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Indoor Tools for Outdoor Jobs

An empirical study on the relationship between time-saving household appliances and female labour force participation in India

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Abstract

Higher female labour force participation leads to positive development outcomes at both the micro and macro level. The low and declining female labour force participation in India is alarming and rather puzzling, since its economy is growing rapidly. One of the labour market barriers facing women is time constraint brought about by time-consuming household tasks. This thesis applies national micro-level panel survey data to assess the effect of time-saving household appliances on the female labour force participation of married women in India. The study specifically looks at the ownership of a refrigerator, washing machine, sewing machine, mixer/grinder, and pressure cooker, as these appliances can facilitate a significant reduction in time spent on household work. To identify causal effects and to control for endogeneity, an instrumental variable technique and individual and year fixed effects are used. A married woman's appliance ownership is instrumented by the average ownership rate among unmarried women living in the same district, serving as a proxy for factors that affect appliance ownership. When controlling for the possible biases, the results suggest a positive effect of household appliances on the female labour force participation.

Keywords: Female labour force participation, household appliances, intrahousehold decisionmaking, technological change, instrumental variable technique

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"In the fast-paced world where people have no time for anything but work, it has become increasingly important for manufacturers and designers of food processing products to make sure that the consumers are offered ***the most convenient and time save gadgets****. The Indian mixer grinder is one such product that helps the aspirant users to concentrate their priorities on work after the cooking processes are sped up."*
– Product advertisement, Boss Home Appliances India –

1 Introduction

Gender differences – either of biological or social nature – are as old as mankind itself. In prehistoric foraging societies, men were involved in hunting activities, while women stayed behind to collect wild plants and care for the children. Men were involved in the 'productive' and subsistence activities that kept the tribe alive, whereas women occupied themselves with nurturing activities. Fast forward to modern-day society and the same ancient division of labour still prevails in most societies: men produce and women care. The man is the breadwinner, while women produce children, are mothers and wives, cook, sew and do laundry. According to the *World Economic Forum* (2016), the amount of unpaid work carried out by men accounts for 34 percent of that done by women, who spend two hours per day more in developed regions and three hours more in developing regions on unpaid work (UN, 2015).

Now consider a world (or simply look around) where women have access to tools that 'liberate' them from these daily household tasks. Refrigerators ensure that women are not compelled to do grocery shopping and cooking as frequently as once was the case. Washing machines and electric irons greatly reduce laundry time. Pressure cookers, mixers and grinders allow women to prepare food much faster (and simultaneously require less energy, lowering the time needed to collect fuel). All this saved time can sequentially be used in the 'productive' sector as women can enter the labour force. This has both substantial micro- and macro-level consequences, as an increase in female labour force participation (FLFP) is often associated with higher economic growth.

This paper empirically examines the effect of the ownership of time-saving household appliances on the female labour force participation rates of married women in India, using national micro-level panel survey data from 2005 and 2011. Gender equality signals the level of development of a country and can contribute to a more stable society (EIGE, 2017; Kabeer & Natali, 2013; UN, 2015b). It is therefore incumbent on policy makers to stimulate women and facilitate their entry into the work force, especially as female educational attainment increases, which hypothetically should lead to a higher FLFP through the mechanism of lower fertility (Heath & Jayachandran, 2016; Psacharopoulos & Tzannatos, 1989). If this is not converted into an increase in FLFP, it could cause high productivity losses since talent would be wasted and education investments unused. This research can assist policy makers in understanding one of the determinants of FLFP so that policy can be adequately designed.

Although there is a large branch of literature examining the elements that influence FLFP, such as income, fertility, education, husband's employment, and other socio-economic variables, only a small proportion is dedicated to the causal effect of household appliances on FLFP. These previous studies, referenced below, consist of competing theories as there appears to be no apparent positive or negative relationship between these two variables. Some authors point to a positive relationship between household appliances and FLFP (Cavalcanti & Tavares, 2008; Coen-Pirani, León, & Lugauer, 2010; Greenwood, Seshadri, & Yorukoglu, 2005; Omotoso & Obembe, 2016), while others find a negative one (Bittman, Rice, & Wajcman, 2004; Ramey, 2009; Vanek, 1974) or are unable to establish any relationship at all (Cardia, 2008). The authors that do find a positive relationship strengthen the causality of their research by employing instrumental variable techniques.

The motive for undertaking this analysis is that, while numerous research pieces have studied this relationship for developed countries in the twentieth century (a period characterised by rapid appliance expansion), there is no such literature for this relationship in developing countries. These countries have a different appliance diffusion history, contrasting views on female labour supply, and variable market structures. Results from previous research on developed countries can therefore not easily be extrapolated to a wider context. Given the competing theories on the subject, this research aims to clarify which hypothesis is most applicable to India. India specifically presents an interesting study as the largest emerging market in South Asia (as classified by MSCI), encouraging both appliance acquisition as well as FLFP. Studying this country will give new insights into the effect of household appliances on FLFP in an emerging market setting.

India also emerges as a pertinent subject owing to its extensive economic growth and exceptionally low FLFP, which has perplexed academics and policy makers. According to the *World Economic Forum's* Global Gender Gap Index 2017, India is placed at the 139th place (before five strict Islamic countries) out of a total of 144 countries in women's economic participation and opportunity. This presents an interesting case study, as numerous factors determine India's low ranking, most of which are unexplained as of now. In terms of methodology this research employs panel data, whereas most previous studies on this subject applied cross-sectional regression techniques. Following the same individuals in two consecutive survey rounds allows an analysis isolated of unobservable external forces that arise across time and individuals.

To allow for causality, an instrumental variable (IV) approach is implemented. Appliance ownership of a married woman is instrumented by the district-average appliance ownership of unmarried women. This IV affects appliance ownership, but not female labour force participation, satisfying the exclusion restriction. Individual and year fixed effects are used to control for omitted variable bias (OVB). When both the IV and the fixed effects are implemented, one can observe a positive effect from having household appliances on FLFP. Acquiring such appliances can reduce time spent on household tasks and encourage Indian women to use that time in the productive labour market.

The rest of the paper is organised as follows. In Section 2 background information will be provided on FLFP in general and in India, as well as a history of appliance diffusion in India. Section 3 details previous literature on the link between appliances and FLFP, including a literature study of other covariates influencing FLFP. Section 4 describes the theoretical framework and Section 5 outlines the empirical framework, along with an explanation of the instrumental variable. Following this, Section 6 presents the data source and first descriptive statistics. The regression results of the multiple model specifications are discussed in Section 7. This section includes a range of robustness check as well as a discussion on the limitations of the research. Section 8 concludes and sets the path for future research.

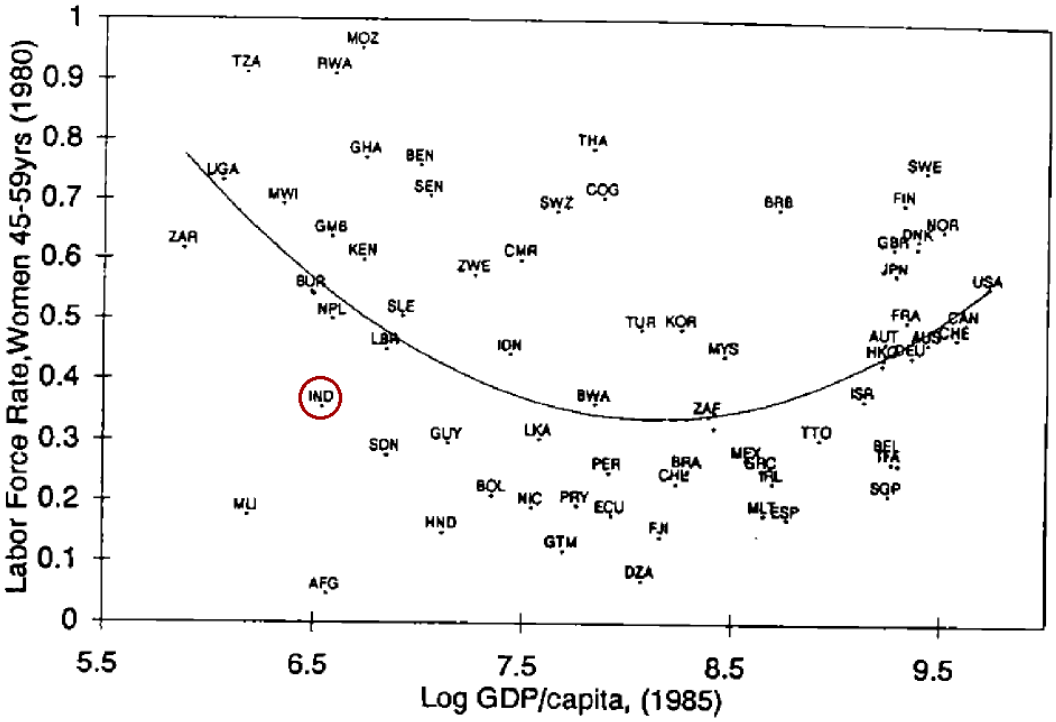
2 Background

2.1 U-shaped hypothesis

Explanations in trends in FLFP across countries at different stages of development are often attributed to the U-shaped female labour force function, introduced by Goldin in 1995. This relationship shows that the labour force participation rate of married women first decreases as countries develop, and then rises again after a certain threshold (Figure 1). This is explained by the income and substitution effect: the former describes how, when income rises in a country, the market often expandeds to more industrial and manufacturing sectors precipitating a decrease in the demand for labour in agriculture, which employs a lot of women. The latter states that when female education improves and the value of their time in the market increases, women will move back into the labour force. If this hypothesis is confirmed, then the decline in female employment reflects a growing economy and is only temporary. Lechman and Kaur (2015) empirically confirm the global U-shaped relationship for the period 1990 to 2012, but there remains high cross-country variation and the relationship is the strongest for middle- and high-income countries while it is sometimes reversed for low-income countries.

