005-2012

	2005			2012		
	Obs	Mean	sd	Obs	Mean	sd
Total assets (0-33)	64426	14.35	5.43	64398	17.33	5.17
Respondent's age in years (18-70)	64426	35.96	11.85	64426	43.03	12.05
Respondent's sex (male=1, female=2)	64426	1.49	.50	64426	1.50	.50
Highest male adult education (0-15)	62990	8.59	4.68	62990	9.24	4.56
Highest female adult education (0-15)	62990	5.80	5.12	62990	7.11	5.17
Household size	64426	6.21	3.07	64426	5.60	2.73
Log average district income	64426	12.16	0.42	64426	11.84	0.45
Average district poverty (0-1)	64426	0.22	0.18	64426	0.16	0.13
Peak Load Surplus/Deficit (%)	65674	-17.76	17.92	65674	-11.85	17.81
Electricity payment per hour (Rs.)	64160	.999	1.904	65362	.844	1.382

Source: IHDS, authors calculation, observations for individuals with electricity access. Peak Load Surplus/Deficit (%) is percentage value which hypothetically ranges from -100 to 100. The variable is derived as: (availability – requirement)/requirement of electricity in mega-watts by state.

Table 2.5: Effects of additional hours of electricity on the likelihood of employment, 2005-2012, India. Linear probability analysis with individual fixed effects.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Variables	All	Men	Women	All	Men	Women	IV-All	IV-Men	IV-Women
Panel (a) (>30 days)									
10 Electricity Hours	0.012***	0.011***	0.012***				0.034***	0.028***	0.042***
	(0.000)	(0.000)	(0.000)				(0.001)	(0.001)	(0.001)
Base quartile (0-9)									
2nd quartile (10-16)				0.013***	0.004	0.023***			
				(0.005)	(0.006)	(0.008)			
3rd quartile (17-22)				0.011**	0.005	0.018**			
				(0.005)	(0.006)	(0.008)			
4th quartile (23-24)				0.024***	0.022***	0.026***			
				(0.006)	(0.007)	(0.009)			
Panel (b) (>180 days)									
10 Electricity Hours	0.010**	0.012***	0.011**				0.039***	0.040***	0.039***
	(0.00)	(0.00)	(0.00)				(0.00)	(0.00)	(0.00)
Base quartile (0-9)									
2nd quartile (10-16)				0.008	0.005	0.010**			
				(0.01)	(0.01)	(0.01)			
3rd quartile (17-22)				0.017***	0.016*	0.018***			
				(0.01)	(0.01)	(0.01)			
4th quartile (23-24)				0.016**	0.025***	0.017**			
				(0.01)	(0.01)	(0.01)			
F test (instrument)							17,442	8,429	8,998
Observations	122,971	63,018	59,953	122,971	63,018	59,953	120,876	61,957	58,919
No. of Individuals	63,620	32,283	31,347	63,629	32,283	31,347	62,553	31,774	30,810
Panel (c) Work days p.a									
10 Electricity Hours	4.081***	4.771***	2.634*				18.005***	16.519***	28.011***
	(0.921)	(1.110)	(2.521)				(1.539)	(2.511)	(5.357)
Base quartile (0-9)									
2nd quartile (10-16)				5.911***	5.836***	5.060***			
				(1.532)	(1.751)	(3.117)			
3rd quartile (17-22)				9.447***	6.965***	10.934**			
				(1.532)	(1.744)	(3.204)			
4th quartile (23-24)				4.4801**	8.017***	7.827***			
				(1.816)	(2.023)	(4.703)			
Work both periods	Y	Y	Y	Y	Y	Y	Y	Y	Y
F test (instrument)							8,453	6,862	1,551
Observations	66,497	48,817	17,680	66,497	48,817	17,680	65,509	48,074	17,435
No. of Individuals	34,348	24,992	9,357	34,348	24,992	9,357	33,841	24,614	9,228

Robust standard errors (clustered at individual level) in parentheses

$***p < 0.01$, $**p < 0.05$, $*p < 0.1$. Additional independent variables in all regressions.

Table 2.6: Effects of additional electricity hours on subsidiary and principal status of employment for rural/urban and poor/non-poor in India, 2005-2012. All specifications are IV-linear probability model

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Variables	Men		Women		Men		Women	
	Rural	Urban	Rural	Urban	Non-Poor	Poor	Non-Poor	Poor
Panel (a) (>30 days)								
10 Electricity Hours	0.033***	0.029*	0.013	0.091***	0.029***	-0.002	0.044***	0.025
	(0.010)	(0.015)	(0.015)	(0.016)	(0.009)	(0.025)	(0.011)	(0.0036)
Panel (b) (>180 days)								
10 Electricity Hours	-0.002	0.103*	0.030*	0.055***	0.036***	0.071*	0.044***	0.009
	(0.009)	(0.014)	(0.013)	(0.014)	(0.008)	(0.022)	(0.010)	(0.022)
F test (instrument)	3,271	2,464	3,100	2,199	5,272	1,011	5,101	978
Observations	37,581	25,243	36,596	23,159	54,740	8,066	52,016	7,721
No. of individuals	19,388	13,145	19,074	12,052	27,671	4,075	26,858	3,981

Robust standard errors (clustered at individual level) in parentheses

$***p < 0.01$, $**p < 0.05$, $*p < 0.1$. Additional independent variables in all regressions.

Table 2.7: Effects of additional hours of electricity on log of annual work hours, 2005-2012. Log-linear model, conditional on working in both waves

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Variables	All	Men	Women	All	Men	Women	IV-All	IV-Men	IV-Women
10 Electricity Hours	-0.015***	-0.016***	-0.006				-0.040**	-0.045***	0.043
	(0.007)	(0.008)	(0.019)				(0.017)	(0.018)	(0.046)
Base quartile (0-9)									
2nd quartile (10-16)				0.007	0.004	0.014			
				(0.011)	(0.012)	(0.024)			
3rd quartile (17-22)				-0.020	-0.021**	0.054**			
				(0.013)	(0.014)	(0.030)			
4th quartile (23-24)				-0.033***	-0.019	-0.075**			
				(0.015)	(0.017)	(0.037)			
F (test) instrument							8,450	6,887	1,551
Observations	66,444	48,777	17,667	66,444	48,777	17,667	65,456	48,034	17,422
No. of individuals	34,321	24,972	9,350	34,321	24,972	9,350	33,814	24,594	9,221

Robust standard errors (clustered at individual level) in parentheses

$***p < 0.01$, $**p < 0.05$, $*p < 0.1$. Additional independent variables in all regressions.

Table 2.8: Effect of additional hours of electricity on log of annual earnings, 2005-2012, India. Log-linear model, conditional on hours worked.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Variables	All	Men	Women	All	Men	Women	IV-All	IV-Men	IV-Women
10 Electricity Hours	0.035***	0.035***	0.010				0.162***	0.156***	0.167***
	(0.008)	(0.010)	(0.022)				(0.019)	(0.020)	(0.061)
Base quartile (0-9)									
2nd quartile (10-16)				0.043***	0.042**	0.040*			
				(0.013)	(0.014)	(0.026)			
3rd quartile (17-22)				0.080***	0.079***	0.080**			
				(0.015)	(0.016)	(0.039)			
4th quartile (23-24)				0.074***	0.067***	0.120***			
				(0.019)	(0.021)	(0.045)			
Work Hours	Y	Y	Y	Y	Y	Y	Y	Y	Y
F (test) instrument							14,169	11,246	2,876
Observations	48,441	35,203	12,562	48,441	35,203	12,562	46,924	34,587	12,337
No. of individuals	32,285	22,823	9,463	32,285	22,823	9,463	21,694	22,412	9,283

Robust standard errors (clustered at individual level) in parentheses

$***p < 0.01$, $**p < 0.05$, $*p < 0.1$. Additional independent variables in all regressions.

Table 2.9: Effects of additional hours of electricity on fuel and water collection time, 2005-2012.Linear probability model with individual fixed effects and instrumental variables.

	(1)	(2)	(3)	(4)	(5)	(6)
Variables	Men	Women	Men	Women	Men	Women
Panel (a) Weekly fuel Collection minutes						
10 Electricity Hours	-15.794**	-26.337**			-26.633***	-37.697***
	(3.964)	(6.476)			(7.991)	(12.286)
Base quartile (0-9)						
2nd quartile (10-16)			-2.606	-29.047***		
			(6.624)	(10.810)		
3rd quartile (17-22)			-37.163***	-66.623***		
			(7.043)	(9.456)		
4th quartile (23-24)			13.474	20.891		
			(8.799)	(14.453)		
F (test) instrument					11,295	11,293
Observations	43,452	43,456	43,452	43,456	43,041	43,055
No. of individuals	32,050	32,053	32,050	32,053	31,724	31,727
Panel (b) Daily Water Collection Minutes						
10 Electricity Hours	0.093	-5.870***			-12.105***	-31.519***
	(0.098)	(0.096)			(0.205)	(0.212)
Base quartile (0-9)						
2nd quartile (10-16)			-0.234	-4.948***		
			(1.791)	(1.596)		
3rd quartile (17-22)			-0.928	-3.256**		
			(1.674)	(1.613)		
4th quartile (23-24)			0.613	-14.062***		
			(1.367)	(1.704)		
F (test) instrument					2,438	4,491
Observations	38,335	51,460	38,335	51,460	318,002	51,013
No. of individuals	28,988	35,208	28,988	35,208	28,757	34,822

Robust standard errors (clustered at individual level) in parentheses

$***p < 0.01$, $**p < 0.05$, $*p < 0.1$. Additional independent variables in all regressions.

Table 2.10: Effects of additional hours of electricity on women's economic decision, mobility, reproductive freedom, and health, 2005-2012. Linear probability model

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	FE	FE	IV-FE	IV-FE	FE	FE	IV-FE	IV-FE
Panel (a)	Purchase Decision				Number of Children			
10 Electricity Hours	0.001		0.048***	0.042***	0.034***		0.066***	0.063***
	(0.009)		(0.012)	(0.023)	(0.014)		(0.012)	(0.034)
Base quartile (0-9)								
2nd quartile (10-16)		0.018***				0.013		
		(0.007)				(0.010)		
3rd quartile (17-22)		0.001				0.051***		
		(0.007)				(0.010)		
4th quartile (23-24)		0.004				0.054***		
		(0.009)				(0.012)		
Employment ≥30 days				0.006***				0.007***
				(0.021)				(0.032)
Log annual earnings				0.004				0.004
				(0.004)				(0.006)
F (test) instrument			15,713	7,182			15,142	7,002
Observations	34,768	34,768	34,196	15,880	33,921	33,921	33,358	15,422
Number of individuals	18,237	18,237	17,942	10,797	18,159	18,159	17,865	10,591
Panel (b)	Permission to visit health center				General Health			
10 Electricity Hours	-0.087***		-0.133***	-0.172***	0.041***		0.092***	0.071**
	(0.013)		(0.014)	(0.034)	(0.012)		(0.016)	(0.037)
Base quartile (0-9)								
2nd quartile (10-17)		0.003				-0.014		
		(0.009)				(0.010)		
3rd quartile (17-22)		-0.102***				0.016		
		(0.009)				(0.011)		
4th quartile (23-24)		-0.128***				0.074***		
		(0.012)				(0.013)		
Know Doctor/H.Workers	-0.028***	-0.029***	-0.027***	-0.057***	0.029***	0.027***	0.030***	0.042***
	(0.007)	(0.007)	(0.007)	(0.012)	(0.007)	(0.007)	(0.007)	(0.013)
Any health insurance	-0.016	-0.016	-0.021*	-0.016	0.011	0.010	0.010	0.022
	(0.012)	(0.012)	(0.013)	(0.023)	(0.012)	(0.012)	(0.013)	(0.022)
Employment ≥30 days				0.056*				-0.009
				(0.031)				(0.034)
Log annual earnings				-0.007				0.002
				(0.006)				(0.006)
F (test) instrument			15,602	7,823			15,001	6,911
Observations	34,599	34,599	34,037	15,840	34,646	34,646	34,080	15,858
Number of individuals	18,227	18,227	17,933	10,781	18,230	18,230	17,936	10,790

Robust standard errors (clustered at individual level) in parentheses

$***p < 0.01$, $**p < 0.05$, $*p < 0.1$. Additional independent variables in all regressions.

Table 2.11: Effects of additional electricity hours on energy choices and household amenities, 2005-2012. Linear probability model except for column 1,2,3 in panel (a)

	(1)	(2)	(3)	(4)	(5)	(6)
	FE	FE	FE-IV	FE	FE	IV-FE
Panel (a)	Log of fuel expenditure			Cooking with fire-wood		
10 Electricity Hours	-0.031		-0.122***	-0.014***		-0.073***
	(0.003)		(0.008)	(0.001)		(0.004)
Base quartile (0-9)						
2nd quartile (10-16)		0.031**			-0.010*	
		(0.002)			(0.001)	
3rd quartile (17-22)		-0.018			-0.016***	
		(0.002)			(0.001)	
4th quartile (23-24)		-0.013			-0.012*	
		(0.002)			(0.001)	
F (test) instrument			1,877			2,112
Observations	30,172	30,172	29,666	40,884	40,884	40,122
Number of households	21,279	21,279	20,933	23,974	23,974	23,549
Panel (b)	Household Toilet			Indoor Pipe Water		
10 Electricity Hours	0.021***		0.016**	0.031***		0.019**
	(0.004)		(0.003)	(0.004)		(0.004)
Base quartile (0-9)						
2nd quartile (10-16)		-0.003			0.002	
		(0.008)			(0.008)	
3rd quartile (17-22)		0.017***			0.038***	
		(0.007)			(0.007)	
4th quartile (23-34)		0.041***			0.036***	
		(0.010)			(0.010)	
Public/Private Toilet Prog.	0.233**	0.240**	0.243***			
	(0.003)	(0.003)	(0.003)			
Water in House	0.028**	0.028**	0.028***			
	(0.007)	(0.008)	(0.006)			
F (test) instrument			1,676			1,698
Observations	40,433	40,433	39,687	40,875	40,875	40,113
No. of households	23,927	23,927	23,503	23,971	23,971	23,546

Robust standard errors (clustered at individual level) in parentheses

$***p < 0.01$, $**p < 0.05$, $*p < 0.1$. Additional independent variables in all regressions.

Table 2.12: Effects of additional electricity hours on household toilet and indoor piped drinking water by rural/urban and poor/non-poor, India, 2005-2012.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
VARIABLES	Rural	Urban	Poor	Non-Poor	Rural	Urban	Poor	Non-Poor
	Household Toilet				Indoor Pipe Drinking Water			
10 Electricity Hours	0.023***	0.009***	0.011*	0.027***	0.047***	0.001	0.007**	0.023***
	(0.010)	(0.014)	(0.026)	(0.010)	(0.004)	(0.005)	(0.009)	(0.003)
Public/Private Toilet Prog.	0.281***	0.045*	0.322***	0.226***				
	(0.03)	(0.06)	(0.06)	(0.03)				
Water within house	0.022***	0.011***	-0.021	0.021***				
	(0.01)	(0.02)	(0.03)	(0.01)				
Observations	24,087	16,346	4,658	35,346	24,316	16,559	4,669	35,737
No. of households	14,585	9,777	2,812	20,692	14,617	9,796	2,816	20,722

Robust standard errors (clustered at individual level) in parentheses

$***p < 0.01$, $**p < 0.05$, $*p < 0.1$. Additional independent variables in all regressions.

Table 2.13: Extensive margin: effects of electricity access on employment and earnings, 2005-2012

	(1)	(2)	(3)	(4)	(5)	(6)
	All	Men	Women	All	Men	Women
	Employment UPSS			Log of Annual Earnings		
Electricity Access (0/1)	0.003	-0.014***	0.020***	0.071***	0.074***	0.077**
	(0.00)	(0.00)	(0.01)	(0.02)	(0.02)	(0.03)
Highest Adult Education	-0.000	0.002***	-0.002***	-0.001	0.002	-0.006*
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Household Size	-0.007***	-0.006***	-0.008***	-0.026***	-0.028***	-0.020***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.01)
Wealth (Assets, 0/33)	-0.001	0.001*	-0.003***	0.036***	0.039***	0.028***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Monthly HH Con. Exp.	0.000***	0.000***	0.000***	0.000***	0.000***	0.000
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Age in years	-0.004***	-0.005***	-0.004***	-0.009***	-0.012***	-0.001
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Year fixed effects	0.035***	0.029***	0.038***	0.203***	0.165***	0.301***
	(0.00)	(0.01)	(0.01)	(0.02)	(0.02)	(0.03)
House Rented	-0.003	-0.002	-0.004	0.005	0.001	0.004
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Marital Status						
Married	0.018	0.052**	0.005	-0.075	0.050	-0.105
	(0.01)	(0.03)	(0.01)	(0.06)	(0.09)	(0.07)
Unmarried	-0.206***	-0.186***	-0.054*	-0.534***	-0.468***	-0.224
	(0.01)	(0.03)	(0.03)	(0.06)	(0.09)	(0.15)
Widowed	-0.044***	-0.061**	-0.041**	-0.053	-0.145	-0.036
	(0.02)	(0.03)	(0.02)	(0.07)	(0.11)	(0.09)
Separated	-0.019	-0.035	0.036	-0.099	-0.066	-0.024
	(0.02)	(0.04)	(0.03)	(0.08)	(0.12)	(0.11)
No gauna	-0.062	-0.065	0.222	-0.400*	-0.329	-0.164
	(0.05)	(0.06)	(0.18)	(0.21)	(0.23)	(0.31)
Constant	0.908***	1.041***	0.744***	10.031***	10.473***	9.023***
	(0.02)	(0.04)	(0.04)	(0.10)	(0.12)	(0.17)
Observations	170,397	85,392	85,005	115,308	74,201	41,107
Number of Individuals	86,391	43,582	43,020	69,320	41,822	27,499

Robust standard errors (clustered at individual level) in parentheses

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

Chapter 3

Who benefits from piped water supply?