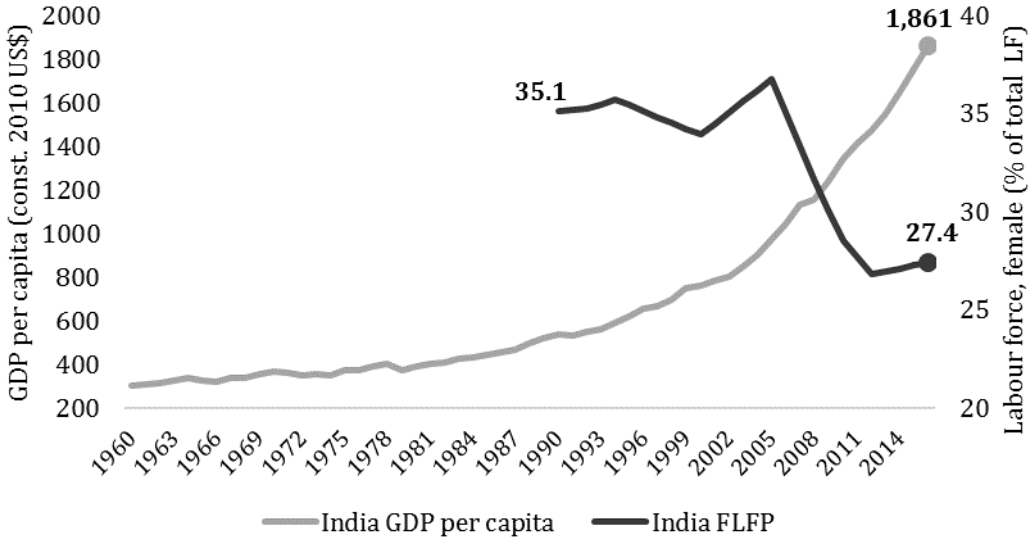
Applying this hypothesis to the country of interest, India, one can potentially observe a U-shaped female labour force participation trend in the data (figure 2). In the early 2000s, India's GDP grew rapidly, and simultaneously its FLFP rate decreased sharply. This may imply that India has reached its trough, after a period of decline in its FLFP and before the period of expansion. However, some research argues that the U-shaped hypothesis is not applicable in this instance and that other forces affect the low FLFP, such as the composition of growth and lack of employment opportunities (Lahoti & Swaminathan, 2013). As India's GDP continued to grow rapidly in the early 2000s, it assumed a position of having one of the lowest FLFP in the South Asian region, where in 2017 Nepal had a FLFP of 51 percent, Bhutan of 40 percent, Sri Lanka of 34 percent, and Bangladesh of 29 percent. Only Afghanistan and Pakistan had a lower FLFP rate, of 17 percent and 22 percent respectively (all World Bank data).

Figure 1: The U-shaped female labour force participation curve



Source: Goldin, 1995
Note: The small circle surrounding 'IND' shows the position of India on the curve. India is located below the curve: their level of GDP per capita results in a lower FLFP than in similar countries.

Figure 2: GDP per capita and FLFP in India, 1960 – 2016



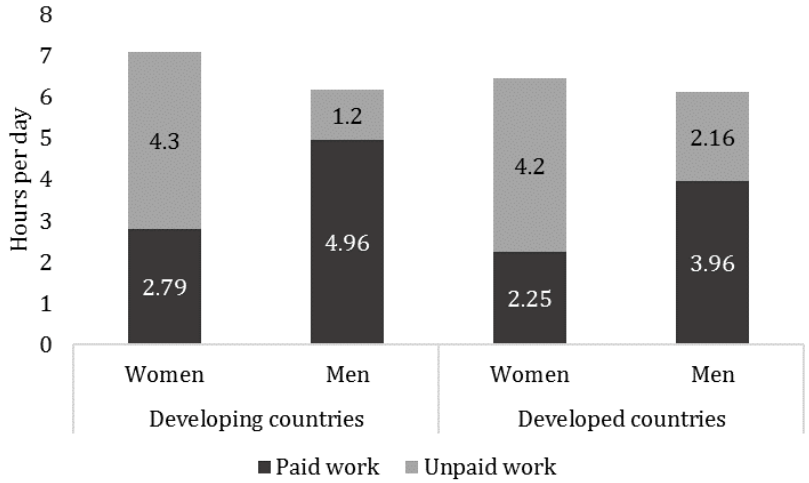
Source: World Bank – World Development Indicators – compiled by the author

The sharp decline in FLFP in India in the mid-2000s is not necessarily due to one major economic or political change but is driven by both labour supply and demand factors. It is likely an aggregate result of an increase in GDP (the U-shaped hypothesis), an increase in male education, an emerging middle class, and other unobservable factors (Das et al., 2015). Furthermore, the growth boom that India experienced during this period consisted of mainly jobless growth, except for the construction sector, one which generally does not employ a lot of women. At the same time, manufacturing and service employment declined during this period. The rise in female employment in the early 2000s was mostly caused by rural distress, while agricultural improvement from the mid-2000s on led to the rapid decline of FLFP afterwards (Thomas, 2012).

2.2 Unpaid work

While women are underrepresented in the labour market, they often engage more in unpaid and household tasks. Globally, the amount of time spent on unpaid work has diminished over time for both sexes, and in turn so have the gender differences. This is predominantly due to the reduction in time allocated to household work for women. Factors contributing to this decline are higher FLFP, smaller family size, growing opportunities for outsourcing domestic work, and "the use of time-saving infrastructure and technologies that reduce the time required for fetching water or household tasks" (ILO, 2016, p.20). Yet, when considering both paid and unpaid work, as in Figure 3, a woman's workday remains longer, despite the fact that men spend double the amount of time on paid work in comparison to women. A woman's workday is especially long in developing countries, where she works longer on both paid and unpaid activities. Unpaid work often takes the form of household tasks and caring for the family. Time used on these activities could be substantially reduced if a household were to purchase labour-saving appliances, freeing up time in a woman's daily schedule.

Figure 3: Time spent on paid and unpaid work by sex (employed, unemployed or inactive), developing and developed countries, 2005–2013



Source: United Nations, The World's Women 2015: Trends and Statistics, 2015, p.114

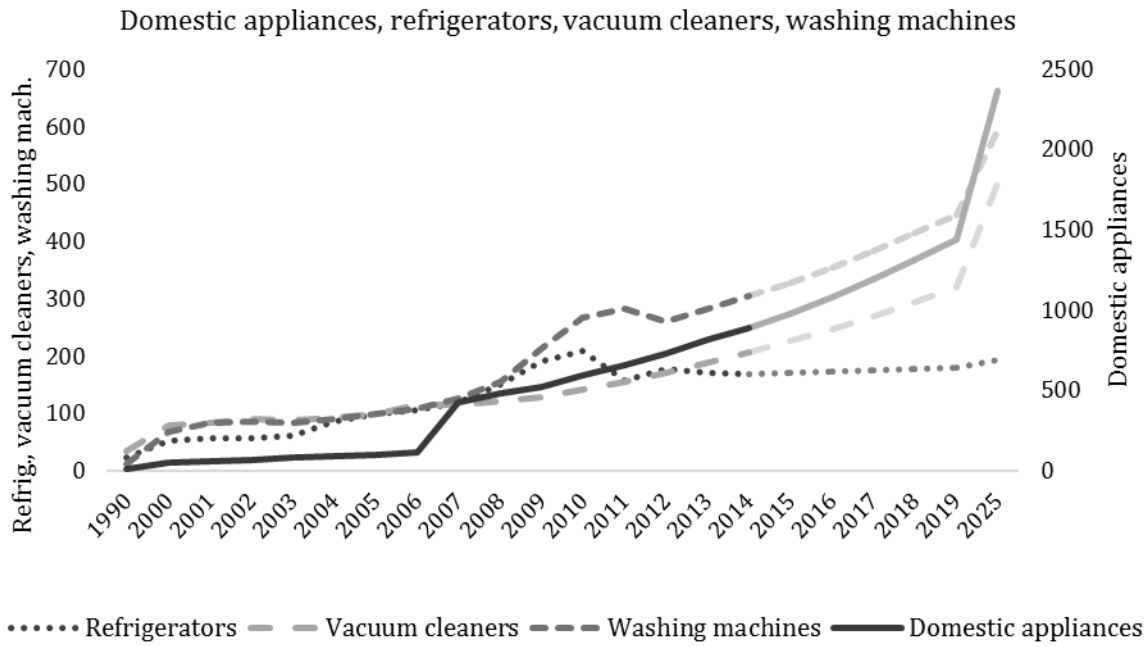
2.3 Appliance diffusion

The United States – the subject of most of the previous research on the relationship between appliances and FLFP – reached its appliance saturation rate in the mid-twentieth century, as the increase in the adoption of modern refrigerators during the 1940s went from 44 percent to 80 percent and affected both urban and rural areas (Cardia, 2008). The development of the modern domestic refrigerator, invented in the US in the early 1900s, was a slow process. While the commercial refrigerator had been invented before this period, this machine was not suitable in a household setting: a domestic refrigerator had to be smaller and lighter, not require constant supervision or servicing, and needed a power source that could be operated by an unskilled domestic worker (Cowan, 1983, p.131). It also had to be mass produced and safe. Thus, while the American market could only gradually adapt to the household refrigerator, which was only available to the richest households at first, developing countries do not have to reinvent the wheel and can reap the benefits of having a market consisting of well-developed and cheap appliances. The same holds true for washing machines and electric irons, that greatly reduced laundry duties in now developed nations. Thanks to these, women were relieved of tasks such as burning water with wood or coal, scrubbing and wringing out clothes, and using heavy flat irons that continually had to be reheated (Greenwood et al., 2005).

Developing countries are currently at a much earlier stage in their household appliance adoption cycle. However, they have the opportunity to leapfrog and bypass older and more expensive appliances, accelerating their diffusion. A household in a developing country does not need to belong to the upper middle-class to afford household appliances. Appliance diffusion could quickly take off in the 21st century in emerging countries, such as India, because of rapidly changing technology and declining prices. From 1994 to 2010, India experienced a steep decline of around 25 percentage points of the wholesale price index of electrical appliances (Indiastat). It is likely the price is even lower nowadays. The graph in Figure 4 presents the increase in the demand of household appliances. Washing machines, vacuum cleaners and smaller domestic appliances experienced a large increase from 2005 to 2011 (the period of interest). Refrigerators increased until 2010 and stabilised thereafter.

In the case of India, refrigerator and washing machine ownership reveal an interesting conundrum. While 34.5 percent of the population has a two-wheeler, 60 percent has a colour tv, and 73.4 percent a mobile phone, only 23.9 percent has a refrigerator and 7.9 percent a washing machine (India's Consumer Economy (ICE) 360° Survey, 2014). The latter two have witnessed a slow diffusion rate. There is a clear correlation between rising incomes and higher appliance ownership, both in developed and developing countries (Dargay & Sommer, 2007; McNeil & Letschert, 2005). A threshold level of income is a necessary condition for the purchase and ownership of a refrigerator. However, in the case of India, this relationship cannot explain the low rate of diffusion of refrigerators. There is a high percentage of households that owns a two-wheeler, which is significantly more expensive than a refrigerator. Furthermore, the ICE 360° Survey shows that even among the top 20 percent of the richest Indian families, refrigerator ownership is at a low 60 per-

Figure 4: Past and future demand predictions of several appliances



Source: Indiastat, 2014, compiled by the author
Note: In the data domestic appliances and refrigerators were measured in billion Rs., vacuum cleaners in million Rs., and washing machines in thousands of units. In the graphs, 2005 is taken as the base year and represents a value of 100. The curves are the growth rate since 2005. The light shaded parts (from 2015 on) show the predictions of the future demand curve

cent (Mahambare, 2017), implying factors other than monetary concerns are important in determining refrigerator ownership. Dhanaraj, Mahambare and Munjal (2017) allude to two factors that influence this decision. First, refrigerators have different energy access needs than other appliances and do not function well if there is interrupted power supply, which is often the case in rural India. Second, a refrigerator mainly benefits the female members of the household in lowering the time spent on household tasks, and hence the decision to purchase such an appliance depends on the intra-household bargaining power of women. While the authors do not model the ownership of washing machines, the same analogy can be applied here, as washing machines do not only rely on energy but also on access to piped water. Although time-saving appliances could influence FLFP and the composition of household tasks, several prerequisites must be met in order for these appliances to operate sufficiently. To set the reference point for the importance of household appliances in determining FLFP in India, the following section assesses previous academic and empirical studies on this topic.

3 Literature review

3.1 Technology and FLFP

There is a large body of literature that examines the relationship between technological progress and the woman's role in the household in different regions of the world and different centuries. Technological progress is a broad term and research has focused on, for example, communication technology (Dettling, 2017; Efobi, Tanankem, & Asongu, 2016; Nikulin, 2017), medical technology (Albanesi & Olivetti, 2007; Bailey, 2006), and several electronic household appliances. It is common in most literature on this subject to employ an instrumental variable to solve the endogeneity issue.

Efobi et al. (2016) apply the question of technology and FLFP to the developing country scenario in order to understand the relationship between technological advancement and FLFP in Sub-Saharan Africa. Technological advancement is measured with three indicators: internet penetration, mobile phone penetration and fixed broad band subscriptions, all three of which have increased exponentially during the past two decades. These technologies can dilute social stereotypes on the role of women in the economy and can therefore actively contribute to FLFP. The authors highlight a positive relationship, where the mechanism is the volume and quality of information accessible to individuals. Moreover, a discernible yet indirect link is established as technological advancement can lead to increased foreign direct investment inflows and small business expansions, which both can bring about an increase in FLFP.

Bailey (2006) establishes a positive relationship between the rise of the birth control pill and female labour supply. While there is a time-dimension in this mechanism – as women delay childbearing due to the new technology – this study is mostly interested in the time-saving aspect of the relationship between technology and FLFP. Albanesi and Olivetti (2007) develop a model that assesses the effect of two medical technological improvements: the decline in time cost associated with pregnancy, childbirth and recovery, and the introduction of infant formula, a substitute to breast milk, which enables both parents to feed the infant. The advancement of both technologies was essential for the rise in FLFP between 1920 and 1960 in the United States, while home appliances became the predominant driver between 1950 and 1970.

3.2 Household appliances

The positive effects of modern refrigerators are remarkably self-evident and they require no further discussion. Craig, Goodwin and Grennes deem it "one of the great inventions" (2002, p.155) as it directly contributed to the rise of perishable commodity markets and indirectly to improved biological standards of living, as well as nutrition, stature, and height as it allowed "homo sapiens to escape the tyranny of salt" (2004, p.332). Besides these tangible outcomes, refrigeration can also impact household work and the time devoted to food collection and preparation, activities that are the most time intensive and which are two tasks primarily executed by women.

Technological progress in household appliances intuitively affect the distribution of time allocation amongst family members. Time-saving technologies, such as washing machines, refrigerators and gas stoves, can reduce the amount of time spent on household tasks. Multitude research focused on the appliances transition in the United States in the 1900s, but the literature fails to determine if this caused an increase or decrease in the amount of time spent on household work. There are conflicting views in the literature on the effects of household technology on FLFP. Ramey's model (2009) on the role of home technology on labour supply finds that a shift from home labour to market labour only occurs "if the elasticity of substitution between labour and capital in home production is sufficiently high" (2009, p.6), meaning the ratio of the market wage to the price of appliances. The direction of the relationship between the two variables is not fixed to be positive or negative but depends on the key elasticities of substitution.

An unexpected article by Vanek (1974), who believed that time spent in housework would have declined between 1926 and 1966 because of the rise of labour-saving appliances, concludes that housework time for non-employed women had remained constant during that period. Bittman, Rice and Wajcman (2004) replicate this research with precise survey data from the Australian 1997 Time Use Survey and conclude that owning household technology rarely reduces unpaid household work. In some instances, it marginally increases the time spent on the relevant task. This is dubbed the Cowan Paradox by Mokyr (2000), as Cowan (1983, Ch.7) posed an interesting question: why did women end up working longer hours despite the growing mechanisation of household activities (in the century after 1870)? Explanations can be found in the increase in volume of household activities, the decline in the supply of domestic servants, an increase in the expectations and standards regarding the cleanliness and care environment of the home, and persistently low demand for female labour in the market. Ramey (2009), who consolidates these conclusions with new time estimates, finds that time spent in home production was virtually unchanged during the twentieth century.