Empirical evidence from a gendered analysis in India

3.1 Introduction

The importance of water for personal and household use in everyday life is understood most sharply when one does not have access and must wait for it and/or carry it from a distance.[58] While the lack of access to safe drinking water affects all humans universally, the unproductive burden of water collection is disproportionately placed on women and children in many patriarchal societies, where men choose, or are socially conditioned to be responsible for providing labor income or farming. In contrast, women and children are responsible for home production, such as fetching water and firewood, cleaning, cooking, and general maintenance.[59] Developing countries, including India, have made impressive progress in providing households with piped water in the last two decades. Yet, access and quality of water available for daily use remains very low in some areas. Given the disproportionate burden of home production, the 'hidden' agricultural labor of women, and the fact that India has inadequate access to clean water for daily use, intra-household labor and health inequality could be larger in the absence of piped water access.

The basic trade-offs in the context of piped water are highlighted in the standard economic theory of time allocation and labor productivity (Becker, 1965). First, lack of indoor piped drinking water (IPDW) affects women disproportionately through an increase in the amount of time spent on household chore of collecting water, especially in rural areas. The argument for employment is that the time saved from not having to fetch water daily, could be reallocated to the labor market (Meeks, 2017). Also, village level access to piped water significantly reduces the time spent

[58]This study is available as a working paper at the Asian Development Bank Working Paper Series.

[59]See O'Reilly (2006); Fletcher et al. (2017); Jayachandran (2019).

on plantation of crops, the responsibility of which is primarily borne by women in developing economies.[60] Second, lack of IPDW leads to weak personal health due to higher surface-water contamination-based illness. In absence of IPDW, families often resort to public and less clean water sources of drinking water (such as open wells, hand pumps, or other surface level sources), may wash their hands less often leading to more illness in the family, implying more time spent on unpaid care by women (such as caring for diarrhea-stricken children, or elders with fever, cough and other infection).[61] A sick child in the house, due to the lack of IPDW, constrains women's labor force participation because of the child's reduced school participation which increases unpaid care time for women.

This background is compelling enough to examine the overall effect of IPDW on labor force participation, education, and health outcomes, and then subsequently test whether those effects are differentiated by gender and location. Does access to IPDW through efficiency in time allocation and agricultural productivity reduce participation in farm work and increase wage/salary work for women? Does IPDW increase work days and earnings more for women than men given the lower benchmark? Does overall health condition improve, and are children less likely to have short-term morbidities or miss school with IPDW? To our knowledge, there has been no large scale longitudinal study in India that looks at the effect of IPDW on employment outcomes for men and women.[62] This study aims to fill this gap by identifying the labor, health and educational effects of access to IPDW on women and men in rural and urban households.

The National Rural Drinking Water Program (NRDWP, 2009), along with the inception of Integrated Management Information System (IMIS) for monitoring the status of water supply projects and coverage across rural India were launched to improve piped water delivery to households.

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[60] In developing countries, between 60 and 80 percent of food crops grow from seeds that are planted by a woman's hand (Gupta, 2009).

[61] For details, see Dehury and Mohanty (2017); Koolwal and Van de Walle (2013); Ashraf et al. (2021).

[62] Though the issue of IPDW, education and health have been broadly studied in developing economies including India (Ashraf et al., 2021; Ilahi and Grimard, 2000), these studies have largely been cross-sectional (Koolwal and Van de Walle, 2013; Ivens, 2008). So far, a robust temporal study on IPDW and its impact on gender differences in labor, earnings, health and schooling at the national level in India is missing.

The impact of these programs provides ample variation in the treatment (IPDW) with significant increase in the investment outlay from 2009-2013 in rural areas (Wescoat Jr et al., 2016; Cronin and Thompson, 2014).[63] To capture the variation in treatment, I use the nationally representative gender-disaggregated panel of the India Human Development Survey (2005-2012) which covers the pre- and post- treatment period.

Empirical analysis is mainly based on longitudinal individual fixed effects linear probability models. This is because "access to IPDW is largely driven by community-level water distribution systems, therefore, the cost of installing piped water within the household premises is relatively small once such piped water network is available within the village or the community" (Choudhuri and Desai, 2021). In rural India and China, if a community (locality/village) has the infrastructures for piped water delivery, most households within the community would also have IPDW (Choudhuri and Desai, 2021; Mangyo, 2008; Zhang and Xu, 2016). Communities could be selected to deliver piped water through public programs and/or other interventions which is largely external to household decisions, in effect, individuals and households do not directly determine village level access to piped water. Therefore, once I control for individual's movement through a balanced longitudinal sample, and time varying characteristics such as the temporal effects of living in a particular state, income, age, public program for sanitation, social networks[64] and community income, I argue that the coefficients (Average Treatment Effects, ATE) give us the most conservative point estimates. In addition, to substantiate the direction of effects of IPDW, I analyze a more recent panel data from the Access to Clean Cooking Energy and Electricity–Survey of States

[63]The Eleventh Five Year Plan, 2007-2012 identified major issues that needed to be addressed during the period: the problem of sustainability, water availability and supply, poor water quality, centralized vs. decentralized approaches and financing of operation and management cost while ensuring equity with regards to gender, socially and economically weaker sections of the society, school children, socially vulnerable groups such as pregnant and lactating mothers, and disabled senior citizens among others. In order to address the above issues, the rural water supply program and guidelines were revised w.e.f. Jan, 4, 2009 as the National Rural Drinking Water Program (NRDWP) (erstwhile known as the Accelerated Rural Water Supply Program (ARWSP), introduced in 1972-73 by the Government of India). The project's stated objective was to increase the supply and coverage of potable water to rural communities.

[64]By social networks, I refer to dummy variables for acquaintance or associations with school teachers, doctors, nurses, police, politicians.

(ACCESS), 2015-2018. Using household fixed effects, I examine the effect of IPDW on latent outcomes of women empowerment and household savings.

As a first measure of robustness, to determine the Local Average Treatment Effects, I use a Two Stage Least Squares Instrumental Variable Individual Fixed Effects (2SLS-IV-FE) approach with 'non-self community access to IPDW in the household's district' as the instrument to identify the causal point estimates. Similar 'leave out' instrumental variable has been used by Mangyo (2008) and Lamichhane and Mangyo (2011) to identify the effect of in-yard water access on child and maternal health in China, and by Vanaja (2020) in India. As a second robustness measure, I take the selection issue head on and conduct village level fixed effects with exogenous village level controls (Koolwal and Van de Walle, 2013). I aggregate individual level observations to community level (village/PSU) and incorporate time varying exogenous village level characteristics (see table 3.5) to identify the village level effects where selection into pipe water system is a major issue. Village fixed effects with exogenous village characteristics as covariates allow us to interpret our point estimates as conditionally exogenous (Koolwal and Van de Walle, 2013).

Individual fixed effects analysis shows that in rural areas, access to IPDW increased the likelihood of wage/salary employment and reduced likelihood of farm work for women, while in urban areas there was small reduction in farm work but no increase in the likelihood of wage/salary work. In effect, IPDW helped women transition from mostly unpaid farm work to paid employment activity, but only in rural areas, underlining the time-cost efficiency given higher time spent on water collection in rural areas. There is a 2.1 percentage point increase (approx. 12 percent from mean at 18 percent) in likelihood of wage/salary employment for women, while a corresponding 2.3 percentage point decrease (approx. 12 percent from mean at 19 percent) in farm work. For rural men, there is no effect of IPDW on either wage/salary or farm work, while in urban areas, there is slight decline in both wage/salary and farm work. In rural areas, IPDW increased total annual work days controlling for work hours by 8.29 days for women and 4.78 days for men. Total annual earnings in rural areas increased by 14 percent for women and 8.3 percent for men. Results show that women tend to benefit from IPDW more than men. Overall, the effects of IPDW on employment are more

pronounced in rural areas, with little to no effect of IPDW in urban areas. As anticipated, the panel fixed effect models gives us the most conservative estimates of the effects of IPDW on employment and health outcomes, with village fixed effects and IV-FE estimates showing larger magnitudes of effect in the same direction.

Contrary to the employment outcomes, the self reported health of women significantly improves with IPDW, both in rural and urban areas, especially for the poor. The likelihood of diarrhea reduces by 0.7 pp for poor households, and by 0.8 pp in urban areas. A smaller, and insignificant effect of IPDW is observed in rural areas. In rural areas, school absence with IPDW reduces by 0.88 days for girls and by 0.21 days (insignificant) for rural boys. In urban areas, school absence for girls reduces by 0.56 days and by 0.45 days (insignificant) for boys.

Section 2 discuss the literature on water scarcity for households, available studies that highlight the effect of household water supply on women's employment, and studies that look at the effect of household water supply on women and child health and educational outcomes. Section 3 and 4 discuss the data and the empirical methodology. Section 5 discusses the results of disproportionate effects of IPDW on women and section 6 concludes with policy implications and the need for a social demand curve for IPDW.

3.2 Linkages: water and and women's empowerment

3.2.1 Household water scarcity in India

Access to government-provided water services vary widely across the country (Balasubramaniam et al., 2014). As of 2015, while 87.9% of the urban households were found to have access to water for use in toilets, only 42.5% rural households had this facility (Malakar et al., 2018). India ranks among the poorest in household water access in the world. In 2001, the per capita annual surface water availability was $1902m^3$, which went down to $1614m^3$ in 2011 and is expected to reach $1154m^3$ in 2050 (Jain, 2011).

Water supply in India, both in rural areas and in cities is only available for a few hours per day, pressure is irregular and the water is of questionable quality (McKenzie and Ray, 2009). Adding

to the scarcity, water inequality is pertinent in both urban and rural India owing to social (caste) and religious differences, which are major challenges to the water distribution system. Inequality and scarcity of water is expected to increase in the future due to the increasing depletion of ground water resources and the demand side pressures due to the rising urban population (Malakar et al., 2018). The majority of India's population in rural area depends heavily on publicly provided water and have to deal with economic hardship due to sustained water shortage. In addition to poverty and inequality, historically persistent social divisions are intricately linked to access to water in rural India with caste boundaries and hierarchies (Banerjee et al., 2005; Freed, 1970).[65]

In 2008, no major Indian city had 24 hour supply of water, with 4 to 5 hours of supply per day being the norm (McKenzie and Ray, 2009).[66] In comparison to Asia-Pacific region where the average is 19 hours per day, the reliability of water supply in India is dismal. Even the averages conceal a great deal of heterogeneity within and between rural and urban areas. National level estimates from the IHDS, 2012 survey show that only 25% of the households had 24 h supply of indoor pipe drinking water with the average hours of water supply being 6 h a day. The market failure in household water supply imposes both financial (employment, assets, earnings, capital costs) and health costs (short and long term morbidities) on households (Ambrus et al., 2020; Blakeslee et al., 2020; Hill and Ma, 2017; Galiani et al., 2005). Recently, the government has decided to make access to IPDW universal in India by 2024. The argued Rs. 3.6 trillion ($49 billion) program will put piped water in all of India's 192 million rural homes — more than all the houses in the US—over the next four years. The government aims to supply at least 55 liters of potable water to each person per day by building new pipelines and refurbishing existing networks.

Infrastructure placements, such as IPDW in a populous country, where monitoring of water distribution and quality is haphazard, is challenging. McKenzie and Ray (2009) found that ground water in most urban areas in India exceeded permissible limits in terms of fluoride, ammonia and

[65] To this extent, even pop up infrastructures for water supply, such as the Water ATMs have faced the issue of social division in access and distribution of drinking water (Schmidt, 2020).

[66] The argument is also valid up until 2012, where using the IHDS survey, I find that the average supply hours of indoor pipe drinking water is 3-4 h a day.

hardness. Municipal water supply in some cities was also high in contaminants. A 2003 survey of 1,000 locations in Kolkata found that 87% of water reservoirs serving residential buildings and 63% of taps had high levels of fecal contamination. Interestingly, a 2003 study by the Centre for Science and Environment in Delhi, subsequently repeated in 2006, found that even popular brands of bottled water had high levels of pesticides (McKenzie and Ray, 2009). Overall, given the myriad social, economic and political aspects of water supply to households in India, a market or a public solution, either subsidized or sponsored or both, should take priority.

3.2.2 Water, time use and employment

Women in developing economies are argued to spend more than economically efficient time in domestic labor tasks, and too little time in other productive tasks, including market-based labor activities.[67] Women are argued to be spending significantly more time in fuel and water collection in developing economies, especially in South Asia (Koolwal and Van de Walle, 2013; Ilahi and Grimard, 2000). In Zambia, Ashraf et al. (2021) find that a one standard deviation increase in water supply complaints is associated with about 10 minutes more housework per day for young women. In India, in addition to the decreased economic autonomy and access to pooled income, the family system presses women to provide domestic labor (cooking, cleaning, collecting water and fuel, etc.). This is especially true for daughters-in-law or young married women in India, both in rural and urban areas (Dhanaraj and Mahambare, 2019; Anukriti et al., 2020). These issues call for better tailored infrastructure investments, so as to reduce the time needed for domestic chores. One such infrastructure is provisioning access to piped water within the household (Dinkelman, 2011; Ilahi and Grimard, 2000).

Adult women in India, on average, typically spend 1-2 hours every day in collecting and distributing water for the household, more than men, both in proportion and levels (Fletcher et al., 2017; Ferrant and Thim, 2019). The relationship between water and gender mirrors gender inequalities in various realms, including ownership and control over assets, employment, wages,

[67] See Ilahi and Grimard (2000); Fletcher et al. (2017); Choudhuri and Desai (2021); Anderson and Eswaran (2009); Meeks (2017).

household division of labor, exposure to and management of risk, access to services, and decision making, all of which are often intertwined with basic household infrastructures, such as the access to indoor piped drinking water (IPDW).[68] This issue, in the context of gender differences, i.e., women's employment, socio-economic well-being and health, is central to resource planning, not only in India, but in many low-income nations struggling to provide adequate and safe water supply to households.

Household constraints, such as the lack of access to water, electricity, clean cooking fuel and credit have limited women's economic opportunities and restricted their contributions to socio-economic decision making in the household, and elsewhere (Anderson and Baland, 2002; Anderson and Eswaran, 2009; Dinkelman, 2011; Rathi and Vermaak, 2018; Sedai et al., 2020a; Aklin et al., 2016). Decision-making about basic infrastructure provisions—whether by household heads, local leaders, or higher-level authorities—undervalue women's time in domestic labor and thus, may place inadequate weight on the implications for women (Koolwal and Van de Walle, 2013; Berik et al., 2009; Darity and Mason, 1998).

It is widely observed that earned income through labor market participation and entrepreneurship by women could lead to desirable empowerment and developmental outcomes for women at the household and national level (Anderson and Eswaran, 2009; Sedai et al., 2021b). Labor force participation enhances control over economic resources which could then translate into higher financial independence, socio-economic status and bargaining power in the household (Anderson and Eswaran, 2009). Market work by women has also been associated with child welfare, especially for girls through more equitable investment of women's earnings on children in the household (Schultz, 2001). In these contexts, I argue that the effect of IPDW on women's employment and economic freedom is channeled through: (i) reduced time spent in household chores; (ii) better personal health and productivity gains; (iii) improvements in child health due to reduced likelihood of water borne illnesses which increases school participation; and (iv) better health for family members overall, implying less unpaid care for women.

[68] see Das (2017); Fletcher et al. (2017); Ferrant et al. (2014); Koolwal and Van de Walle (2013); Hulland et al. (2015)

3.2.3 Water, Health and Education

According to Bartram et al. (2005), far more people endure largely preventable effects of poor sanitation and water supply than by war, terrorism, and weapons of mass destruction combined; yet somehow the issue of hygiene and water receive comparatively lower public and political imagination and public resources. The irony, as also argued by Bartram et al. (2005) of water supply issue is that the ones who can read articles such as this find it hard to imagine defecating daily in plastic bags, open pits, agricultural fields, and public areas for want of a private hygienic alternative (as do some 2.6 billion people).

In much of the world, especially in developing economies, diseases from inadequate safe water supply such as diarrhea, fever, cough and respiratory problems are a major public health issue and constraint to development. The most widespread health hazards linked to water are diarrheal diseases, which disproportionately affect young children.[69] The UNICEF (2012) report underscores the need to intensify global commitment and funding for the fight against childhood diarrhea and argues that scaling up interventions among the poorest children would save lives. Key preventive interventions include an improved water supply and the promotion of community-wide sanitation.

In India, where diarrhea is most common among all developing economies (WHO et al., 2009), it is important to examine the effect of indoor pipe drinking water on the likelihood of diarrheal disease among children under 5. Previous research by Jalan and Ravallion (2003) using propensity score matching technique to combine two cross-section surveys find that expanding piped water reduces the likelihood of diarrhea in India. They find that the prevalence of diarrheal diseases amongst those without piped water would be 21% higher and illness duration would be 29% higher, than those with IPDW. However, they also argue that indoor pipe water supply is not a sufficient condition to improve child health status; the source of ambiguity lies in the uncertainty about how access to piped water interacts with private health inputs, such as hygienic water storage, boiling water, oral re-hydration therapy, medical treatment, sanitation, nutrition, and also adult

[69] Kumar and Vollmer (2013) in their study of India using the District Level Household Survey 3, 2008, find that the incidence of diarrhea for children living in a household with improved sanitation is 2.2 percentage points lower than that for children living in a household without improved sanitation.

women's education and household income (Jalan and Ravallion, 2003). Also, contamination of drinking water due to the sheer volume of production in cities could drive the level of diarrheal, typhoid, fever, cough and cholera diseases up. In this regard, when analyzing the effect of IPDW on diarrhea, I control for the hygiene behavior post access to piped water.

For households living on the edge of subsistence, lack of, or shocks to the provision of a human necessity, such as IPDW, can have considerable consequences.[70] If households end up drinking dirtier water and wash their hands less often,[71] this increases the risk of waterborne illnesses and infectious diseases. If households, especially women, spend long hours to get water, then this could decrease their labor hours and earnings, and the time that children spend doing schoolwork or getting vaccinations. Direct time loss and illness may also decrease overall economic activity.

3.3 Data

The data used for our analysis is derived from the second and third wave of the Indian Human Development Survey (2005-2012) (Desai and Vanneman, 2018). IHDS are nation-wide multi topic gender-desegregated stratified random sample surveys jointly carried out by researchers from the University of Maryland and the National Council of Applied Economic Research (NCAER) in New Delhi. IHDS covers wide-ranging topics at the household, individual, village and school level on demographic, health, education and socio-economic characteristics. The survey covers key gender disaggregated labor and non-labor market characteristics, employment: wage salary, farm, non-farm employment, annual earnings, work days, self-reported health, incidence of illness, such as diarrhea, and water collection minutes, among others at the individual level which are of relevance in our analysis.[72] The interviewers ask a knowledgeable person, typically the male head

[70] See Sedai et al. (2021b,a, 2020a); Ashraf et al. (2021).

[71] Ashraf et al. (2021) argue that different medical technology, political institutions and culture affect the quality of water supply to households in developing economies, but IPDW is nevertheless the most secure source of drinking water for households. They argue that antibiotics and water therapy for water supplied through pipes have significantly reduced the mortality consequences of many diseases.

[72] Unlike the National Sample Surveys that asks for a woman's principal and secondary status activities, the IHDS has separate modules for different types of work (e.g., own farm and non-farm work, wage and salary labor, animal husbandry) and asks which household members participated in each type of work during the previous year. In this

of household, questions related to the socioeconomic status of the household (members), including questions related to income, employment, consumption expenditure, physical and social capital. An eligible woman between the ages of 15 and 59 in each household are interviewed about health, education, and gender relations, among others, in the household and community.

The treatment variable 'access to indoor piped drinking water (IPDW)' is derived from the household survey item, "Does your household have access to indoor pipe drinking water?" Yes is 1 and No is 0. After dropping the observations for households missing IPDW and individuals below the age of 14, I have a time balanced sample of 78,751 men and 71,623 women in each round of the IHDS survey.[73] Employment and health variables are derived from the individual level questionnaire. Treatment variable, IPDW, is from the household level questionnaire. Control variables are from individual, household and village level questionnaires. For the conditionally exogenous analysis, I use village level data from 1,401 villages covered in both rounds of the survey. However, due to missing observations for some variables, I am restricted to 1,386 villages for the rural village level analysis. It is important to note that the comparison of outcomes between men and women is not necessarily for the same household. The inferences drawn and compared are not for couples, or adults in the same household, but for the overall sample. A unique contribution from our analysis is the use of conditionally exogenous village fixed effects in a dynamic set up.

As a measure of robustness, I also analyze the effect of IPDW on household outcomes more recently using the ACCESS panel, 2015-2018. The ACCESS survey cover six relatively poorer and populous states: Uttar Pradesh, Madhya Pradesh, Bihar, Jharkhand, Odisha and West Bengal. Similar data coding, estimation, control and treatment strategy is followed for both surveys. However, due to data limitations in the ACCESS survey, the outcome variables in both surveys are not similar. Therefore, I use latent effect variables to analyze gender differences as a measure of robustness through the ACCESS survey analysis. In addition, I use the India Time Use Survey,

study, following Chatterjee et al. (2018), anyone who worked for at least 240 hours in the previous year across all types of work is considered to be in the labor force.

[73]Note: the balancedness of the sample is by households at the beginning of the analysis, not by each outcome variable. I use the sample in which the households are tracked in both the waves, there could be cases where some households do not respond the questions (missing covariates) in both waves.

2019 to motivate the hypothesis of the effect of time spent on water collection on employment outcomes. I also use the rainfall shocks measured as the z-score in a single season by district between 1996-2011 constructed from Climate Hazards Group Infrared Precipitation (CHIRPS) as a control in the fixed effect regressions. This is because rainfall has been found to be positively correlated with access to IPDW, and has been found to affect employment outcomes and agricultural output, especially in rural India (Fishman, 2018; Emerick, 2018).

3.4 Empirical Model

3.4.1 Fixed Effects

Identification for the empirical analysis is mainly based on individual fixed effects regressions. First, there is ample policy induced positive increase in rural household access to piped water between 2005 and 2012 in the IHDS data which allows us to estimate the ATE for households that acquired piped water post-2005. Second, given the argument that household choices within a community do not determine access to piped water in India, especially in rural areas, using a longitudinal fixed effects model controls the selection issue. The individual fixed effects model is given below:

$$Y_{it} = \pi W_{it} + \phi X_{it} + \delta_i + \sigma_t + \epsilon_{it} \tag{3.1}$$

In equation 3.1, Y_{it} is the outcome variable for individual i at time t. It is the likelihood of farm work, wage/salary work, business activity, annual work days and earnings, self-reported health, household's short term morbidities, likelihood of diarrhea, and school absence. W_{it} is an indicator for access to IPDW. The reference households are those that do not have access to indoor pipe drinking water, and the treatment is switching from no access to IPDW to access between 2005-2012, or vice versa. X_{it} are a vector of individual, household and community characteristics: household income, individual's age, marital status, education, access to electricity, public program for sanitation, community income and Z score of district level variation from average rainfall. δ_j

captures the individual specific effects. σ_t captures the trend effect. The aim is to estimate the impact of W_{it} on Y_{it}.[74]

One major issue in estimating the relationship between pipe water and welfare outcomes is the lack of variables on latent preferences and knowledge of available water resource. Some households within a community with restricted access to pipe water may have latent preferences, knowledge, or unobserved resources that lead households to have better access to infrastructure than other (observationally similar) households (Koolwal and Van de Walle, 2013). For instance, a household close to a petrol pump (gas station), a government office or politician's residence may be able to gain access to pipe water through social network even in areas where the community as a whole does not have such an infrastructure. To control for the effects of these social networks on access to IPDW, I use the unique variables in the IHDS survey which ask households if they have connections or acquaintances with government officials, politicians or police, teachers or school workers, doctors or health care workers. These controls, I argue account for most of the latent preferences and knowledge of households in areas where access to pipe water is largely unavailable at the community level. In addition to the extensive controls for individual, household and community characteristics, I interact the state and time fixed effects to capture the effect of state level conditions and endowments over time, which is critical given the topography of India.

3.4.2 Robustness

Conditionally Exogenous Village Fixed Effects

As a first robustness measure, following Koolwal and Van de Walle (2013), I take the issue of village level selection head on and exploit the difference in average community level access to IPDW by controlling for time-varying exogenous community characteristics affecting the supply of IPDW overtime. The technique requires adequately capturing relevant geographic characteristics jointly influencing outcomes and infrastructure through the vector G_{jt}, and any geographic means

[74] A randomized control trial would not be a feasible option given that our aim is to observe the macro-level effects of the intervention of IPDW. Also, Ravallion (2008) argue that it is rarely feasible to randomize the location of infrastructure projects and related programs, which are core activities in almost any poor country's development strategy.

of X_{it} not included in G_{jt}. The addition of community specific effects and time trends presents an additional layer of robustness compared to Koolwal and Van de Walle (2013). The modification to the analysis in equation 3.1 is given below:

$$Y_{ijt} = \pi W_{ijt} + \phi X_{ijt} + \lambda G_{jt} + \delta_{ij} + \sigma_t + \theta_{jt} + \epsilon_{ijt} \tag{3.2}$$

Here, the exogenous community characteristics G_{jt} affects the placement of IPDW.[75] In equation 3.2, the error term has two components, a geographic effect θ_{jt} and an idiosyncratic (household-specific) effect ϵ_{ijt}. The geographic component of the error term sweeps up all level differences in the error term between areas (Koolwal and Van de Walle, 2013), so that the geographic mean of ϵ_{ijt} vanishes (Koolwal and Van de Walle, 2013). All regressors are exogenous except W_{ijt}, which is correlated with ϵ_{ijt} through individual choices, that is, $Cov(W_{ijt}; \epsilon_{ijt}/G_{jt}; X_{ijt}) \neq 0$. According to Koolwal and Van de Walle (2013), aggregating individual level covariates within a given area and adding exogenous village level characteristics in a regression model makes the point estimates conditionally exogenous; that is, $Cov(\bar{W}_{jt}; \theta_{jt}/G_{jt}; \bar{X}_{it}) = 0$, where the bar over a variable denotes its geographic or community-level mean. Aggregating equation 3.2 over geographic areas, giving the standard "between estimator" overtime, as below:

$$\bar{Y}_{jt} = \pi \bar{Z}_{jt} + \phi \bar{X}_{jt} + \lambda G_{jt} + \theta_{jt} \tag{3.3}$$

I use a range of time-varying geographic controls such that the latent geographic effects on outcomes and placement can be treated as uncorrelated. To do so, I refer to geographic controls used by Koolwal and Van de Walle (2013) (See table 3.5). While individual fixed effects applied to equation 3.1 could still yield a biased and inconsistent estimates, equation 3.3 shows that π can be identified by geographic aggregation under a weaker assumption that the geographic placement is conditionally exogenous.

[75]Note: G_{jt} also includes community means of X_{ijt}. In the absence of G_{jt} and θ_{jt}, the regression specification in equation 3.2 is similar to that of equation 3.1.

Instrumental Variable Analysis

If water infrastructures were placed in the areas where employment and health were poorest, the impact of the facilities would exhibit a downward bias. On the other hand, if water infrastructures were placed in more accessible and prosperous areas, it would lead to a positive bias (Lamichhane and Mangyo, 2011). Therefore, the effect of time-varying unobserved heterogeneity (correlation with the error of the outcome and access to IPDW across time due to unobserved data) cannot be accounted with fixed effects model. Following Vanaja (2020); Mangyo (2008); Li et al. (2021); Zhang and Xu (2016); Ilahi and Grimard (2000) and Lamichhane and Mangyo (2011) I use 'non-self community level access to IPDW' in the district as an instrument.[76] The instrument captures average access to IPDW at the community level (village and PSU level), excluding the community of the household in the district of the state at time t. The instrument has been widely used in the literature to capture the unobserved heterogeneity in infrastructure placements such as electricity and water supply.[77] The first stage estimation is given as:

$$IPDW_{it} = \rho IPDW_{-jt} + \phi X_{it} + \delta_i + \sigma_t + \epsilon_{it} \tag{3.4}$$

Where, $IPDW_{-jt}$ represents the non-self community level access to IPDW. It gives the average level of village/PSU level access to IPDW in the district of a state, excluding the village/PSU of the treatment household.

Insert figure 3.1 about here

Figure 3.1 shows the change in non-self community level access to IPDW between 2005-2012 in the six administrative regions in India. States in West, South and North-East saw a significant increase in access to IPDW at the community level between the survey waves, while states in central and eastern regions saw little to no increase in community level access to IPDW.

[76] An IV for presumably high degree of selection is a demanding requirement, as one can reasonably question whether any observed household characteristic that might influence access to household-specific infrastructure would not also be a relevant determinant of overall outcomes, independently of infrastructure (Koolwal and Van de Walle, 2013; Ravallion, 2008; Kumar and Vollmer, 2013; Gamper-Rabindran et al., 2010).

[77] See Sedai et al. (2020a), Sedai et al. (2021b), Vanaja (2020), Dang and La (2019).

The instrument, I argue is strong because (i) higher non-self community level IPDW in neighboring communities indicates the economic and geographic feasibility of having IPDW in own community, which implies higher likelihood of the household i having access to IPDW, and (ii) higher IPDW in other communities, $-j$, does not directly affect a household i's gendered outcomes in community j if the average value of the instrument is relatively low across districts, which is the case in India, especially in rural areas. The exogeneity condition for the instrument holds as IPDW in other communities does not directly affect labor market differences in one's own community.[78] As discussed in the potential threats to identification, I do anticipate that household's own community level IPDW and the availability of other infrastructures will have an impact on individual LFP, hence excluding one's own community from the instrument is key to the exclusion restriction. I successfully tested the relevance and strength of the instrument using tests of under-identification (Kleibergen- Paap rk LM statistic), and weak identification (F-statistic of the instrumental variables in the first stage equation and Cragg-Donald Wald F test). Also, as the average access to IPDW increases in the other $-j$ villages increases, the j^{th} village will be more likely to have piped water, thus satisfying the monotonicity of the IV criteria, as in Angrist and Imbens (1995). Following the argument that there is no self-selection in access to IPDW at the household level (Choudhuri and Desai, 2021),[79] I posit that in the light of lack of district level data on phase wise implementation of the NRDWP, and the argument by Ravallion (2008) and Koolwal and Van de Walle (2013) that it is difficult to find an IV for a resource as basic as piped water, the most plausible empirical strategy for India is the use of fixed effects in a longitudinal set-up.

[78] Our IV method follows Zhang and Xu (2016) and captures the implementation of the water program through large or discrete increase in the ratio of households with access to water in a community, which is more likely a exogenous government program rather than a spontaneous change in each household's demand.

[79] There are low costs to household access to IPDW once the pipe water supply infrastructure is present in the village (Mangyo, 2008; Vanaja, 2020). Choudhuri and Desai (2021) present a detailed discussion on the issue of endogeneity of IPDW in India. They argue that the more significant role in facilitating access to drinking water to the household are played by village infrastructure and water systems, and the local administrative units, and these are largely external to the household decisions in India.

3.5 Results

3.5.1 Descriptive analysis

Figure 3.2 shows district level access to IPDW in 2005 and 2012. It shows a clear lack of adequate IPDW at the household level in India. A significant increase in IPDW (above 5 pp) is observed in Punjab, Haryana, Himachal Pradesh, Uttarakhand, Manipur, Nagaland, Mizoram, Andhra Pradesh, Goa, Maharashtra, Tamil Nadu and Karnataka, while Delhi, Madhya Pradesh and Puducherry saw a significant decline between the survey waves. The figure also shows disparities between and within states in India. Districts within states have differential access to IPDW.[80] Figure 3.3 shows hours of water supply on a typical day in the household at the district level in India. Barring a few districts where the average hours of supply are between 6-12 hours, most districts receive water supply for about 1-7 hours a day. Figure 3.2 and 3.3 together present the picture of a serious lack of drinking water infrastructure at the household level in India, which exemplifies the universal lack of IPDW within India.

Figure 3.4 shows the access to IPDW, water within house, water supply hours, distance to water in minutes, and men and women's daily water collection minutes from the IHDS survey. The figure shows that there was a significant increase in rural IPDW (in percentage) between 2005-2012, highlighting the effect of the revised NRDWP, effective 2009 which focused on rural household water supply, moving away from community water infrastructure provisioning. In urban areas there is no significant difference in access to IPDW. There was no significant change in the availability of water supply within the household premises both in rural and urban areas. Figure 3.4 shows that women's water collection minutes dropped significantly in rural areas between 2005-2012, a similar but smaller drop in women's water collection minutes was noted in urban areas. Men's water collection minutes also dropped both in rural and urban areas between the survey period, but the drop was from a smaller base as compared to women's water collection minutes.

[80] Since IHDS does not cover all districts, some districts are shaded in white color meaning no data is available.

Figure 3.5 shows the kernel density plot of time spent in water collection by men and women. Figure 3.5a using IHDS 2005–2012 shows that at around 60 minutes and onwards the time spent by women in water collection is higher than that of men, the difference is neutralized after 200 minutes of water collection in a day. Figure 3.5b shows similar statistics using the latest India Time Use Survey, 2019. Also, the number of women collecting water daily are 2.5 times more than men in the IHDS sample,[81] this could further skew the labor force participation between men and women.

Figure 3.6 shows correlation between time spent per day on water collection and minutes of market work activity using an ordinary least squares regression (controlling for National Sample Survey Region, education, marital status and age). The data for the figure is derived from the India Time Use Survey, 2019, a nation wide survey, where 22,800 individuals out of 3,81,100 eligible people above 14 years reported time spent on 'fetching water from natural or other sources for own and household consumption use' on the day of the interview. The figure shows that the falling trend of market work activity with water collection activity is evident across gender, and all castes (panel (a) shows the result by gender in rural and urban areas and panel (b) shows the effect for men and women by caste categories). The correlations show a stronger negative effect of time spent on fetching water on paid employment activity for men as compared to women.

The descriptive statistics in table 3.2 shows that the national level access to IPDW in 2005 was 26% and it increased to 30% in 2012. However, for the six relative poor and populous states in India (ACCESS survey of rural areas), access to IPDW was 5.7% in 2015 and 6.6% in 2018. I also mapped the six states of the ACCESS survey in the IHDS data set and found the same corresponding level of access to IPDW between 2005 and 2012 for the states of Odisha, West Bengal, Uttar Pradesh, Madhya Pradesh, Jharkhand and Bihar. Therefore, using the IHDS data set does not disregard any recent development in household access to IPDW.

Table 3.3 shows the descriptive statistics for the IHDS dataset with the treatment being access to IPDW between 2005 and 2012. 33% of the households had access to water within household

[81] In ITUS, 2019, I find 22,800 observations out of 445,000 people reported collecting water on an everyday basis.

premises in 2005, similar to 2012. There is no significant difference in water supply hours between households that had and did not have access to IPDW, conditional on having source of water in the house. On average, the walk time to water was around 10-12 minutes for households that did not have IPDW. Figure 3.4 shows that in 2005, on average, women spent significantly higher time in water collection, 73 minutes as compared to men's 35 minutes in households that did not have IPDW. In 2012, the average water collection time was 50 minutes for women and 29 minutes for men with no IPDW. Choudhuri and Desai (2021) report that among households without IPDW, the participation rate in water collection activity was 94.8% among women and 70% among men in 2012.