Cardia (2008) researches this relationship in an American setting using 1940 and 1950 US Census data. She concludes, using the percentage of dwellings that had radios in 1940, the percentage of rural farm dwellings with lights in 1940, and the change in the presence of ice-boxes as instruments, that the adoption of modern refrigerators did not impact the FLFP, except for Southern counties where it had a positive impact, most likely due to warmer climates in that region. Additionally, Bar and Leukhina (2005) find that the decline in the relative price of home appliances leads to a modest increase in FLFP but generates strong gains in leisure for both working and non-working women, with the latter group enjoying the most significant gains.

Not all research on this topic contradicts the intuitive relationship between appliances and FLFP. An influential paper by Greenwood, Seshadri and Yorukoglu (2005) finds that in the US between 1900 and 1980 household technological progress may have accounted for more than half the increase in FLFP during that period, as home appliances 'liberated' women from housework. The adoption of household technology increased because of

technological progress and the subsequent decline in the price of such goods. The authors apply a 'Beckerian model of household production', in which households decide whether to adopt the new technology or not, and whether a woman should work or not. Building on this hypothesis, Coen-Pirani, León and Lugauer (2010) empirically test the previous conclusion using micro-level data from the 1960 and 1970 U.S. Census of the Population. To allow for causal inference, they employ an instrumental variable (IV) strategy by using the state-level ownership rate of an appliance among unmarried women as an instrument for a married woman's ownership of that appliance. Their empirical results reinforce Greenwood et al.'s outcome that the diffusion of household appliances contributed to an increase in married American women's LFP during the 1960s but did not materially affect unmarried women's LFP. Specifically, they find that higher appliance ownership accounted for a 4.6 percentage point increase in FLFP. Omotoso and Obembe (2016) apply this question to a developing country setting and find that the ownership of a washing machine has a positive significant effect on FLFP in Nigeria. They used primary data with a sample of 400 women who were either working or looking for job opportunities. Other technologies, such as a freezer or gas cooker, do not provide significant results.

Other authors use macroeconomic country data to assess the possible relationship. Cavalcanti and Tavares (2008) undertake a similar analysis by looking at the association between the relative price of home appliances[1] and FLFP for 17 OECD countries from 1975 to 1999. As an instrument they use both the relative manufacturing price index and the terms of trade. They encounter a robust negative relationship: for example, in the United Kingdom the decline in home appliances prices accounted for 10 to 15 percent of the increase in FLFP from 1975 to 1999.

Using the Pakistan Social and Living Standards Measurement Survey (PSLM) microdata of 2004/05 and 2006/07, Ejaz (2007, 2011 respectively) finds a significant negative effect of having home appliances on FLFP in Pakistan. This is explained by the financial status of the family (having such goods implies higher earnings in the household) and the value placed on leisure (higher earnings might lead to a greater preference for leisure). In Ejaz' second research, she employs an IV approach based on Coen-Pirani et al.'s (2010) IV of the average ownership of home appliances in a particular district. She categorises household appliances into two categories: labour-saving and time-consuming appliances. Including unpaid family helpers as female workers in the data, she finds the negative effect explained before. Excluding this group of workers, observing only paid employees, leads to a positive relationship between appliances and FLFP.

3.3 Other factors affecting FLFP

There are numerous pull and push factors that either encourage or discourage a woman from entering the workplace. Factors affecting a woman's participation in the market include her age, education, marital status, gender and employment status of the head of the household (usually a male), presence of a male household member, family size,

[1]The relative price of appliances is the ratio of the home appliance index to the general price index.

the presence of children of ages 0–5, and the area of residence (Naqvi & Shahnaz, 2002). Cultural and social influences, having access to a vehicle, household income, and living in a nuclear family (living with your spouse and children, without extended family) are other factors affecting FLFP (Ejaz, 2007, 2011). In India, financial inclusion, infrastructure, and labour market regulations and policies also play a role in determining women's participation (Sorsa et al., 2015).

While the relationship between each factor and the FLFP seems intuitive and straightforward, this is often not the case. There exists a nexus between all of them and it is difficult to disentangle the precise direction of the correlations. The most important determinants of FLFP – and the ones that will be used in the empirical analysis later – will be discussed in detail below.

Marriage and fertility

The relationship between marriage and FLFP does not have a global trend, as it is highly related to cultural factors in a country and as it is endogenous in determining a woman's participation in the labour market. Marriage has a strong negative influence on FLFP in India, and this effect has increased over time (Sorsa et al., 2015). Women tend to concentrate more on providing household services after they get married. It is for this purpose that this study looks at married women, as they represent a group with lower LFP and thus more time-saving potential.

Fertility and the number of children have a negative effect on the FLFP in India (Sorsa et al., 2015). This covariate is discussed together with the marriage covariate as there is simultaneity in the timing of marriage and fertility; it is often not possible to disentangle the effects of 'being married' and 'having children' variables in microdata as they are highly correlated: the one usually precedes the other. Assaad and Zouari (2002) find that for Morocco, marriage does not discourage participation, while having children – which often comes with marriage – result in lower FLFP rates.

Income

There is a negative wealth effect of a rise in a husband's earnings on a woman's labour supply, but this can differ for low-, middle- and high-income families. For OECD countries rising incomes at the top for men caused a flattening participation of married women (Albanesi & Prados, 2017). Income and FLFP are negatively correlated in India (Sorsa et al., 2015).

Income and marriage are also two linked covariates for FLFP in a rather surprising way. According to Bertrand, Kamenica and Pan (2015), when a woman becomes more likely to earn more than her husband, she is less likely to be in the labour force. This can be explained by cultural norms where 'a husband should earn more than his wife'.

Education
Education tends to increase FLFP, as it increases women's potential earnings and the opportunity cost of not working (Baah-Boateng, Nketiah-Amponsah, & Frempong, 2013; Jaumotte, 2003; Tansel, 2001). Simultaneously, because of higher income, an individual prefers leisure to work and might reduce her working hours. Because of these two effects, the relationship between education and FLFP is not straightforward and is often U-shaped (Chaudhary & Verick, 2014). Complementary to the previous income result for India, Sorsa et al. (2015) find a negative correlation between education and FLFP (as well as Dasgupta & Goldar, 2006; Klasen & Pieters, 2013). This can be explained by the fact that educated women prefer white-collar jobs but cannot find suitable employment opportunities in India and withdraw from the labour force (Das & Desai, 2003).

Education, income and marriage can be complementary covariates. If a woman has completed more years of education, and therefore a higher 'skill premium', she is more likely to participate in the labour force as her wages will be higher. Simultaneously, she is more likely to be married to a man with a high education level. His labour supply and higher income can offset her increase in labour supply, leading to an overall decline in her FLFP (Albanesi & Prados, 2017).

Religion
Some find a negative relationship between FLFP and strong religious views (Maneschiöld & Haraldsson, 2007), especially for Muslim and Catholic countries (Psacharopoulos & Tzannatos, 1989), rural areas (Amin & Alam, 2008), and households where the male spouse is highly religious (Heineck, 2004). While being quite intuitive, this relationship can be spurious, and the stated association does not have to be robust (Bayanpourtehrani & Sylwester, 2012; Ross, 2008). Others find the relationship to be only statistically significant in urban areas (Sackey, 2005) or discover a large religious effect on both men's and women's employment (Murphy, 1995). Furthermore, conservative and patriarchal norms, that see women as the primary caretaker, and that can be correlated with religion but need not be, affect FLFP (Dildar, 2015; O'Neil & Bilgin, 2013). In Northern India the low FLFP reflects strong conservative and religious factors (Sorsa et al., 2015).

4 Theoretical framework

4.1 The theoretical model

The theoretical framework for analysing labour force decisions begins with the work of Mincer (1962) and Becker (1965). Mincer takes a 'household view', where the family is the unit of analysis, when analysing married women's decisions to enter the workforce. In basic labour force models, an increase in income results in a decrease in hours of work and an increase in leisure. In the household labour force model, an increase in the male's income thus results in the decrease of the other members' hours of work. Mincer's model depends on the unit of income and its effect on work and leisure decisions in the household.

$$D_i = f(Y_H, W_i, U_{Hi}) \tag{1}$$

where D_i is the individual's decision to enter the labour market, with $D_i \in 0, 1$, Y_H is the family income, W_i the wife's full-time market wage, and U_{Hi} reflects other individual factors or household characteristics, such as education and the presence of children. However, as Becker points out, there is a time constraint faced by the worker. When allocating their time, individuals have three options to spend it on: leisure, work at home and work in the market. Time spent on work in the market has an opportunity cost of time spent on household work or leisure, and vice versa.

$$C_i = f(TH_i(w_i), TL_i) \tag{2}$$

is the constraint function of the time an individual spends on household tasks, TH_i, dependent on the market wage w_i, and on time spent on leisure, TL_i; both constraining his or her decision to enter the labour market. Becker's theory of allocation of time assumes that labour supply decisions are a trade-off between household production and market production. It concerns the division of labour among members of the same household, where a member can either produce in the household or in the market and rationally allocate its time. This time depends on the income w one can obtain from market activities, which affects the 'value of time'. Members of the household who can perform more efficiently in market activities use less 'consumption time' (leisure or household work) than other members. An increase in their relative market efficiency reallocates the time that all other members of the household spend on consumption activities.

While countless economic, political, and cultural variables affect the three time-alternatives facing an individual, this paper assesses the effect of household appliances on a woman's choice to operate in the market or not. Depending on the type of household appliances, they can be used as proxies for time spent on household work or leisure activities. In this study the time constraint is alleviated by time-saving household appliances and this enters the decision function directly.

$$D_i = f(A_H(AD_A), Y_H, U_{Hi}) \tag{3}$$

where A_H represents a vector of household appliances. The wage variable has been omitted as this model looks at the internal household decision, and the subsequent labour supply decisions, independently of the market and labour demand conditions. This equation is constrained by the appliance adoption decision, AD_A, introduced by Greenwood et al. (2005), which depends on several characteristics of the household and the appliances market:

$$AD_A = f(P_A, R_A, E_H, Y_H, U_{Hi}) \tag{4}$$

where AD_A is the binary decision to adopt an appliance or not, with $AD \in 0, 1$, P_A is the price of the appliance, R_A the resources needed to allow the (electrical) appliance to function, and E_H the household's external environment, such as neighbours or village and district characteristics. The adoption rate[2] also depends on the household income, Y_H,

[2]Due to data constraints it is not possible to model the household adoption rate. The empirical analysis takes appliance ownership as given, reducing the labour supply decision equation to $D_i = f(A_H, Y_H, U_{Hi})$.

and other individual and household characteristics, U_{Hi}. Combining expression (3) and (4), one can derive the final decision equation:

$$D_i = f(A_H(P_A, R_A, E_H, Y_H, U_{Hi}), Y_H, U_{Hi}) \tag{5}$$

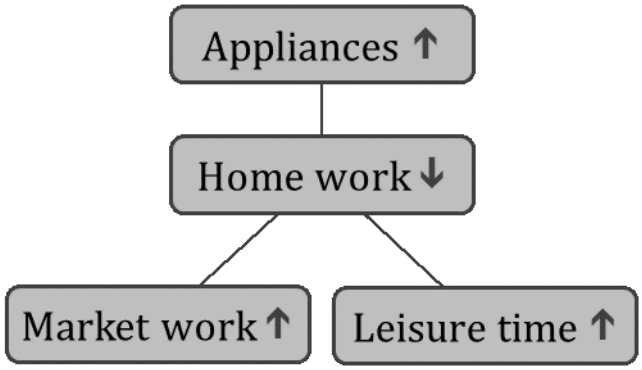
where $A_H(P_A, R_A, E_H, Y_H, U_{Hi})$ is taken as given and is simply modelled as the amount of appliances a household owns.

4.2 Hypothesis

There are two types of household appliances one can possess: time-saving and time-consuming. The former category includes appliances such as refrigerators, microwaves, and washing machines, while the latter one includes radios, televisions, and other appliances used for leisure. This paper uses time-saving appliances as the main independent variable, as it is assumed they will affect the FLFP. The relationship between appliances and FLFP is illustrated in Figure 5. The main hypothesis of this paper is that if a woman has access to time-saving household appliances, she will be more likely to participate in the market. The mechanism behind this relationship is that the time she needs to spend on household work will be reduced.

H_1: An increase in time-saving household appliances will increase the FLFP,
$A_H > 0$

Figure 5: Hypothesis diagram



However, as discussed in the previous section, there are conflicting theories on this hypothesis, as some authors argue that the increase in household appliances has caused women to spend more time on household tasks. On the other hand, Roberts and Rupert (1995) find that for the US, married working women saw a decline in home work of 4.3 hours per week between 1976 and 1988 while married non-working women only experienced 1.8 hours less home work. This can imply that working women were more eager in adopting time-saving technologies, or that non-working women, while adopting appliances, did not diversify their time away from home production. Although these assumptions are difficult to test, they highlight the underlying issue of the direction of

the main hypothesis, namely that there is no strict academic consensus on the sign of the effect of household appliances on FLFP. Both directions have at least some theoretical background. The empirical analysis in the later section will prove if H_1 holds true or not.

Another issue occurs in which if a woman participates in the market, then she might be more likely to purchase time-saving appliances, as both the household income and necessity of ownership increases. This 'reverse causality' problem will be thoroughly discussed in later sections. Instead of working in the market, she could also increase her leisure time, but this relationship is beyond the scope of this paper, mainly because of data limitations.

5 Empirical framework

5.1 Estimation strategy

The main purpose of this research is to estimate the effect of time-saving household appliances on female labour force participation. To test this relationship, an LPM model[3] including individual and year fixed effects to control for unobserved year-specific characteristics and individual-specific characteristics is employed. As India is an emerging economy, it experiences large economic and political shocks. In the five-year period between 2005 and 2011 it is likely that rapid changes affected the daily lives of Indians. Hence, it is crucial for the analysis to control for year fixed effects. Furthermore, because of the wide range of person-specific determinants of FLFP, individual fixed effects control for these factors.

The model specification used is the following:

$$Pr(FLFP_{it} = 1|A_{it}, X'_{it}, \mu_{it}) = \beta_0 + \beta_1 A_{it} + \beta_j X'_{it} + \sigma_1 \delta_t + \delta_i + \mu_{it} \tag{6}$$

$$Pr(FLFP_{it} = 1|A'_{it}, X'_{it}, \mu_{it}) = \beta_0 + \beta_k A'_{it} + \beta_j X'_{it} + \sigma_1 \delta_t + \delta_i + \mu_{it} \tag{7}$$

The dependent variable in this regression is the female labour force participation, which is a binary variable and takes a value of 1 if the married woman is working and 0 otherwise. The main independent variable is the household appliances. In equation (6) this is measured by an aggregate index of all the appliances, A_{it}, while equation (7) regresses a vector of different appliances, A_{it}', on the FLFP to disentangle the different effects appliances can have. δ_t is a dummy for the second year, to create an intercept for the second time-period. In this model, the intercept for the first wave (2005) of the survey is β_0 and for the second wave (2011) it is $\beta_0 + \sigma_1$. Unobserved individual fixed effects are denoted by δ_i. μ_{it} is the error term. For all variables, the i stands for individual and the t for the year in which the individual i was interviewed.

[3]Most previous research on this subject uses probit models. While this regression technique has advantages over the LPM model, the results are biased when integrating fixed effects into the model, leading to the *incidental parameters problem* (as introduced by Neyman & Scott, 1948). The maximum likelihood estimator is inconsistent when both T and N are finite. While the bias diminishes with group size – and the group size here being rather large – there is still an apparent bias, especially with the small T size of our sample (Greene, 2002). As fixed effects are crucial here, because of the large changes across time and across states in India, LPM is preferred over the probit model.

To strengthen the causal interpretation of the results, the analysis includes a set of time-varying control variables to reduce the omitted variable bias. X' is the vector of control variables: the respondent's age, education, number of children, household income, urban or rural living environment, access to electricity, and the spouse's education. While spouse's employment is an important indicator for FLFP, this is captured in the household income control. While cultural factors, such as religion or observing purdah,[4] also play a role in determining the FLFP, they are not included in the covariate vector. These factors are time-invariant and will hence be controlled for by the year fixed effects.

5.2 Instrumental variable

The model is likely to suffer from endogeneity, as the levels of household appliances are determined within the model by household characteristics. Using an IV can solve the most prominent heterogeneity issues of our model: reverse causality, omitted variable bias, and measurement error. Household appliances are endogenous in this empirical framework as their adoption can be influenced by women working; a household where a woman engages in the labour force might have more disposable income and simultaneously less time to spend on household tasks, urging the household to purchase household appliances. There can also be common exogenous factors, such as urban density (Cardia, 2008), that affect both the adoption of household appliances and FLFP. These causality issues can be controlled for by using an IV.

Furthermore, the model is likely suffering from omitted variable bias. There are variables, such as personal attitudes and values or state- and district-based variables, such as inflation, important industries, unemployment or taxes, that affect the FLFP rate, but that are difficult to measure accurately. This bias is solved by using an IV approach.