Households without IPDW tend to have slightly higher employment (wage, salary, farm, business and animal husbandry) as compared to household with IPDW. Similarly, households without IPDW tend to have slightly higher likelihood of having a wage/salary employment (24% in 2005 and 32% in 2012) as compared to households with IPDW (20% in 2005 and 28% in 2012). Households with IPDW tend to have higher annual work days as compared to households without IPDW. Descriptively, there is no significant difference in self-reported health for women with and without the access to IPDW. The likelihood of having diarrhea (past month) is slightly lower in households with IPDW as compared to households without IPDW in 2005, and there is no such difference observed in 2012. However, the number of days a child missed school in the last month is significantly lower in households with IPDW as compared to households without IPDW. Table 3.5 shows the time varying exogenous village level characteristics used in the conditionally exogenous village fixed effects results as controls. Table 3.4 shows the descriptive statistics of the household, individual and district level controls used for our analysis. The wetness and/or dryness characteristics of the district affects both our outcome variables and access to IPDW, hence the standardized Z score for rainfall at the district level is used as a control variable.[82]

[82]Rainfall shocks measured as the z-score in a single season's rainfall is constructed from CHIRPS. I extract daily precipitation for each day in a monsoon season that is 1st June to 30th September and sum it for a given year. I construct rainfall z-score for a given year as a deviation from the long-term average precipitation (1996-2011) and scale it with long term standard deviation. I assign rainfall z-score calculated for 2004 and 2011 to wave 1 and 2 respectively to construct rainfall z-score used in the analysis.

Figure 3.7 shows the individual fixed effects estimates of sources of water on any employment (farm, business, wage, salary and animal husbandry) for men and women in rural and urban areas. For the analysis, I control for the time trends, individual specific effects and the month of the interview. Piped water supply is the base category in the fixed effects regression, with the point estimates being compared for tube-well, hand-pump, open-well and all others.[83] Results show that having hand-pumps as a source of water for the household has a significant negative effect on both men's and women's employment, both in rural and urban areas. For men, open-well also has a significant negative effect on their employment in rural areas. In urban areas, the sources of water in comparison to piped water do not yield any significant differences in the likelihood of employment.

3.5.2 IPDW, Time Use & Employment

Table 3.6 shows the main results of our analysis on labor market outcomes of piped water using individual fixed effects. In rural areas, access to piped water reduces women's likelihood of farm work by 2.3 percentage points and increases women's likelihood of wage/salary[84] work by 2.1 percentage points. The above result highlights the significance of pipe water in transitioning women out of mostly unpaid farm work to paid employment thereby providing them economic resources, which Anderson and Eswaran (2009) argue is critical for women empowerment. Given the high degree of disguised unemployment (surplus labor), especially for women in the agricultural sector in India (Mazumdar and Sarkar, 2020; Ivens, 2008), a higher increase in wage/salary employment with IPDW is expected. Access to pipe water increase work days more for women, 8.29 days, than men 4.78 days in rural areas. Piped water also increases annual earnings by 14.2 percent for women and 8.3 percent for men. In urban areas, piped water reduces the likelihood of women's farm work by 0.6 percentage points and does not affect any other employment margins. Piped

[83] All other categories of sources of water include: covered-well, rainwater, tankers, bottled water, etc. All of these sources combined are less than 5% of the overall sources of water and hence, are clubbed in the other category.

[84] The variable wage/salary employment is derived from the survey questionnaire which asks: "Besides work on the household farm or in any of the household's businesses, what work did [NAME] DO LAST YEAR for payment in cash or kind."

water reduces the likelihood of men's farm work by 0.6 percentage points, and increases their annual income by 4.3 percent. Table 3.7 shows similar findings using the conditionally exogenous village fixed effects[85] model with slightly higher magnitudes of effect, but with similar signs and significance of the coefficients.

Table 3.8 shows the point estimates of the effects of IPDW on labor market characteristics using IV-FE model. The sharpened two stage q-values are derived from Anderson (2008) to reduce the likelihood of false rejections when testing testing multiple hypotheses. The point estimates of the IV-FE regressions show that access to IPDW reduces the likelihood of women's farm work and increases their likelihood of wage/salary work, just as in the individual fixed effects model in Table 3.6. The Local Average Treatment Effects of the IV model also show slightly higher magnitudes of coefficients compared to the individual fixed effects model, but the direction of effect and the gendered impacts remain the same. As observed with any form of employment, there is no effect of IPDW on women's wage and salary employment in urban areas. A trend of increase in women's relative share of wage/salary employment as compared to men's employment with household water supply has also been observed in rural India during 1996/97 by Koolwal and Van de Walle (2013). The economic empowerment effect of increased water access in developing economies according to Ivens (2008) is rarely observable on women's daily workload. They argue that women are already working for 9-11 hours in a day on agriculture and home production combined. Thus, access to IPDW could be critical in transitioning to wage/salary based employment where women gain economic resources, and moving away from own farm agricultural work where there is no payment for the work.

3.5.3 IPDW Health and Education

In this section, I discuss the effects of IPDW on the self-reported health outcomes for adult women, likelihood of diarrhea in the household in the past month, and school absence of the child in the past month. I use fixed effects and instrumental variable fixed effects for the analysis. In

[85]The exogenous village characteristics controls are described in table 3.5.

addition, I extensively control for household time varying factors that could affect access to IPDW such as average community income, education, household size, public programs for sanitation (latrines/toilets), wide range of social networks, electrification, and any time trends.

Table 3.9 shows the effect of IPDW on women's self-reported health. I make two classifications of self-reported health (i) assigning good and very good health as equal to 1 and assigning poor, very poor and OK health as 0, and (ii) assigning good, very good and OK health as equal to 1 and assigning poor and very poor health as 0. In the first scenario, instrumental variable fixed effects analysis shows that access to IPDW leads to a 33.7 pp increase in women's self-reported health in rural areas and 50.6 pp increase in self-reported health for poor women. In the second case of moving from poor health to OK health and above, having IPDW has significant positive association with self-reported health for rural and poor women.[86]

Household IPDW and health outcomes are intricately linked, both directly and indirectly. The direct impact of IPDW disruptions is that families may substitute into less clean water, which should increase the prevalence of water-borne illnesses (Ashraf et al., 2021). Due to a large amount of time spent in the household (Sedai et al., 2021b; Fletcher et al., 2017), the impact of water disruptions on women could extend beyond water-borne illnesses into highly contagious diseases (for instance, respiratory issues, intestinal worms or malaria) due to the lack of piped water for hand-washing and consumption. This consequently affects women's labor productivity and participation, meaning more sick people in the household will lead to less working opportunities, days and hours. According to the study by Ashraf et al. (2021) in Lusaka, Zambia, a one standard deviation increase in outstanding supply complaints was associated with 57 extra cases of respiratory infections and 0.83 extra cases of the measles, increases of 13% and 18%, respectively.

Table 3.10 shows the effect of IPDW on diarrhea and the number of days individuals were ill in the last month. In addition to the controls used in the previous analyses, I include two additional controls, purify water (0/1) and store drinking water with lid (0/1), which could lead to illness

[86]Due to data limitations on the self-reported health (available only for the eligible women's survey in both the IHDS waves), I could not draw the same estimates for men.

regardless of the sources of water for the household. Diverging from the previous specifications for gendered analysis, I analyze the full sample, the rural-urban sample and the poor and non-poor sample. In panel (a), the IV-FE model shows that having access to IPDW reduces the likelihood of diarrhea by 1.5 percentage points for the overall sample, approximately 4,500 less death as per the National Commission on Macroeconomics and Health report in 2005 (Lakshminarayanan and Jayalakshmy, 2015). I anticipated and found a stronger effect of IPDW on diarrhea in urban areas, a 2.2 percentage point reduction owing to higher surface level contamination of household water supply (Paul, 2020; McPike and Luke, 2012; Jalan and Ravallion, 2003). In panel (b), the IV-FE model shows that IPDW reduces the number of days an individual is ill by 0.31 days for the overall sample, and by 0.58 days for women from poor households.

Our finding is in line with meta analysis of literature by McKenzie and Ray (2009) who argued that in India, the surface level contamination of water, which could lead to diarrheal diseases among others, is higher in urban areas as compared to rural areas. Hence, I anticipate a higher negative association between IPDW and diarrhea cases in urban areas. The fixed effect analysis also shows that access to IPDW has a significant association with reduction of diarrheal disease for poor households, the coefficient is 0.7 pp, while no significant association exists for non-poor households. Similar to our study, Ashraf et al. (2021) find that a one standard deviation increase in outstanding supply complaints (24 days) led to an increase of 24 cases of diarrhea, and 0.05 cases of typhoid fever, an increase of 12% and 22%, respectively.

Next, I analyze the association between IPDW and school absence for boys and girls (monthly) under age 15 for the overall sample and by rural and urban areas. The individual fixed effect and instrumental variable analysis shows that access to IPDW is negatively associated with school absence in the past month, the negative association is expectedly stronger for girls as compared to boys.

Access to IPDW leads to 1.48 less days of absence from school for the overall sample. For girls the association is 1.55 less days of school absence in a month. The association is also more pronounced for rural girls as compared to urban girls, 2.44 and 1.39 less days of school absence in

the past month, respectively. There is a negative effect of IPDW on school absence for boys, both in rural and urban areas, however, the association is insignificant in urban areas. In a cross-country analysis involving nine developing countries, including India, Koolwal and Van de Walle (2013) noted that increased access to piped water improves the extent of children's enrolment in schools.

3.5.4 Robustness

As means of robustness, using the ACCESS survey, 2015-2018, I conduct fixed effect regressions on total cooking hours, non-male head decision making and total annual household savings.[87] I do this to control for the time-variant location factors that could be correlated with both IPDW and employment outcomes. I also cluster the standard error at the village/PSU level to check for the robustness of the standard errors. However, the caveat with the use of the ACCESS survey is that the data are available only at the household level and comparison of individual level employment outcomes is not feasible.[88] Therefore, to capture latent effects on household welfare and women empowerment outcomes, I use the following variables: (i) non-male head decision making in the household, (ii) cooking hours in a day, (iii) total fuel collection minutes in a day, and (iv) household savings annually.

Following Sedai et al. (2020a) and Kabeer (1999), I argue that the above variables have a latent effect on women's economic decision making and social empowerment. Non-male head decision making in the household can be inferenced to be women's decision making ability in the ACCESS data. This ability to take decisions in the household is critical for women's social empowerment and household bargaining power (Sedai et al., 2021a; Ashraf, 2009). Long cooking hours, which is mostly women's responsibility, tend to have a negative effect on women's health (Parikh, 2011),

[87] Following Kabeer (1999); Sedai et al. (2021a); Pelz et al. (2021) and Sedai et al. (2021b), I choose the outcome variables out of the possible indicator variables that could have a latent effect on women empowerment from the ACCESS survey.

[88] ACCESS survey has 8,562 households in each round of the survey. Approximately 65% of the respondents across the ACCESS survey are household heads. Analysis is carried out using the balanced sample of the households across the surveys, and not for each outcome. For certain outcome variables, observations might be lower due to truly missing data points.

and women would benefit more with overall reduction in fuel collection time in the household (Ferrant et al., 2014; Sedai et al., 2021b).

For the analysis, I control for: household's below and above poverty line status, household adult education, age, household size (number of children and adults), household monthly consumption expenditure in Rs., and the wave dummy. Table 3.12 shows that access to IPDW increases the likelihood of non-male decision making ability by 3.5 pp (the mechanism of effect is presumed to be either through economic empowerment of women through employment because of the time saved in water collection, health improvements for women and children as discussed earlier). Having access to IPDW reduces cooking hours by 5.4 percent, a considerable amount of time saved in the cooking process which often involves collecting and purifying water. Access to IPDW also reduces time spent in firewood 0.61 hours on a daily basis. Access to IPDW also increases annual household savings by Rs. 2558 (nominal savings, Rs. 2400 in real savings). These results confirm to the trend of a positive effect of IPDW on women's empowerment in recent times and is robust to sample changes.

3.6 Policy and conclusion

3.6.1 Policy

A number of studies have argued for direct policy intervention to reduce the gender gap in employment and economic outcomes—not just because it is ethical, but because it would help alleviate poverty. One step in this direction would be to relieve the burden of water collection and maintenance which can facilitate women's participation in market-oriented activities. This is expected to increase their contribution to personal care expenses and household income. In addition, with lesser burden of water collection and maintenance, households in general and women in particular will likely be healthier and could invest more time in children's nutrition, and education. Therefore, a significant long-term consequence of better work opportunities and earnings through IPDW for women could be inducing households to invest in the education of their daughters. As a result, IPDW could be crucial in breaking the vicious cycle of women not getting quality formal

education leading to limited employment opportunities which leads to limited or no earnings and consequently, leading to little human capital.

Given the recent progress in provisioning of basic infrastructures such as electricity, liquefied petroleum gas, toilets and bank accounts, a similar and in fact stronger impetus should be laid on provisioning of indoor pipe drinking water as it has multi-dimensional effects on gendered and household outcomes, especially in rural areas. A back of the envelope calculation shows that the 11.8 pp increase in overall employment with IPDW could engender 2 million jobs as of 2012 conditional on adequate demand for the increase in labor supply.[89] The fixed effects estimate shown in table 3.12 (column 1) shows that average household savings with IPDW is approximately Rs. 2400 annually (in six relatively poorer and populous states). This estimate could be regressed across income levels and socio-economic status to understand the willingness to pay for indoor pipe water.

3.6.2 Conclusion

This study examines the effects of access to indoor piped drinking water on gender differences in general employment, wage and salary employment, amount of annual earnings and annual work days between men and women in India. In addition, the study examines the effect of indoor piped water on the likelihood of incidence of diarrhea, and the likelihood of child school absence. The study is a first in India to use longitudinal analysis approach which controls for time invariant factors that could affect selection into piped water in the household, and any systematic recall bias. In addition, the study is the first one at the national level which allows for a comparison of rural-urban effects of indoor pipe water on gendered outcomes. The study uses three empirical strategies to arrive at a conservative point estimate of effects which could be policy relevant. To control for arguments of self-selection which is imperative in basic household infrastructures, such as access to water, I use conditionally exogenous (village fixed effects) and instrumental variables regressions.

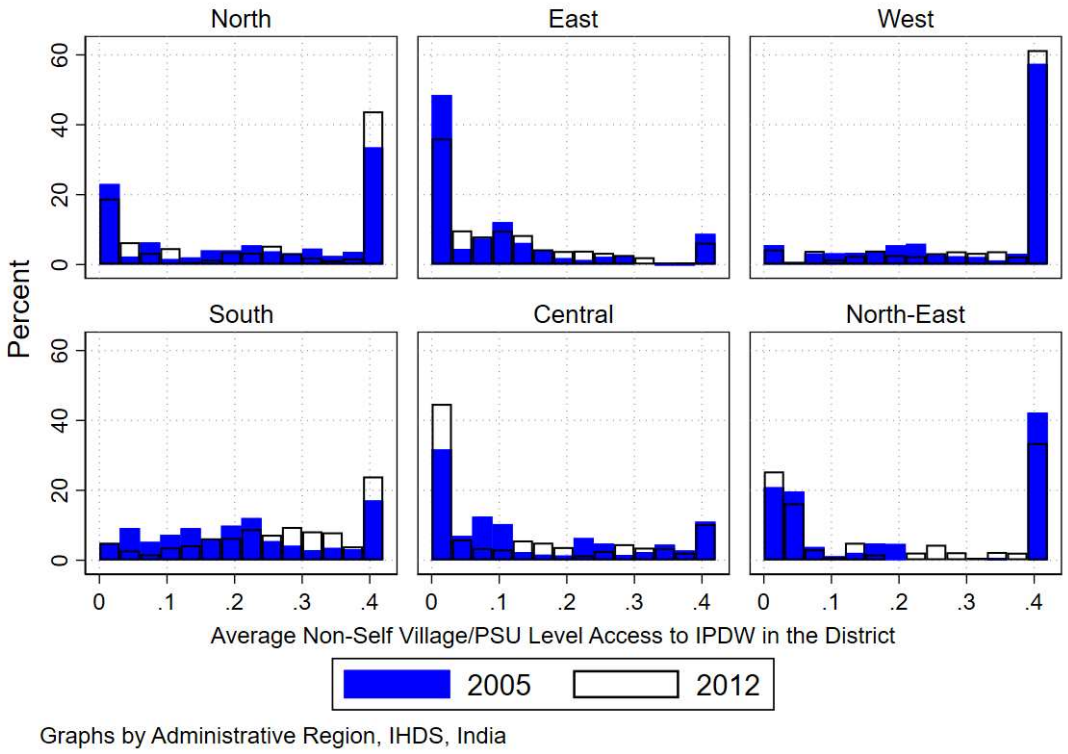
[89] In 2012, there were 26 million unemployed people in the labor force, out of which 65% households did not have IPDW. Multiplying the unemployed (in the labor force) without IPDW by 1.118 yields the probable increase in supply of 2 million workers.

The study finds indoor piped water to be critical in reducing gender differences in employment with women disproportionately benefitting from access to pipe water in the house in terms of employment opportunities, especially in rural areas both on and off the farm. Underscoring the rapid fall in women's labor force participation rate in India, 30% in 1990 to 20% in 2020, especially in rural areas, the positive effect of IPDW on employment and earnings, especially in rural India could be pivotal in reducing gender differences in rural India.