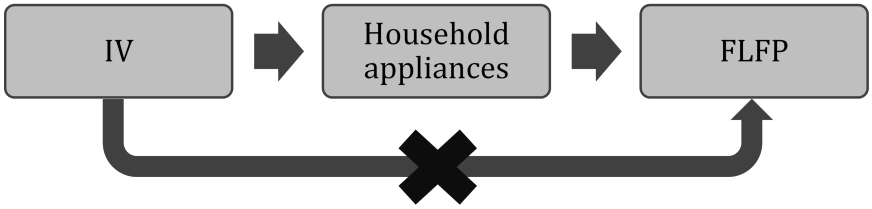
Lastly, IV deals with the measurement error that arises from using sample surveys, which could lead to attenuation bias. Measurement error in sample surveys is commonplace and consists of four sources: the questionnaire, the data-collection mode, the interviewer, and the respondent, causing a "difference between the value of a characteristic provided by the respondent and the true (but unknown) value of that characteristic" (Kasprzyk, 2005, p.172). As this research is based on sample surveys with self-reported data which are conducted in a face-to-face environment, there is likely some source of measurement error. For example, respondents could forget to report the true value of their household income, which often consists of multiple different sources. Other survey questions related to monetary values, such as consumption expenditure, or time values, such as time spent on water collection, could also produce measurement error. Additionally, this survey was conducted in two rounds within a five-year period and the respondents were interviewed at different times by different interviewers; all factors that could influence the final responses. One can assume, however, that the two most relevant variables for this research – the rate of appliances and the labour participation rate – consist of little to no errors,

[4]Purdah is an Islamic and Hindu religious practice of physical segregation of sexes and the seclusion of women from public by means of concealing clothing (veil).

as there can scarcely be any doubt in the respondent's ability to know if she possesses appliances or if she has a job. There is, however, some margin for error in the understanding of what consists of 'work'. The respondent could, for example, perform little or menial tasks for which she receives a wage, without considering them to be an actual job, while the interviewer might, conversely, be interested in such tasks.

A strong instrument must satisfy two conditions: (1) relevance: the instrument must be correlated with the endogenous explanatory variable; and (2) exclusion restriction: the instrument must be uncorrelated with the error term or any other determinants of the dependent variable, and thus must only affect the dependent variable through the main independent variable that is instrumented for. The second condition cannot be tested and must therefore be based on theory and intuitive knowledge. For this empirical framework these conditions imply that the IV must be correlated with household appliances, and that the IV only affects FLFP through the channel of household appliances (Figure 6). If these two conditions are not met, the instrument is deemed 'weak', giving a biased estimator.

Figure 6: IV relationship



An appealing IV would be the price of appliances at a state- and year-level: it is highly probable that the price of appliances affects the ownership of appliances, while not directly affecting the FLFP. However, such data is unfortunately not available. Household electrification, and in some cases running water, are necessary preconditions to having electric household appliances and are therefore highly correlated in theory (Jacobsen, 2012). Rathi, Chunekar and Kadav (2012) found that in the Indian context, there is a strong correlation between electricity and appliance ownership, with an even stronger relationship if there is a reliable supply of electricity (electricity of adequate voltage and few power cuts). Appliance ownership is higher in states which have higher levels of electricity supply. Household electrification and FLFP are correlated as well, as electrification "operates as a labour-saving technology shock to home production" (Dinkelman, 2011, p.3080), reducing time spent on home work. This suggests that one channel through which electricity affects FLFP is labour-saving technology in the household. However, this is not the only channel through which electricity can affect the FLFP. Electrification is an indicator of the economic development of a region and can thus influence the type of market activities, which in turn can affect the FLFP. Furthermore, electrification can reduce the time spent on collecting other sources of fuel, such as firewood, without increasing the number of appliances. This can influence FLFP without household appliances playing a role.

Coen-Pirani et al. (2010) use the average state-ownership rate of household appliances among single women who are household heads as an IV. While their instrument is appealing, it is not easily extended to the Indian context. In the complete dataset only 7.7 percent of women serve as household heads. Unmarried women who are household heads represent 5 percent of the total dataset used in this study. This number is too low to get a reliable average appliance ownership rate of this specific group. Observing all unmarried women, on the other hand, gives a more realistic indication of the amount of assets unmarried women own. The average ownership rate of appliances of these unmarried women in a district is thus a good IV in the Indian case. This average rate signals the adoption and distribution of such an appliance in the state in which a married woman lives as well as the price index of the appliance; both factors could impact the appliance ownership of the individual woman (this is in line with equation (4) in the *Theoretical Framework*). This instrument serves as a proxy for the price of appliances and how common they are in a certain area in India. It is argued that the instrument does not directly influence the FLFP. Before including the instrument, it needs to be tested to determine if it fulfils the two conditions.

Condition 1: Relevance

The relevance of an instrument is tested using the first-stage regression analysis. To consistently estimate the β_1 in equation (6), the endogenous regressor $\mathrm{A_{it}}$ is instrumented with the district-year mean appliance ownership rate of unmarried women, $\mathrm{Z_{st}}$, and apply a two-stage least squares (2SLS) estimation. In order to assess the relevance of the instrument, the first-stage regression should yield statistically significant results. In the first-stage (equation (8)), the endogenous regressor is regressed on the instrument and the other exogenous instruments, as well as year and individual fixed effects.

$$\hat{A}_{it} = \pi_1 Z_{st} + \pi_2 X'_{it} + \lambda_1 \delta_t + \delta_i + u_{it} \tag{8}$$

If the first stage is successful, the second-stage regression substitutes the first-stage fitted values in the regression of interest, equation (6):

$$Pr(FLFP_{it} = 1 | A_{it}, X'_{it}, \mu_{it}) = \beta_0 + \beta_1 \hat{A}_{it} + \beta_j \hat{X}'_{it} + \sigma_1 \hat{\delta}_t + \hat{\delta}_i + \varepsilon_{it} \tag{9}$$

The results section further on will display the results from the first-stage and will confirm the relevance of the IV.

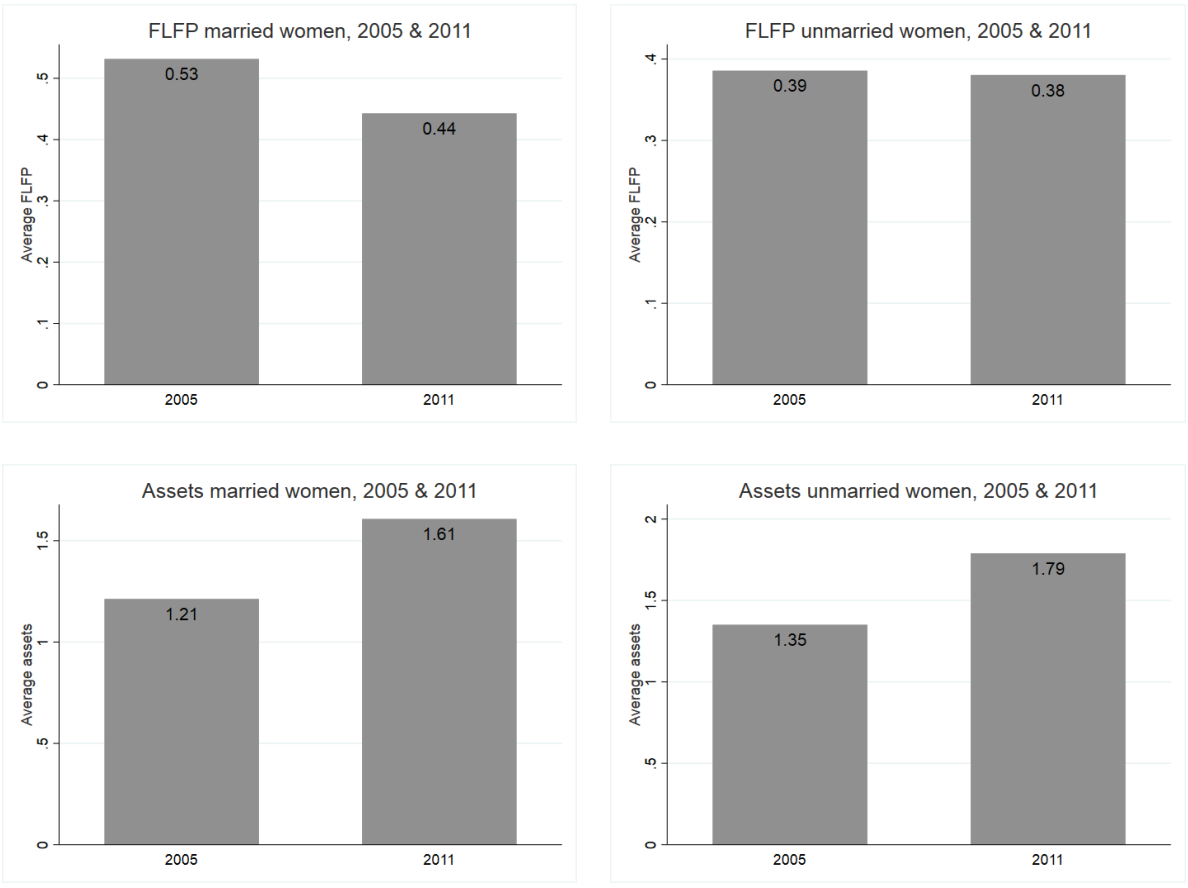
Condition 2: Exclusion restriction

The second condition an IV should satisfy is that it must be uncorrelated with the error term or any other determinants of the dependent variable. This cannot be tested empirically and should be based on theory. It should now be argued that this instrument – the average appliance ownership of unmarried women in a district – only affects FLFP of married women through the effect it has on their individual appliance ownership. The instrument employed serves as a combined proxy for (predominantly) unobserved factors that influence the average ownership of appliances. These factors are, for example, the price of the appliance, the operation and maintenance costs, different sales taxes, and