After controlling for the process of water purification and storage, I found significant decreases in diarrhea with access to indoor piped water, suggesting that indoor piped water is a superior substitute to other sources of drinking water for the house, both in terms of employment and health. Any other source of water is found to be inferior to piped drinking water in terms of its effects on employment for both men and women, as was also found by Ashraf et al. (2021) in Lusaka, Zambia. Having access to piped water influences a number of everyday activities, therefore there are significant costs to not having it. For families with fewer resources, the substitutes such as hand sanitizers, bottled water or gym showers are hard to come by; therefore, a policy solution to supply adequate drinkable water through pipes should be a priority, if human development is of significant concern.

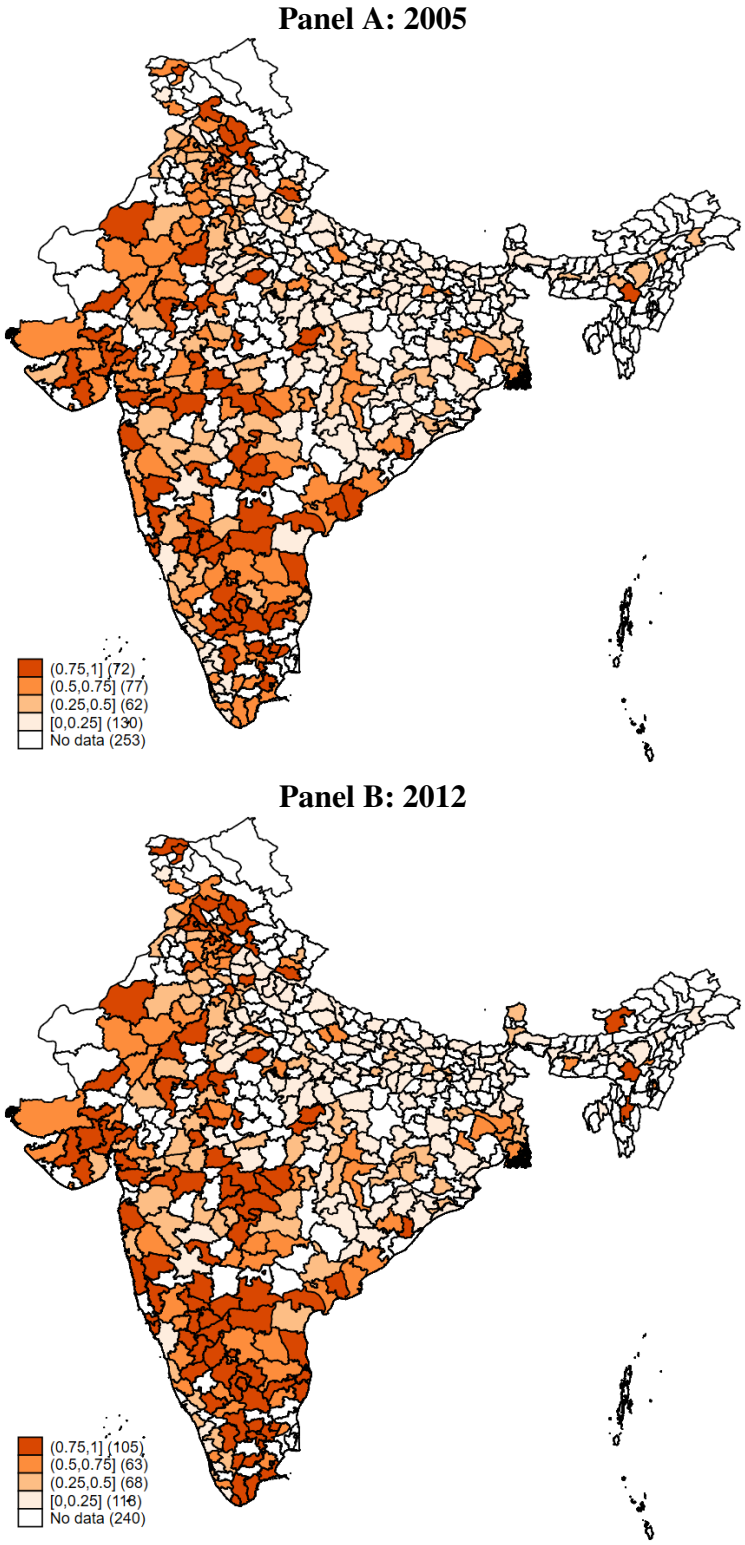
Results show that when piped water is lacking, women's economic freedom is lower than what it could be. Increase in adult women's employment and earnings through adequate provisioning of basic infrastructures–water, electricity, toilets, gas–could be a welcome increase in consumption at the national level, potentially better technology and standard of living. If the poor people could be protected from the drudgery of water collection from open wells, boreholes, civic taps, etc., it could go a long way in reducing economic inequality. Given the consistency in the effect of piped water on women's socio-economic outcomes in developing economies, lack of access to piped water could indeed be a crucial determinant of differences in women's socio-economic outcomes between developed and developing economies.

3.7 Tables and Figures



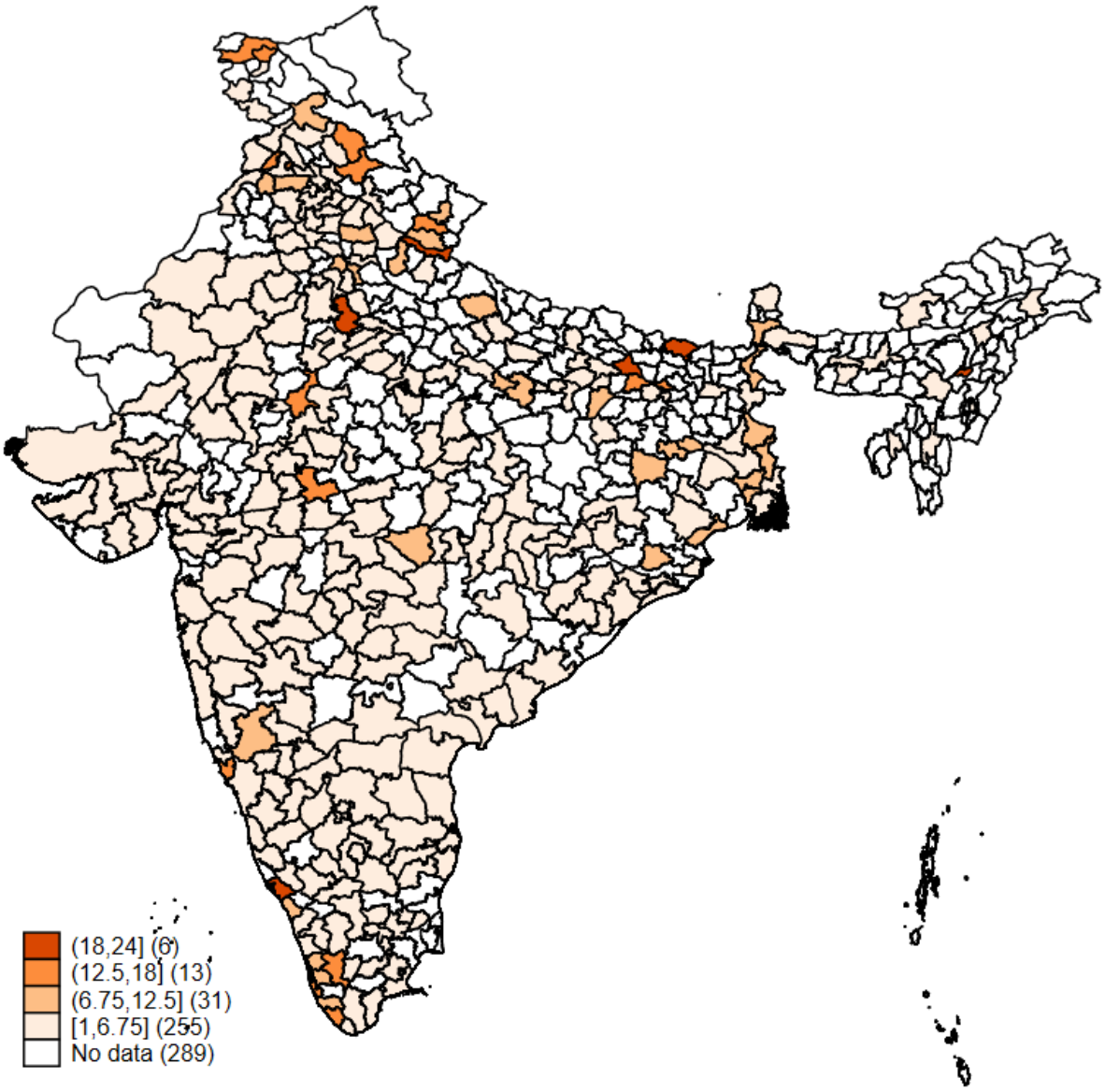
Notes: Authors' computations using IHDS-1 and IHDS-2. North Zone includes Jammu and Kashmir, Himachal Pradesh, Punjab, Uttarakhand , Uttar Pradesh and Haryana. East Zone includes Bihar, Orissa, Jharkhand, and West Bengal. West Zone includes Rajasthan, Gujarat, Goa and Maharashtra. South Zone includes Andhra Pradesh, Karnataka, Kerala and Tamil Nadu. In 2014, the state of Andhra Pradesh was divided into the two states of Andhra Pradesh and Telangana. Central Zone includes Madhya Pradesh and Chhattisgarh. North East Zone includes Assam, Sikkim, Nagaland, Meghalaya, Manipur, Mizoram, Tripura and Arunachal Pradesh.

Figure 3.1: Average non-self community level access to IPDW by regions in India



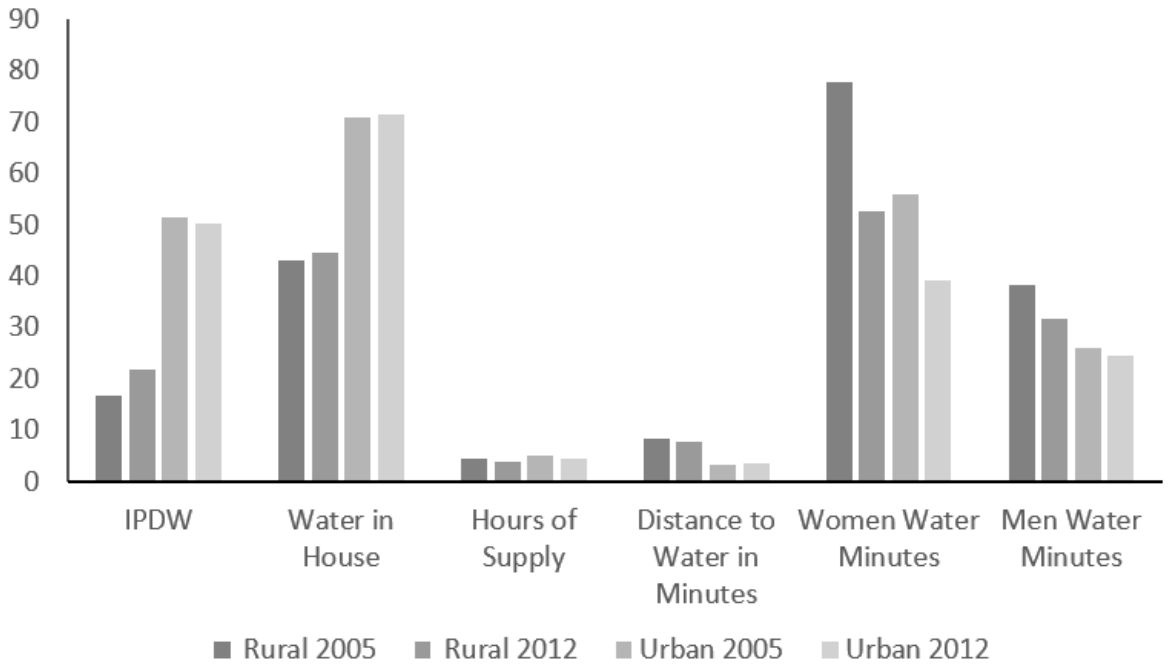
Notes: Authors' computations using IHDS-1 and IHDS-2. Note the map is not representative of actual boundary. Maps are based on the administrative boundaries, "https://www.diva-gis.org/gdata".

Figure 3.2: Intensity of pipe water access at the District Level



Source: Authors calculations, IHDS, 2012. The overlaying map has been taken from the "https://www.diva-gis.org/gdata". The figure was drawn according to the administrative boundary of India, not the actual boundary.

Figure 3.3: Hours of Indoor Pipe Drinking Water on a typical day, India, District Level, Label: Cumulative hours (0-24), IHDS (2012).



Source: Authors calculations, IHDS, 2005-2012.

Figure 3.4: Descriptive Statistics of Access to Water and Water Collection by Gender, 2005-2012. Note IPDW and Water in House are in percentages. Water collection minutes are daily averages conditional on at least some time spent on water collection.

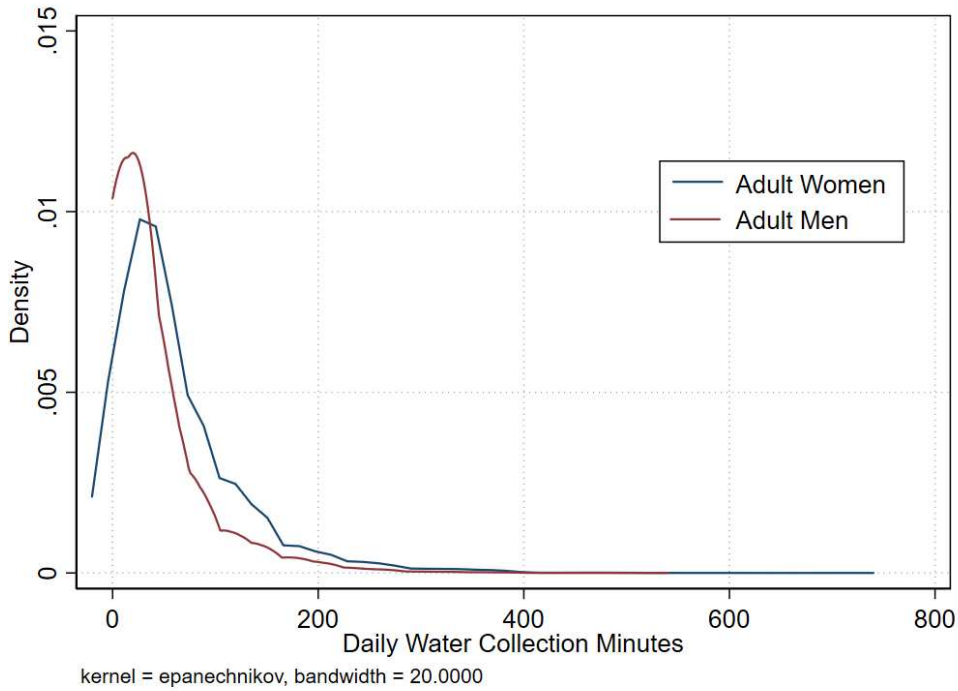


fig 3.a

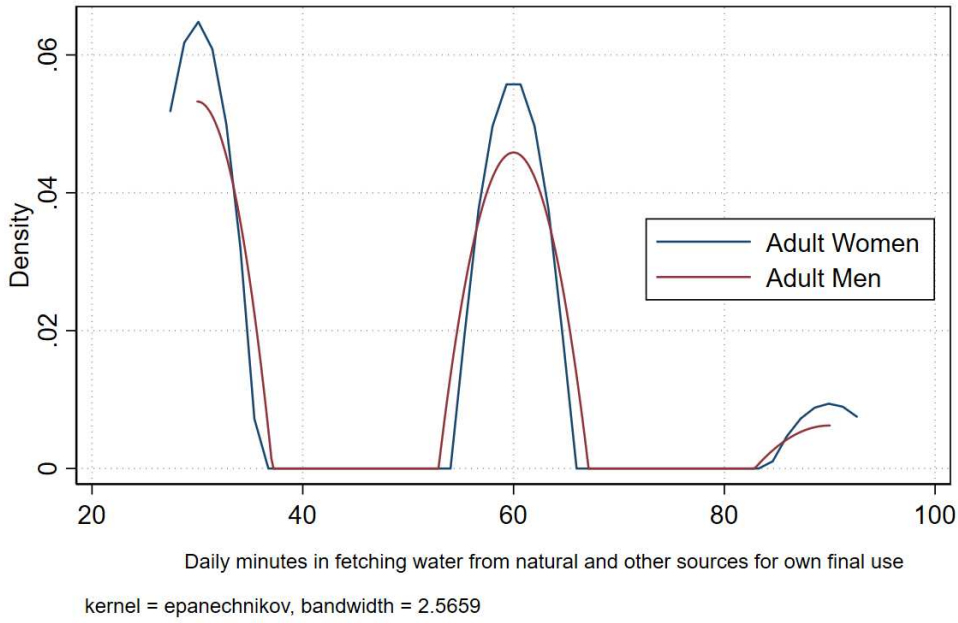
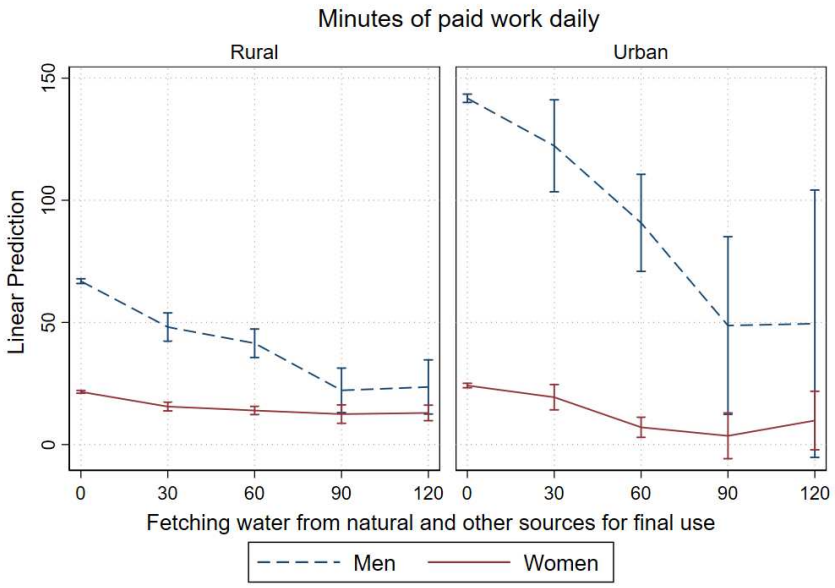


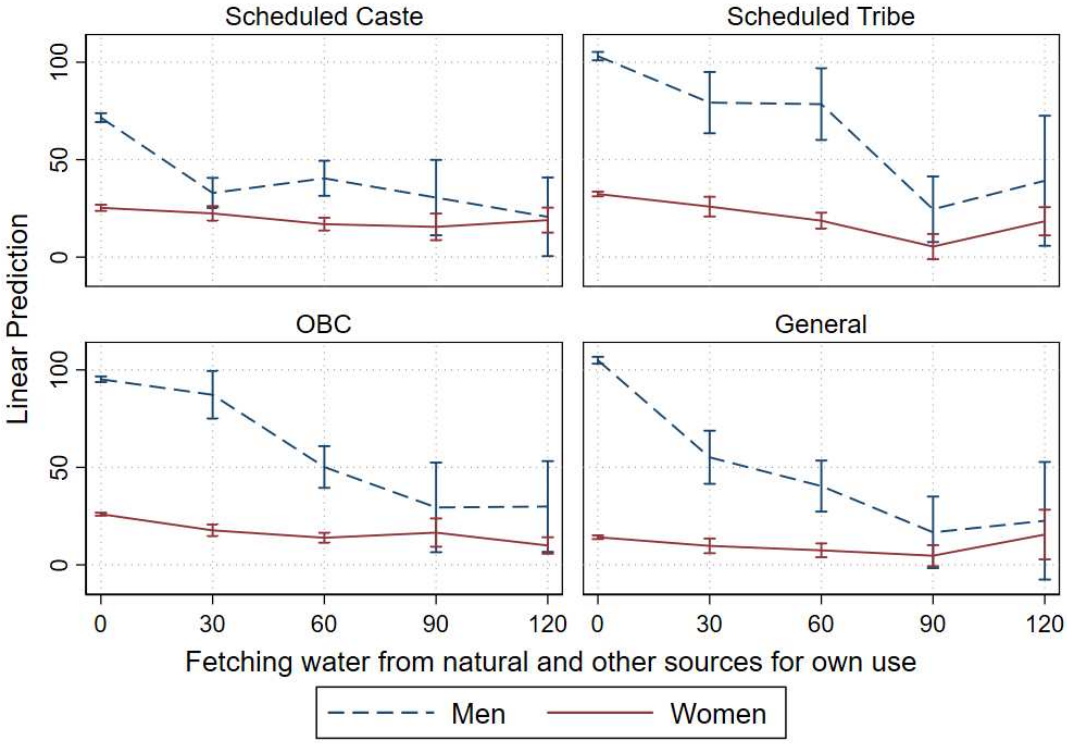
fig 3.b

Figure 3.5: Daily water collection minutes, adult men and women (age $\geq$ 14) in India. Figure 3.a is derived from the India Human Development Survey, 2005-2012, sample: 217,000. Figure 3.b is derived from the India Time Use Survey, 2019, sample: 382,000

Panel A: Rural-Urban

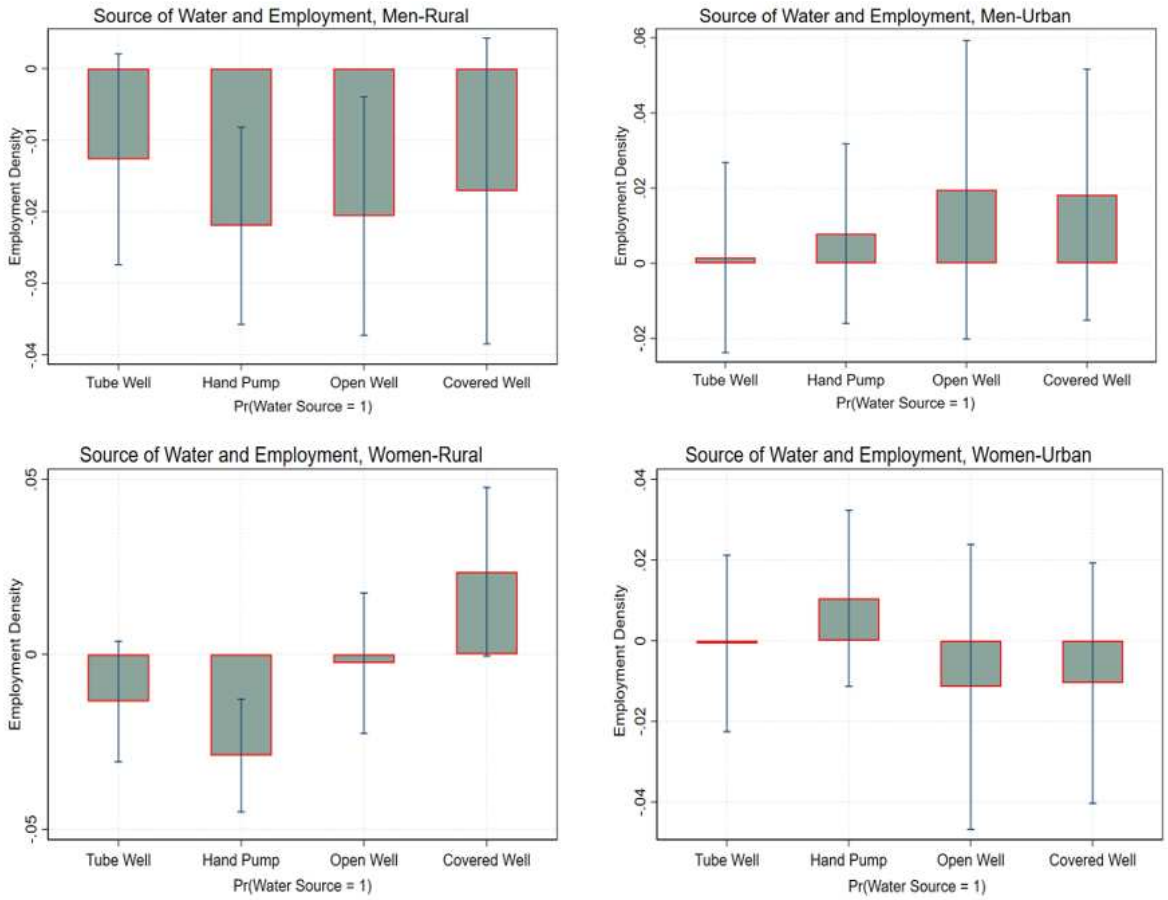


Panel B: Social Groups



Authors' computations using India Time Use Survey, 2019. Margins using OLS

Figure 3.6: Daily water collection minutes and paid employment (age $\geq$ 14) in India



Authors calculations, IHDS, 2005-2012. Controlled for the time trend and the month of interview.

Figure 3.7: Panel fixed effects: Source of Water and Employment by Gender and Location.

Table 3.1: Access to piped drinking water, percentage by asset levels, 2005-2012.

Quintile of Assets	0-2	2-4	4-6	6-8	8-10
	Mean (sd)	Mean (sd)	Mean (sd)	Mean (sd)	Mean (sd)
2005					
IPDW	0.02	0.06	0.19	0.38	0.62
	(0.13)	(0.25)	(0.39)	(0.49)	(0.49)
2012					
IPDW	0.04	0.13	0.26	0.44	0.62
	(0.20)	(0.34)	(0.44)	(0.50)	(0.49)
Observations	7723	6801	9639	7888	7780

Source: author elaboration, IHDS, 2005-2012

Table 3.2: Descriptive Statistics from two household surveys, India, 2005-2018

	Obs	Mean	SD	Mean	SD	T test
IHDS		2005		2012		
IPDW	40,018	0.256	0.442	0.302	0.459	***
ACCESS		2015		2018		
IPDW	8563	0.057	0.232	0.066	0.248	**

Author elaboration, IHDS, 2005-2012, ACCESS survey, 2015-2018. ACCESS survey is for the rural areas in the six relatively poorer states in India namely: Madhya Pradesh, Uttar Pradesh, Odisha, Bihar, Jharkhand, West Bengal. The t-test shows mean difference in access to IPDW by the year of survey, 2015 and 2018.

Table 3.3: Descriptive statistics by treatment and time: Access to Indoor Piped Drinking Water (IDPW), India, 2005-2012

	2005				2012			
	No IDPW		IDPW		No IDPW		IDPW	
Variable	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Any Employment (>30 days)	0.40	0.49	0.36	0.48	0.47	0.50	0.44	0.50
Emp. men, age $\geq$ 14	0.77	0.41	0.70	0.45	0.74	0.43	0.70	0.45
Emp. women, age $\geq$ 14	0.40	0.49	0.26	0.44	0.39	0.48	0.30	0.45
Farm Employment	0.24	0.42	0.13	0.34	0.32	0.46	0.18	0.38
Wage/Salary Employment (0/1)	0.24	0.43	0.20	0.40	0.32	0.46	0.28	0.45
Annual work days	201	98	243	95	200	110	242	105
Real ann. ear. (2011-$)	252	745	498	1320	228	752	383	1187
Health & Education								
Self-reported health (0-5)	2.26	0.81	2.18	0.76	2.19	0.87	2.02	0.84
Diarrhea (30 days) (0/1)	0.03	0.17	0.01	0.12	0.02	0.15	0.02	0.13
Days ill (30 days)	0.96	3.35	0.63	2.62	1.17	3.57	0.80	2.81
School absence (30 days)	3.38	5.79	1.81	3.96	3.95	5.26	2.94	5.04
Observations	109700		40676		103969		46340	

Author elaboration, IHDS, 2005-2012.

Table 3.4: Descriptive Statistics of Individual and Household Characteristics, IHDS 2005-2012

	2005				2012			
	No IDPW		IDPW		No IDPW		IDPW	
Variable	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
Networks								
Doctors/Health Care	0.30	0.46	0.40	0.49	0.55	0.50	0.63	0.48
Teachers/School Workers	0.39	0.49	0.49	0.50	0.59	0.49	0.67	0.47
Politicians/Police	0.29	0.46	0.47	0.50	0.48	0.50	0.63	0.48
Government Officials	0.29	0.46	0.47	0.50	0.27	0.44	0.40	0.49
Log community income	12.00	0.44	12.30	0.38	11.63	0.47	11.98	0.42
Log household income	11.53	0.97	12.15	0.94	11.16	1.01	11.71	0.98
Electricity	0.69	0.46	0.97	0.17	0.83	0.38	0.99	0.10
Public prog. for sanitation	0.03	0.18	0.03	0.17	0.05	0.23	0.05	0.21
Male education	6.47	4.89	9.36	4.46	7.21	4.92	9.66	4.43
Female education	3.69	4.53	6.84	5.19	4.75	4.97	7.68	5.17
Age	26.71	18.90	28.70	18.76	33.69	19.28	35.54	19.05
Household size	6.56	3.12	6.32	3.11	5.82	2.72	5.66	2.61
Rain Z score	-0.36	0.64	-0.32	0.66	0.57	0.85	0.71	0.89
	109700		40676		103969		46340	

Author elaboration, IHDS, 2005-2012

Table 3.5: Characteristics of time varying exogenous village level variables, India, IHDS 2005-2012

	2005		2012		t-test
	Mean	SD	Mean	SD	
Percentage of households with electricity	68.46	33.28	78.29	27.39	***
Local government body in the village	0.61	0.49	0.67	0.47	***
Agricultural cooperative in the village	0.36	0.48	0.36	0.48	
Number of private schools in the village	0.78	1.59	0.82	1.62	**
Number of government schools in the village	1.77	1.64	1.74	1.56	*
Distance to bank in kilometers from the village	2.92	4.49	2.81	4.51	*
ROSCAs in the village	0.25	0.42	0.22	0.38	***
Pucca road in the village	0.67	0.47	0.87	0.34	***
Bus frequency in the village in a day	1.84	3.24	1.84	3.43	
Distance to market from the village	6.44	6.80	6.53	6.67	*

Source: Authors elaboration from the India Human Development Survey, 2005-2012

Table 3.6: Fixed Effects: IPDW and LFP

	1	2	3	4
Variables	Rural Men	Rural Women	Urban Men	Urban Women
Treatment: Piped Water				
Farm Work	-0.009	**-0.023*** **	-0.006*	-0.006**
	(0.007)	(0.007)	(0.003)	(0.003)
Wage/Salary Work	-0.002	**0.021*** **	0.009	-0.009
	(0.007)	(0.006)	(0.009)	(0.006)
Business Activity	0.010**	0.009	0.007	0.009
	(0.003)	(0.008)	(0.006)	(0.006)
Annual Work Days	4.787***	**8.296*** **	-0.695	-3.721
	(1.757)	(2.608)	(1.681)	(5.967)
Log. Ann. Earnings	0.083***	**0.142*** **	0.043**	-0.099
	(0.022)	(0.036)	(0.022)	(0.064)
HH. Ind. Vill. Controls	Y	Y	Y	Y
State X year	Y	Y	Y	Y
Observations	73,636	66,409	35,130	30,379
Number of Individuals	42,837	38,451	20,472	17,614

Robust standard errors (clustered at the individual level) in parentheses, p-values—$***p < 0.01$, $**p < 0.05$, $*p < 0.1$. Additional independent variables in all regressions: age, education, electricity, household size, marital status, consumption quintile, social networks, public sanitation programs and rainfall Z score of variation.

Table 3.7: Village Fixed Effects: IPDW and Labor Force Participation in Rural Areas

	1	2	3
Variables	Rural	Rural Men	Rural Women
Treatment: Piped Water			
Farm Work	-0.019	0.002	**-0.046****
	(0.019)	(0.022)	(0.022)
Wage/Salary Work	0.035**	0.016	**0.056*****
	(0.016)	(0.019)	(0.02)
Business Activity	0.013	0.013	0.010
	(0.009)	(0.013)	(0.007)
Annual Work Days	11.491***	7.071	**13.719*****
	(3.181)	(6.486)	(4.061)
Annual Earnings	0.200***	0.192***	**0.353*****
	(0.068)	(0.07)	(0.12)
Agg. Ind. HH. Controls	Y	Y	Y
Village Controls	Y	Y	Y
State X year	Y	Y	Y
Observations	2,631	2,631	2,631
Number of Villages	1,382	1,382	1,382

Robust standard errors (clustered at the individual level) in parentheses, p-values—***$p < 0.01$, **$p < 0.05$, *$p < 0.1$. Additional independent variable as in the FE regression and in table 3.5.

Table 3.8: 2SLS-IV-Fixed Effects: IPDW and LFP

	1	2	3	4
Variables	Rural Men	Rural Women	Urban Men	Urban Women
Farm Work	-0.021*	-0.053**	-0.001	0.014
	(0.011)	(0.027)	(0.025)	(0.027)
F-test instrument	432	321	279	265
Two stage q values	0.004	0.018	0.342	0.566
Wage/Salary Work	0.026*	0.050***	0.011	-0.018
	(0.014)	(0.023)	(0.024)	(0.029)
F-test instrument	441	338	264	215
Two stage q values	0.088	0.003	0.621	0.771
Business Activity	0.011**	0.010*	0.022	0.013
	(0.005)	(0.004)	(0.019)	(0.021)
F-test instrument	455	389	266	238
Two stage q values	0.018	0.066	0.656	0.709
Annual Work Days	8.736***	18.434***	2.955	-2.199
	(2.765)	(3.507)	(3.019)	(4.202)
F-test instrument	479	472	281	212
Two stage q values	0.003	0.001	0.343	0.951
Log Ann. Earnings	0.133**	0.217***	0.114*	0.021
	(0.084)	(0.092)	(0.086)	(0.097)
F-test instrument	380	312	188	151
Two stage q values	0.042	0.002	0.077	0.499
State* Year FE	Y	Y	Y	Y
Observations	73705	66492	35221	30511
Number of individuals	42336	38037	20404	17600

Robust standard errors (clustered at the individual level) in parentheses, p-values—***$p < 0.01$, **$p < 0.05$, *$p < 0.1$. Additional controls in all regressions. The sharpened two stage q-values are derived from Anderson (2008) to reduce the likelihood of these false rejections. The measure is a way of adjusting for the fact that I am testing multiple hypotheses.

Table 3.9: Panel fixed effects: Household's access to indoor pipe drinking water and women's self-reported health, 2005-2012.

	(1)	(2)	(3)	(4)	(5)
	All	Rural	Urban	Poor	Non-poor
Good & V. Good=1, OK, Poor & V. Poor=0					
FE					
IPDW	0.0294**	0.0316**	0.0352*	0.0686***	0.0241***
	(0.0122)	(0.0154)	(0.0200)	(0.0379)	(0.0128)
IV-FE					
IPDW	0.312***	0.337***	0.273***	0.506***	0.274***
	(0.0432)	(0.0518)	(0.0827)	(0.116)	(0.0465)
Good, V. Good & OK=1, Poor & V. Poor=0					
FE					
IPDW	0.00974	0.0163*	0.000689	0.00115	0.0102
	(0.0066)	(0.0084)	(0.0110)	(0.0198)	(0.0070)
IV-FE					
IPDW	0.0896***	0.142***	-0.0191	0.0951	0.0878***
	(0.0247)	(0.0298)	(0.0400)	(0.0626)	(0.0255)
F test (IV)	866	750	312	181	542
Observations	47,225	32,527	14,698	7,819	39,402
Number of Individuals	24,909	17,196	7,713	4,133	20,772

Robust standard errors (clustered at the individual level) in parentheses, p-values—***$p < 0.01$, **$p < 0.05$, *$p < 0.1$. β reports the percentage point effect of access to piped drinking water within the house on the self-reported health of women (respondents from the eligible women's questionnaires of IHDS, 2005-2012). The model used is individual fixed effects. Additional independent variables in all regressions: household income, household electricity access, any public program for sanitary toilets, individual's age, marital status, education, household size, any social networks or acquaintance with doctors and health care workers, teachers, school workers, politicians, police, military, government officials and the rain Z score.