transportation costs. All these factors affect appliance ownership, as they directly impact the price. While one could argue they can influence a woman's decision to enter the market force, this relationship is dubious and these factors should not strongly affect the Indian FLFP (previous literature has not noted these factors as determinants of FLFP in India; the Consumer Price Index does not statistically affect FLFP (Ricketts, 2014)).

The rationale for Coen-Pirani et al. (2010) to apply this instrument is that they view their instrument "as unlikely to be affected by unobserved determinants of the participation decision of married women. This assertion applies here as well because the labour force participation rates of unmarried women remained constant during the 1960s, while their appliance ownership rates increased in a similar way to those of married women" (p.508). Hence appliances did not affect the external labour force environment as it did not influence unmarried women to increase their participation. This argument eliminates the direct link between an aggregate state-level increase in appliances and an increase in FLFP. The trends observed in the Coen-Pirani et al. paper are also observed in the Indian dataset used in this study. Figure 7 shows that unmarried women's FLFP did not change over the course of six years, while married women's FLFP declined. It is also evident from the figure that the assets ownership of both groups increased by approximately the same magnitude.

Figure 7: Average FLFP and appliances of married and unmarried women



Note: All data from the India Human Development Survey (IHDS)

These figures represent the fact that appliance ownership does not influence labour market conditions. The exclusion restriction also holds for intuitive reasons. No previous research has found links between these specific macroeconomic variables that affect appliance ownership and the FLFP. Average district appliance ownership reflects the appliance diffusion in that specific state; it does not necessarily reflect the employment opportunities for women. Macro-based factors that influence FLFP in India are infrastructure, labour laws, and rural employment programmes (Sorsa et al., (2015), as well as state-level initiatives and social sector spending (Das et al., 2015). Thus, the macroeconomic variables that would affect appliance ownership are different from those affecting FLFP. It could also be the case that FLFP affects the district-level ownership of appliances: districts where a higher proportion of women work could be more prosperous and modern, therefore demanding more appliances. However, if this were true then we would see FLFP variation in both groups of women. At an average state level, factors that affect appliance diffusion do not necessarily affect the FLFP rate. Taking all previous arguments into account, average district appliance ownership of unmarried women is a viable instrumental variable for household appliance ownership.

The IV is based on information of 12,541 unmarried women. Compared to the married women they tend to be younger, live in urban areas, have more education, and fewer children (Table 1). Their average rate of employment is nine percentage points lower than that of married women, possibly linked to the aforementioned factors. Time constraint is of less importance to this group of women as they do not have to take care of others in their households as much as married women do. Thus, while their appliance ownership increased, their LFP rate remained constant.

Table 1: Comparison of characteristics between married and unmarried women

Variable	**Married women**	**Unmarried women**
Age (average), years	38.3	35.1
Urban, %	31	44
Employed, %	49	38
Completed years of education	4.2	6
Income, Rs.	99,025	95,156
# of children (average)	1.9	1.11
Electricity, %	83	87
Assets (average)	1.4	1.6
Observations	67,872	12,541

Note: This data comes from the India Human Development Survey (IHDS)

As with Coen-Pirani et al., the endogenous regressor is at household level, while the instrument varies only at state-year level. They account for that by applying state-year clustered standard errors. In this study, the standard errors are clustered at the IDPSU level, the primary sampling unit (PSU). Clusters should be based on how the sample was selected; in this case the villages – the PSU – were randomly selected from states and districts.

6 Data and descriptive statistics

6.1 India Human Development Survey (IHDS)

The India Human Development Survey (IHDS) is a nationally representative multi-topic longitudinal survey of Indian households and individuals. There have been two waves: IHDS-I in 2005 and IHDS-II in 2011–12, which will henceforth be referred to as the 2005 and 2011 wave. The 2005 wave surveyed 1,503 villages and 971 urban neighbourhoods and the 2011 wave surveyed 1,420 villages and 1,042 urban neighbourhoods. Of the 612 districts in India in 2001, 382 were included in the 2005 wave and 384 in the 2011 wave. The complete survey consists of interviews with household members, test scores of children aged 8–11, and additional youth, village, school, and medical facility interviews.

The breadth of topics included in this survey allows for analyses of associations across a range of social and economic factors. The survey is a research programme between researchers from the National Council of Applied Economic Research in New Delhi and the University of Maryland. As the survey is a panel (the 2011 wave re-interviewed 83 percent of the households of the previous survey, as well as split households, if they were located within the same village or town) and consists of a large range of variables at household, individual, and community level, it can therefore be used as a basis for "analysing causal patterns underling changes in human development", such as "the causes of inequalities in employment" (IHDS User Guide).

In the 2005 wave 41,554 households and in the 2011 wave 42,152 households were interviewed. The sample was drawn using stratified random sampling; village and urban blocks form the primary sampling unit from which the households were selected. 6,911 households from 2005 were lost to recontact in 2011 and 2,134 households in the 2011 wave were not included in 2005. Some households from the 2005 wave split into two or more households in 2011. In both rounds the same 150,995 individuals were interviewed and the 2005 wave consisted of 64,753 and the 2011 wave of 53,582 individuals that were not interviewed in the other round.

To create one large IHDS dataset for the panel analysis, the individual and household files of the respective years were merged at the individual level, and afterwards the two survey rounds were appended. One of the main covariates that affects FLFP is household income. In the IHDS some households report negative income, because of negative farm incomes (resulting from crop failures and high expenses). This totals about one percent of the households. These cases – 1,373 observations in the dataset – should be omitted from the analysis, as these households "do not appear as poor on other economic dimensions as households with low but positive incomes" (IHDS User Guide). Including these households with negative income will provide false information on the economic state of the household. Besides these alterations, a woman's own earnings need to be subtracted from the household income, as her earnings are a direct result of her labour participation, the dependent variable.

6.2 Attrition

The final appended dataset consists of married female respondents aged between 15 and 65. Some observations in the dataset were only interviewed in 2005 and must be omitted to create a balanced panel, where the same respondents are interviewed in both rounds. It is important to distinguish the characteristics of this group to determine if the attrition rate of around 30 percent is problematic or not. This can be investigated by searching for patterns in the outcome variable and household characteristics of the attrition and non-attrition group.

When comparing the attrition group to the balanced panel dataset (the non-attrition group) of the first round, as in Table 2, the respondents who were not observed in 2011 have a slightly higher probability of being the daughter of the household head, being enrolled in school, and being older. These characteristics do not seem to match intuitively, hence attrition could be random. Large discrepancy appears when one observes the values for living in an urban area, being employed and income. The attrition group has a higher percentage of respondents living in an urban area, have a higher income and a lower percentage of women in the workforce. The married attritors could have taken valuable information with them, as they represent a particular group of urban and richer women; this group is more likely to own appliances and less likely to be in the labour force.

Interestingly, when this attrition exercise is performed on the complete dataset of both unmarried and married women, the differences between the urban/rural group and income are negligible, implying that non-response in the second round is not due to specific socio-economic or environmental characteristics. In this case it seems as if the attrition rate is mainly stimulated by the natural flow of young women leaving their parents household, most likely because they married and moved into a new household. Thus, while attrition is not necessarily random, it is likely based on observables.