Table 3.10: Indoor Pipe Drinking Water and likelihood of Diarrhea and illness, India, 2005-2012

	(1)	(2)	(3)	(4)	(5)
	All	Rural	Urban	Poor	Non-Poor
Panel (a) Diarrhea					
FE					
IPDW	-0.002**	0.001	-0.008***	-0.007**	-0.002
	(0.001)	(0.001)	(0.002)	(0.003)	(0.001)
IV-FE					
IPDW	-0.015***	-0.012*	-0.022***	-0.015**	-0.014*
	(0.006)	(0.007)	(0.004)	(0.005)	(0.006)
F test (IV)	1562	1301	831	693	1114
Panel (b) Days ill last month					
FE					
IPDW	-0.007	0.037	-0.076**	0.082	-0.022
	(0.024)	(0.031)	(0.038)	(0.063)	(0.025)
IV-FE					
IPDW	-0.318***	-0.462***	-0.205*	-0.580***	-0.399***
	(0.123)	(0.156)	(0.115)	(0.192)	(0.136)
F test (IV)	1521	1227	836	668	1471
HH & Individual controls	Y	Y	Y	Y	Y
Observations	273,942	188,645	85,297	51,857	222,015
Number of individuals	144,810	101,528	45,785	27,333	117,424

Robust standard errors (clustered at the individual level) in parentheses, p-values—***$p < 0.01$, **$p < 0.05$, *$p < 0.1$. β reports the percentage point effect of access to piped drinking water within the house on the self-reported health of women (respondents from the eligible women's questionnaires of IHDS, 2005-2012). The model used is individual fixed effects. Additional independent variables in all regressions: household income, household electricity access, any public program for sanitary toilets, individual's age, marital status, education, household size, any social networks or acquaintance with doctors and health care workers, teachers, school workers, politicians, police, military, government officials and the rain Z score.

Table 3.11: Panel fixed effects: Effect of IPDW on absence from school in the past month, India, 2005-2012

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Variables	All	Boys	Girls	Rural Boys	Urban Boys	Rural Girls	Urban Girls
FE							
IPDW	-0.437**	-0.272	-0.640***	-0.212	-0.453	-0.882*	-0.568**
	(0.174)	(0.243)	(0.246)	(0.323)	(0.379)	(0.417)	(0.312)
IV-FE							
IPDW	-1.484**	-1.423*	-1.559**	-1.347**	-0.149	-2.440***	-1.393
	(0.586)	(0.636)	(0.419)	(0.362)	(1.151)	(1.106)	(1.484)
F test (IV)	732	512	487	399	118	354	87
Observations	54,446	30,305	24,141	20,738	9,567	16,358	7,783
Number of Individuals	42,421	23,732	18,690	16,471	7,424	12,883	5,956

Robust standard errors (clustered at the individual level) in parentheses, p-values—***$p < 0.01$, **$p < 0.05$, *$p < 0.1$. Additional independent variables in all regressions: water stored with lid, log of annual community income, time trends, any public program for sanitation (latrines/toilets), adult male education, adult female education, household size, age of the respondent, networks with doctors, hospitals and health care workers, teachers, educators, government officials and local politicians.

Table 3.12: Household fixed effects: Effect of IPDW on household savings, decision making, time spent in cooking and firewood collection

	(1)	(2)	(3)	(4)
Variables	Annual Savings Rs.	Non male-head decision making	Log of cooking hours	Firewood collection hours daily
Indoor Pipe Water	2,558.249*	0.035*	-0.054***	-0.612**
	(1,383.294)	(0.021)	(0.017)	(0.303)
Household Controls	Y	Y	Y	Y
Wave Dummy	Y	Y	Y	Y
Observations	16,447	16,057	17,062	4,761
Number of Households	8,562	8,548	8,563	3,794

Robust standard errors (clustered at the household level) in parentheses, p-values—***$p < 0.01$, **$p < 0.05$, *$p < 0.1$. Additional independent variables in all regressions: age, education, household size, monthly household consumption expenditure, wave dummy. The data is derived from the ACCESS panel, 2015-2018.

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Appendix A

Appendix to Chapter 1

Table A.1: Fixed Interest Bidding ROSCA (Interest Rate 1%)

					Player 1 Organizer		Player 2		Player 3		Player 4		Player 5	
Month	Draw	Bid	Pot	Interest	Receive	Pay	Receive	Pay	Receive	Pay	Receive	Pay	Receive	Pay
1	1	0	500	0%	500	100	0	100	0	100	0	100	0	100
2	2	5	495	1%	0	100	495	100	1.66	100	1.66	100	1.66	100
3	3	5	495	1%	0	100	0	105	496.66	100	4.16	100	4.16	100
4	4	5	495	1%	0	100	0	105	0	105	499.16	100	9.16	100
5	5	0	500	0%	0	100	0	105	0	105	0	105	514.6	100

Author's elaboration of a typical bidding ROSCA with 1% fixed interest. The social accounting matrix in the Table above shows the ROSCA cycle for a five members ROSCA with 1% fixed interest bidding cycle initiated by the organizer who takes individual responsibility of the smooth functioning of the ROSCA and in turn receives the benefit of getting the pay-out first without having to pay interest in the subsequent periods. In a bidding ROSCA as described in the table, members receiving the collective sum at the end do not have to pay the bid value while also earning the dividends of other bids. Therefore, even in the absence of a productive investment outlay, simply being a patient member of a bidding ROSCA is rewarding. In this representation of a fixed interest bidding ROSCA, the fifth player receives more than what they contribute in the five draws. They invest $100 recurrently over five periods and accumulate $514.6 at the end of the fifth draw. $14.6 is the reward given over the preceding four draws for being a patient member and by withdrawing the collective contribution at the final draw.

Table A.2: Variables derived from the IHDS eligible women's questionnaire, 2005-2012 survey

Variable	Individual variables	Questionnaire
Economic Freedom	Cash for expenditure	Do you have any cash in hand for day to day expenditures?
	Name on house papers	Is your name on the ownership or rental papers for your home
	Bank Account	Is your name on any bank account?
Economic Decision	Say in purchases	Do you have any say in purchase of expensive items?
	Most say in purchases	Do you have the most say in purchase of expensive items?
	Shopping	Do you do the food and vegetable shopping in your household?
	Husband discusses	Do you and your husband talk about
	1. Work	1. Things that happen at work
	2. Expenditure	2. What to spend money on?
Agency	Contraceptive	Do you currently use any methods to delay or prevent pregnancy?
Mobility		Do you have to ASK PERMISSION of your husband or a senior to:
	1. Health center	1. Visit health center?
	2. Health center alone	2. Can you go alone to health center?
	3. Visit friends	3. The home of relatives or friends in the neighborhood
	4. Visit friends alone	4. Can you go alone to visit relatives and friends?
	5. Grocery shopping	5. To the Kirana shop?
	6. Grocery alone	6. Can you go alone to the Kirana shop?
Household Decision	1. Child Wedding Decision	1. Do you have any say in your child's wedding decisions?
	2. Child's Illness	2. Whether you have any say in what to do when the child is ill?
	3. Number of Children	3. Whether you have any say in how many children you wish to have?

Note: All other variables used as outcome variables in the study are derived from the Household questionnaire, 2005 and 2012.

Table A.3: Descriptive Statistics- Principal Component Analysis (PCA) of empowerment variables, IHDS, 2012

Indices	Rank	Empowerment Variables (0/1)	Obs.	Mean	sd	Weight (PCA)	Interval
Economic	1	Cash in hand for household expenditure	39460	0.91	0.29	0.64	
Freedom	3	Name on home ownership papers	38023	0.17	0.37	0.53	
	2	Currently Employed	39461	0.42	0.49	0.57	(-2.58 1.95)
Mobility	1	Can visit health center alone	39079	0.71	0.45	0.52	
	2	Can visit friends/relatives alone	38966	0.77	0.42	0.52	
	3	Can go to grocery shop alone	37358	0.8	0.4	0.48	
	4	Can go short distance travel alone	38980	0.53	0.5	0.47	(-3.37 1.07)
Agency	4	Currently use contraceptives	35101	0.74	0.44	0.43	
	1	Name on bank account	27769	0.55	0.5	0.59	
	2	Member of Mahila Mandal	39481	0.06	0.23	0.52	
	3	Decide number of children to have	38042	0.92	0.27	0.44	(-3.09 2.91)
Economic	4	Most say in decisions about your work	32826	0.46	0.5	0.15	
Decision	3	Decide purchasing expensive item	39243	0.77	0.42	0.56	
	1	Decides whether to buy land/property	38867	0.75	0.44	0.58	
	2	Decide wedding expense	39294	0.8	0.4	0.57	(-3.37 1.07)
Household	2	Decide to whom your children should marry	37261	0.88	0.32	0.56	
Decision	4	Does food shopping	39465	0.58	0.49	0.22	
	1	Decides what to do if a child falls sick	37474	0.91	0.29	0.59	
	3	Decide what to do if you fall sick	39430	0.85	0.35	0.54	(-4.95 0.79)

Factor loads are the score of individual variables in the empowerment indices and all indices are standardized with mean zero and standard deviation one. PCA analysis in the Table above shows that cash in hand for expenditure has significantly higher weight than property ownership and employment in terms of determining the economic freedom for women. The analysis gives ranks and factor loads (weight) to each variable within each empowerment category. We have five standardized empowerment indices with a mean of zero and a standard deviation of one namely: economic freedom, economic decision-making ability, agency, mobility and household decision making ability. Coefficients of these indices in the cross-sectional model are interpreted as deviations from zero.

Table A.4: Descriptive statistics of raw samples derived from the IHDS panel, 2005-2012.

	2005			2012		
Variables	Obs.	Mean	SD	Obs	Mean	SD
HH. ROSCA member	98704	0.075	0.263	98704	0.113	0.316
HH. NGO member	98674	0.019	0.136	98676	0.014	0.118
HH. SHG member	98694	0.101	0.301	98691	0.195	0.396
Loan from Money Lender	98704	0.131	0.338	98704	0.097	0.295
Loans from Bank	98704	0.132	0.339	98704	0.201	0.401
Loan from ROSCA	98704	0.011	0.106	98704	0.017	0.128
Loan from Government	98704	0.004	0.065	98704	0.004	0.062
Log real HH. Income	97270	11.747	1.008	97331	11.367	1.058
Household Head Education	98601	8.034	4.941	98691	8.910	4.859
Woman's Work Business	48,347	0.037	0.189	48,242	0.048	0.214
Woman's Any Work	47929	0.524	0.499	48162	0.576	0.494
Woman's Education	25295	4.535	4.881	25396	5.611	5.156
Age in years	98704	37.669	14.827	98704	44.830	15.180
Household Size	98704	6.225	3.076	98704	5.583	2.729
Poor	98640	0.217	0.412	98677	0.171	0.377
Cash for expenditure	25321	0.822	0.382	25358	0.935	0.246
Name in house papers	24362	0.155	0.362	24454	0.194	0.395
Woman's bank account	9276	0.461	0.499	17971	0.596	0.491
Husband discusses work	24848	0.803	0.397	24366	0.814	0.389
Husband discusses expenditure	24920	0.883	0.321	24344	0.910	0.286
Woman has a say in major purchases	25391	0.710	0.454	25216	0.817	0.387
Woman has most say in major purchases	25212	0.110	0.313	25171	0.134	0.341
Women does shopping of food and vegetables	25260	0.568	0.495	25358	0.645	0.478
Couple uses contraceptives	23272	0.630	0.483	22918	0.791	0.407
Household member of Mahila Mandal	98663	0.080	0.271	98682	0.097	0.295
Indoor pipe drinking water	98607	0.286	0.452	98369	0.323	0.468
Household has toilet	98100	0.441	0.497	98333	0.570	0.495
Household has separate kitchen	98411	0.628	0.483	98352	0.614	0.487
Household's electricity hours in a day	77508	15.924	6.721	87487	15.095	6.885
Woman need permission to visit health center	25377	0.751	0.433	25192	0.767	0.423
Women can visit health center alone	24466	0.696	0.460	25091	0.748	0.434
Woman need permission to visit friends/relatives	25028	0.760	0.427	25258	0.683	0.465
Women can visit friends/relatives alone	24035	0.716	0.451	25024	0.806	0.396
Woman need permission to visit grocery store	20867	0.549	0.498	21759	0.560	0.496
Women can visit grocery store alone	21180	0.752	0.432	24140	0.830	0.375
Woman has a say in child's marriage	23910	0.798	0.402	24738	0.896	0.305
Woman has most say in child's marriage	24351	0.102	0.302	24650	0.157	0.364
Woman has a say in what to do in Child's Illness	24300	0.857	0.351	24852	0.920	0.271
Woman has most say in what to do in Child's Illness	24562	0.307	0.461	24795	0.325	0.469
Woman has a say in the number of children	25393	0.807	0.395	24243	0.925	0.263
Woman has most say in the number of children	24762	0.195	0.396	24180	0.265	0.441

Source: Authors elaboration, IHDS, 2005-2012

Table A.5: Summary Statistics by Women's ROSCA Participation and Non-Participation, IHDS, 2012

	ROSCA			No ROSCA			T test for Mean Difference
Variables	Obs.	Mean	sd	Obs.	Mean	sd	p-value
Real income (Base 2005) Rs/1000	2783	67.65	104.97	36696	77.25	125.03	***
Household Member in ROSCA	2567	1	0	32482	0.05	0.21	***
Household Head Education	2783	9.00	4.74	36696	8.75	4.91	***
Household Head Sex	2782	1.13	0.34	36694	1.13	0.33	
Household Head Age	2782	47.89	11.54	36694	48.51	12.62	
Household Size	2783	4.97	2.21	36696	5.49	2.48	***
Urban (0/1)	2783	0.32	0.47	36696	0.34	0.47	****
Women's Age	2783	37.70	8.72	36696	36.23	9.93	****
Number of Children Alive	2783	2.45	1.20	36682	2.56	1.58	
Women's Education (0-3)	2783	1.16	0.46	36504	1.19	0.52	**
Cash in hand for expenditure	2779	0.94	0.25	36646	0.91	0.29	***
Ownership of property	2688	0.25	0.43	35303	0.16	0.37	***
Currently Employed	2774	0.55	0.50	36651	0.41	0.49	***
Can go to health center alone	2757	0.72	0.45	36293	0.71	0.46	
Can visit friends/relatives alone	2756	0.74	0.44	36182	0.77	0.42	***
Can go to Kirana store alone	2675	0.85	0.36	34658	0.79	0.41	*
Can travel short distance alone	2757	0.51	0.50	36196	0.53	0.50	***
Use contraceptives	2477	0.78	0.41	32591	0.74	0.44	*
Joint Bank account with husband	2177	0.70	0.46	25569	0.54	0.50	***
Member of Mahila Mandal	2782	0.29	0.45	36695	0.04	0.19	***
Decision on how many children to have	2668	0.95	0.21	35342	0.92	0.27	***
Decision making ability on work	2539	0.48	0.50	30257	0.46	0.50	***
Decision on major household purchases	2773	0.90	0.30	36438	0.76	0.42	***
Decision on buying land	2718	0.87	0.34	36118	0.74	0.44	***
Decision on Wedding Expenses	2772	0.92	0.28	36490	0.79	0.40	***
Decision on son/daughter marriage	2716	0.95	0.22	34517	0.88	0.33	**
Decision on food and vegetable consumption	2780	0.75	0.43	36650	0.57	0.49	***
Decision on what to do when child ill	2726	0.96	0.20	34719	0.90	0.30	*
Decision on what to do in sickness	2776	0.94	0.24	36621	0.85	0.36	**
Membership Mahila Mandal	2782	0.29	0.45	36695	0.04	0.19	***
Membership Self Help group	2782	0.52	0.50	36694	0.11	0.31	***
Women ROSCA Member	35086	0.07	0.26				
Women Member SHG	35088	0.14	0.34				
Women Member NGO	42088	0.01	0.11				
Loan Government Prog.	41252	0.003	0.05				
Loan micro-credit (group lending)	42114	0.09	0.29				
Loan NGO	42152	0.005	0.07				

p-value: Difference in mean tests between sub-samples, *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$ Note: Women's education is coded as 0 for no education, 1 for education up to the 10th grade (Matriculation), 2 for education above the 10th grade and below undergraduate and 3 for graduation and above. Loans from government programs were taken by 126 women. Household's membership in ROSCAs is driven by women's membership.

Appendix A6: Derivations of the theoretical model for savings in ROSCA and in autarky

Stage 1: Derivation for the equilibrium savings rate in ROSCAs. If the household decides to join ROSCAs, then the maximization of the household utility function given the underlying constraints is as under:

$$Max.Log(U_{HH}) = (1-\gamma)[(U(Y-S^R)) + (U(Y+S^R-D) + (1-\delta)PD - (1-P)(1-\delta)D)]$$

$$+ \gamma[(U(Y-S^R)) + \tau S + (U(Y+S^R-D) + \delta PD + \delta(1-P)D)]$$

subject to

$S^R \geq 0$

$Y \geq C_1 + S^R$

$Y + S^R \geq C_2 + D$(A.1)

First, we take the marginal derivative of the $Log(U_{HH})$ function with respect to our first-choice variable: savings in ROSCAs, S^R

$$\partial LogU_{HH}/\partial S^R = -\gamma U^{'}(C_1) + \gamma\tau + \gamma U^{'}(C_2) - (1-\gamma)U^{'}(C_1) + (1-\gamma)U^{'}(C_2) = 0 \quad \text{(A.2)}$$

$$\partial LogU_{HH}/\partial S^R = -U^{'}(C_1) + \gamma\tau + U^{'}(C_2) = 0 \quad \text{(A.3)}$$

$$U^{'}(C_1) = U^{'}(C_2) + \gamma\tau \quad \text{(A.4)}$$

By the constant relative risk aversion condition, we have: $U^{'}(C_1) = C_1^{-\theta}$ and $U^{'}(C_2) = C_2^{-\theta}$

$$(Y + S^R - D)^{-\theta} + \gamma\tau = (Y - S^R)^{-\theta} \quad \text{(A.5)}$$

Next, we take the derivative of the utility function, $Log(U_{HH})$ with respect to the second-choice variable D:

$$\partial LogU_{HH}/\partial D = -\gamma U^{'}(C_2) - \gamma\delta + 2\gamma\delta P - (1-\gamma)U^{'}(C_2) + (1-\gamma)(1-\delta)P - (1-\gamma)(1-\delta)(1-P) = 0 \quad \text{(A.6)}$$

$$2P(1-\gamma-\delta+\gamma\delta)-(1-\gamma-\delta)=U^{'}(C_2) \tag{A.7}$$

Since, $U^{'}(C_1)=U^{'}(C_2)+\gamma\tau$. We can rewrite the equation A.7 as:

$$2P(1-\gamma-\delta+\gamma\delta)-(1-\gamma-\delta)=(Y-S^R)^{-\theta} \tag{A.8}$$

$$S^R=Y-1/((2P(1-\gamma-\delta+\gamma\delta)-(1-\gamma-\delta)+\gamma\tau)^{1/\theta} \tag{A.9}$$

With $P=1$, the equation becomes:

$$S^{R^*}=Y-\frac{1}{[(2\gamma\delta+1-\delta-\gamma+\gamma\tau)]^{1/\theta}} \tag{A.10}$$

Which is equation 1.12 in the theoretical model. Rearranging this yields the bargaining equilibrium in the model:

$$\gamma=\frac{(Y-S^{R^*})^{-\theta}-1+\delta}{2\delta-1+\tau} \tag{A.11}$$

The above equation shows equilibrium savings rate in ROSCAs, the same maximization analogy applies to savings in autarky and savings and savings through exogenous micro-credit programs. The testable hypothesis is derived from the woman's bargaining γ equation.

Derivation for the equilibrium savings rate in autarky:

If the household decides to save in autarky, then the maximization of the household utility function given the underlying constraints is as under:

$$Max.Log(U_{HH})=\gamma[(U(Y-S)+(U(Y+S-D)+\delta D]+(1-\gamma)[(U(Y-S)+(U(Y+S-D)+(1-\delta)D)]$$

subject to

S ≥ 0

$Y \geq C_1+S$

$Y+S \geq C_2+D$(A.12)

First, we take the marginal derivative of the $Log(U_{HH})$ function with respect to our first-choice variable: savings in ROSCAs, S^R:

$$\partial LogU_{HH}/\partial S = -(1-\gamma)U^{'}(C_1) + (1-\gamma)U^{'}(C_2) - \gamma U^{'}(C_1) + \gamma\tau + \gamma U^{'}(C_2) = 0 \quad \text{(A.13)}$$

$$U^{'}(C_1) = U^{'}(C_2) \quad \text{(A.14)}$$

By the constant relative risk aversion condition, we have: $U^{'}(C_1) = C_1^{-\theta}$ and $U^{'}(C_2) = C_2^{-\theta}$

$$(Y + S - D)^{-\theta} = (Y - S)^{-\theta} => S = D/2 \quad \text{(A.15)}$$

Next, we take the derivative of the utility function, $LogU_{HH}$ with respect to the second-choice variable D:

$$\partial LogU_{HH}/\partial D = -\gamma U^{'}(C_2) + \gamma\delta - (1-\gamma)U^{'}(C_2) + (1-\gamma)(1-\delta) = 0 \quad \text{(A.16)}$$

$$2\gamma\delta + 1 - \gamma - \delta = U^{'}(C_2) \quad \text{(A.17)}$$

By Euler's condition:

$$U^{'}(C_2) = U^{'}(C_1) = (Y - S)^{-\theta} \quad \text{(A.18)}$$

Therefore:

$$(Y - S)^{-\theta} = 2\gamma\delta + 1 - \gamma - \delta \quad \text{(A.19)}$$

$$S^* = Y - 1/(2\gamma\delta + (1-\gamma) - \delta)^{1/\theta} \quad \text{(A.20)}$$

which is equation 1.14 in the text. Similarly,

$$\gamma = \frac{(Y - S^*)^{-\theta} - 1 + \delta}{2\delta - 1} \quad \text{(A.21)}$$

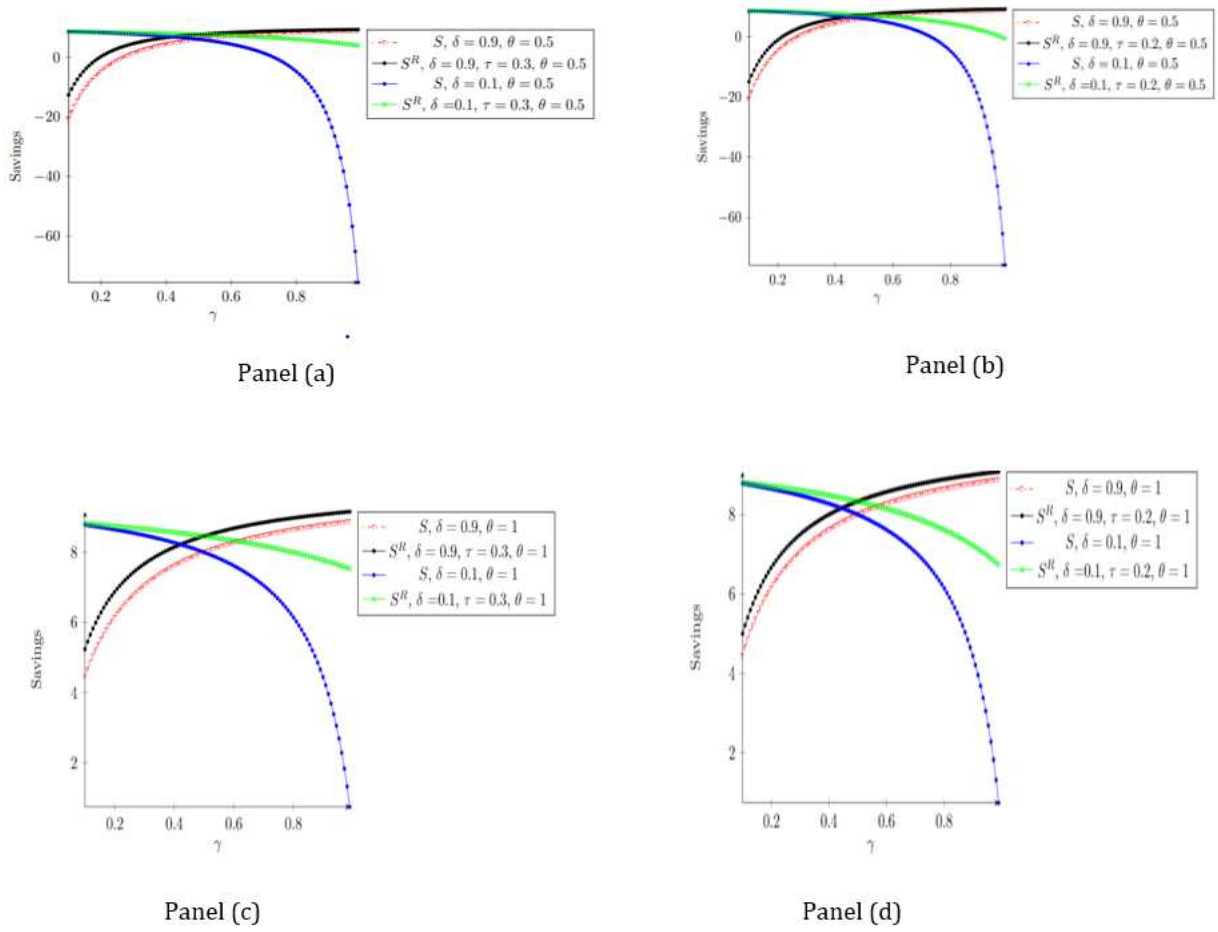

Figure A.1: Women's Bargaining Power and Savings in ROSCA and Autarky

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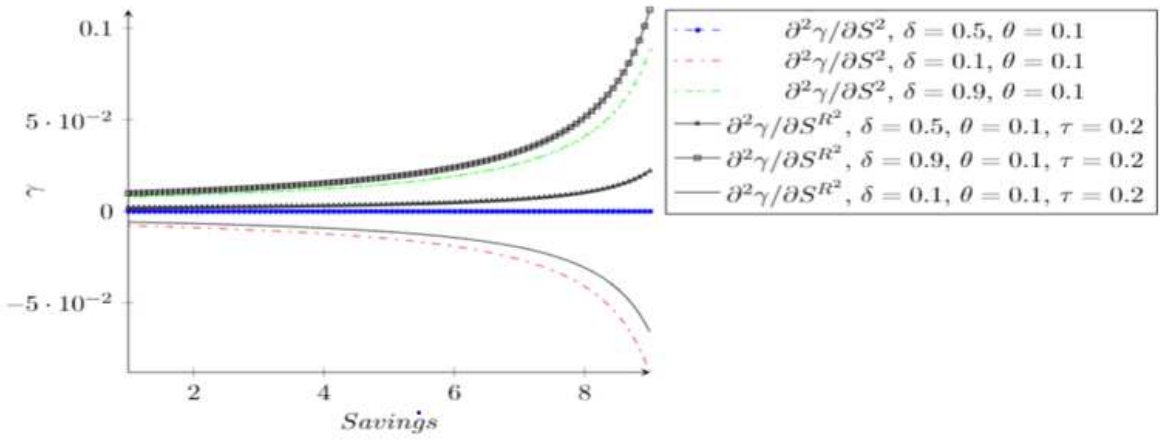
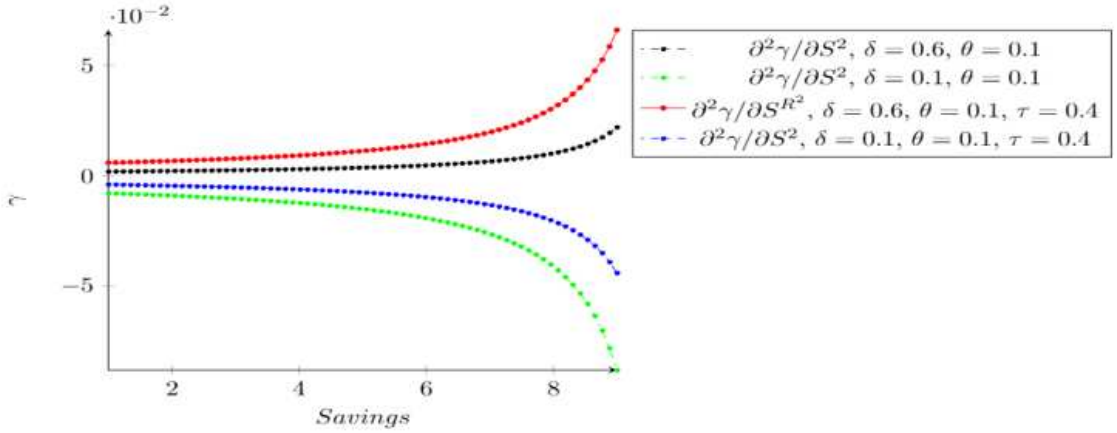
When $P = 1$, $S^{R^*} = Y - \frac{1}{[(2\gamma\delta+1-\delta-\gamma+\gamma\tau)]^{1/\theta}}$ shows equilibrium savings in ROSCA, and $S^* = Y - \frac{1}{(2\gamma\delta+(1-\gamma)-\delta)^{1/\theta}}$ shows equilibrium savings in autarky. Savings are plotted against women's bargaining power in figure A.1. The figure shows that the households would save more in ROSCAs than in autarky when the wife's preferences are very strong as compared to the husband, $\delta = 0.9$, as shown in panel (a) with the rate of return to the wife is $\tau = 0.3$ and the household values consumption in both periods equally $\theta = 0.5$. In panel (b) when we reduce the reduce the value of $\tau = 0.2$, the difference in the savings in ROSCAs and autarky decreases for the same value of all the other parameters. Panel (c) and (d) shows the similar results when we change the value of $\theta = 1$.



Panel (a)



Panel (b)

Figure A.2: The effects of savings in ROSCA and autarky on women's bargaining power

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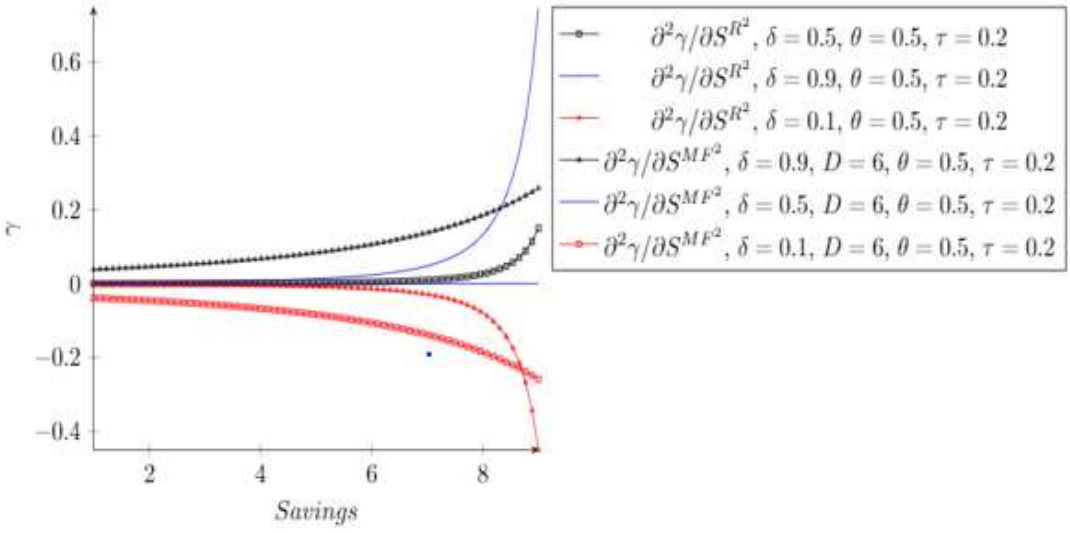
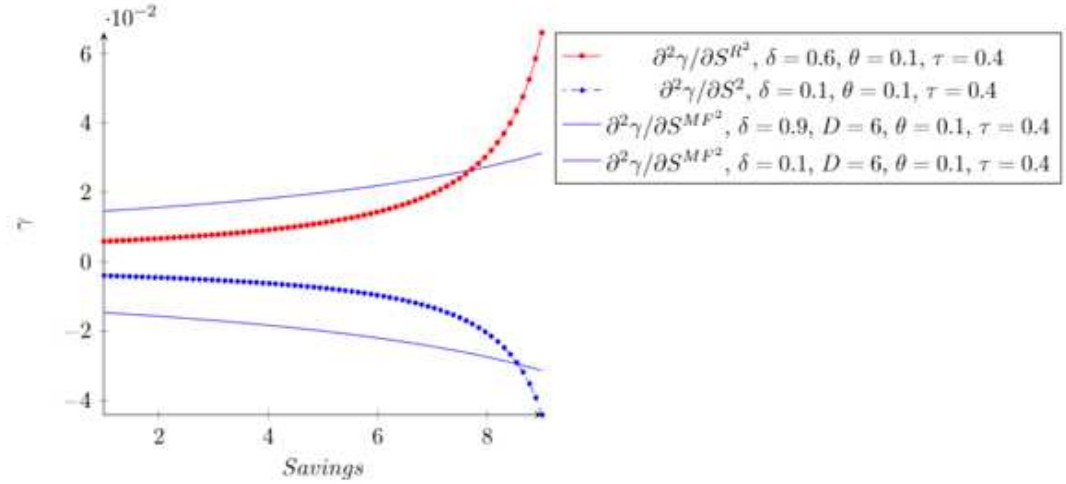
In figure A.2, we plot the equations 1.16 and 1.18 with $P = 1$ under different conditions of the parameters. The figure shows that at similar levels of preferences. In panel (a), we see that at $\delta = 0.5$, savings under autarky does not have any effect on wife's bargaining power, but at the same level of preference, ROSCAs have a positive effect on wife's bargaining power. From panel (a) to (b), the gap between the effects of savings in autarky and ROSCAs on wife's bargaining power increases as we increase the value of τ from 0.2 to 0.4. Therefore, higher the private benefit to the woman, higher is the increase in bargaining power with savings in ROSCA, and higher the difference in the bargaining power between savings in ROSCAs and autarky. Both panel (a) and panel (b) combined shows that at any level of preference, δ, for the good D, ROSCAs yield a higher bargaining power for women as compared to savings in autarky.



Panel (a)



Panel (b)

Figure A.3: The effects of savings in ROSCA and exogenous micro-credit on women's bargaining power

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In figure A.3, we plot the equation 1.18 and 1.23 with $P = 1$ different values of the parameters. The figure shows that at similar levels of preferences, ROSCAs yield higher bargaining power for women compared to exogenous micro-credit. Both panel (a) and panel (b) show that at any level of preference δ for the good D, ROSCAs yield a higher bargaining power for women as compared to savings in exogenous micro-finance.