Table 2: Comparison of characteristics between balanced dataset of the 2005 wave and attrition group

Variable	**Balanced panel group, 2005**	**Attrition group**
Age (average age), years	34.7	39.6
Age (below 20), %	18	17.8
Relationship to head, % daughter	0.7	2.7
Urban, %	30	45
Employed, %	53	37
Completed years of education	4.1	4.8
Student, %	0.5	1
Income, Rs.	57,712	68,892
# of children, av.	2	2
Observations	33,936	12,541

6.3 Descriptive data

Table 3 contains the description of the dependent and independent variables of the empirical analysis. The dependent variable takes the value of 1 if a woman works more than 240 hours a year and 0 if she works less; the IHDS defines work participation as engaging for more than 240 hours a year in the labour market and the analysis is thus constrained by this definition. The endogenous regressor of interest can take two forms: either as a dummy variable for each appliance or as an index which sums the five relevant time-saving appliances a household possesses. Each (group of) endogenous regressor(s) is estimated in the empirical analysis.

Table 3: Description of dependent and independent variables

Dependent variable	
Participation rate	= 1 if a woman works >240 hours
	= 0 if a woman <240 hours
Endogenous regressors of interest	
Ownership of appliance (e.g.	= 1 if household owns the appliance
refrigerator, washing machine)	= 0 if otherwise
Assets index (absolute value)	Sum of five most important time-saving appliances
Covariates	
Age	Age of the respondents
Education	Total number of completed years of schooling
Urban	= 1 if urban
	= 0 if rural
Income	Total household income (minus own earnings)
Children	N children living with the respondent (total)
Electricity	= 1 if household has electricity
	= 0 if household does not
Spouse's participation rate	= 1 if spouse works >240 hours
	= 0 if spouse <240 hours
Spouse's education rate	Total number of spouse's completed years of schooling

Table 4 shows the summary statistics of each of these variables. The overall FLFP rate in the Indian dataset is 49 percent and it decreased from 2005 to 2011 by nine percentage points. This participation rate is low compared to the spouse's rate, which is 89 percent. This rate decreased as well from 2005 to 2011, which could owe to more people exiting the labour force than entering it during the two waves (for example, a male of age 60 in 2005 could have exited the labour force before 2011, while a male of age 16 has not entered the labour force yet as he is still pursuing education). This decrease in the FLFP is observed in India overall (as described in the *Background* section) so the trend in the dataset corresponds to the wider phenomenon of decreasing FLFP. However, according to the World Bank data, the FLFP in India is only 32 percent during the 2005 – 2011 period (Figure 2), contrasting the IHDS data used in this research. The World Bank's definition of FLFP is "the proportion of the population ages 15 and older that is economically active: all people who supply labour for the production of goods and services during a specified period", including people who are unemployed but seeking work. This different definition to the IHDS might lead to diverse data observations.

Table 4: Summary statistics for married women aged 15–65, IHDS

Variable	**All**		**2005**		**2011**	
	Obs.	Mean (sd)	Obs.	Mean (sd)	Obs.	Mean (sd)
Dependent variable						
Participation rate	67,872	0.49	33,936	0.53	33,936	0.44
		(0.50)		(0.50)		(0.50)
Endogenous regressors of interest						
Refrigerator	67,755	0.24	33,839	0.18	33,916	0.30
		(0.42)		(0.38)		(0.46)
Washing machine	65,532	0.07	31,617	0.04	33,915	0.10
		(0.26)		(0.20)		(0.31)
Sewing machine	67,806	0.29	33,885	0.30	33,921	0.29
		(0.46)		(0.46)		(0.45)
Mixer/grinder	67,795	0.30	33,874	0.25	33,921	0.35
		(0.46)		(0.43)		(0.48)
Pressure cooker	67,661	0.51	33,744	0.45	33,917	0.57
		(0.50)		(0.50)		(0.50)
Assets (index IHDS)[1]	67,857	14.12	33,936	12.33	33,921	15.92
		(6.57)		(6.10)		(6.53)
Assets (absolute index)[2]	67,872	1.41	33,936	1.21	33,936	1.61
		(1.49)		(1.40)		(1.56)
Assets (relative index)[3]	67,872	0.28	33,936	0.23	33,936	0.34
		(0.36)		(0.31)		(0.40)
Covariates						
Age	67,872	38.31	33,936	34.76	33,936	41.86
		(11.12)		(10.46)		(10.61)
Education	67,872	4.16	33,936	4.09	33,936	4.22
		(4.66)		(4.65)		(4.66)
Urban	67,872	0.31	33,936	0.30	33,936	0.32
		(0.46)		(0.46)		(0.47)
Income	67,872	99,025	33,936	57,713	33,936	140,338
		(196,393)		(86,243)		(257,469)
Children	67,872	1.91	33,936	2.03	33,936	1.79
		(1.52)		(1.53)		(1.50)
Electricity	67,872	0.83	33,936	0.77	33,936	0.88
		(0.38)		(0.42)		(0.32)
Spouse's participation	67,872	0.89	32,714	0.92	32,199	0.86
		(0.31)		(0.27)		(0.35)
Spouse's education	67,872	6.09	33,936	6.12	33,936	6.05
		(4.92)		(4.90)		(4.94)
Total observations	67,872		33,936		33,936	

[1] The asset index from the IHDS sums 30 dichotomous items measuring household possessions and housing quality. It ranges from 0 to 30 in the 2005 wave and from 0 to 33 in the 2011 wave.

[2] The absolute index is compiled by the author and sums the five most important time-saving assets: refrigerator, washing machine, sewing machine, mixer/grinder, and pressure cooker. It ranges from 0 to 5.

[3] The relative index is the absolute index divided by the number of people that live in the household, resulting in an index of the number of appliances per household member.

The average female respondent is 38 years old, has completed four years of schooling, lives in a rural environment, and has approximately two children living in her household. The average annual household income (minus the female respondent's earnings) is Rs. 99,025 (around US$2,143 in 2010) and most households in the dataset have electricity.

Most appliances increased in ownership from 2005 to 2011, except for the sewing machine, which remained virtually the same. Total refrigerator ownership was 18 percent in 2005 and increased to 30 percent. In Table 4, seven percent of the respondents said they own a washing machine, increasing from four to ten percent between the two waves. Interestingly, most respondents who own these appliances live in urban areas (Table 5). These areas have an appliance ownership of around three to five times the appliance rate in rural areas. At the same time, in the rural areas more women are working. In these areas 60 percent of women reported that they are working, compared to only 22 percent in urban areas. This gives an indication of the nexus between appliances, FLFP, and the area a woman lives in, further explored in the next section.

Table 5: Refrigerator and washing machine ownership in urban and rural India

	All		**2005**		**2011**	
	Urban	Rural	Urban	Rural	Urban	Rural
Refrigerator	44.0	14.6	35.7	10.0	51.7	19.3
Washing machine	16.9	3.4	11.1	1.5	21.7	5.2

Note: The urban percentages are calculated as the total number of urban people that own the appliance as a fraction of the total urban population. The same holds for the rural population.

7 Results and discussion

7.1 OLS regression results

This section presents the regression results from the models discussed before. Table 6 reports the coefficient estimates of the model that includes all the appliances separately. The 1st and 2nd column are estimated using ordinary least squares (OLS). The complete results are reported in Table A1 in Appendix A. Both columns show primarily negative coefficients. The magnitude of the coefficients goes down significantly when covariates are included, as goes the statistical significance. In the model including covariates, only the refrigerator and the pressure cooker have a statistically significant effect on the FLFP. The negative coefficient does not necessarily contradict the aforementioned theories on FLFP, as some previous literature has found a negative relationship between appliances and FLFP. However, the results in Table 6 are seriously biased as the OLS does not account for any endogeneity that exists in the model. The included fixed effects in column 3 eliminate some of the omitted variable bias, yielding insignificant results, except for the mixer/grinder. Estimating the appliances separately does not lead to economically relevant results, as the explanatory power of each is too low. Henceforth, all regressions will have the aggregate appliance index as the main dependent variable.

Table 6: OLS regression results individual appliances

	(1) **OLS** No covariates	(2) **OLS** Covariates	(3) **Fixed effects** Covariates
Refrigerator	-0.111***	-0.040***	0.005
	(0.008)	(0.008)	(0.010)
Washing machine	-0.079***	-0.001	-0.017
	(0.010)	(0.009)	(0.012)
Sewing machine	0.004	0.011	0.005
	(0.008)	(0.007)	(0.008)
Mixer/grinder	-0.082***	0.004	0.019*
	(0.009)	(0.008)	(0.009)
Pressure cooker	-0.160***	-0.062***	0.003
	(0.009)	(0.008)	(0.008)
Observations	65,296	64,999	64,999
R-squared	0.083	0.165	0.033
Indiv. fixed effects	No	No	Yes
Year fixed effects	No	No	Yes

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

Table 7 tries to solve the aforementioned endogeneity problems by applying a fixed effects approach. The independent variable in this model is the absolute index of appliances that a household has, based on the five appliances from the previous regression. This value ranges from zero, where the household has no appliances, to five, where the household owns all five appliances. Before interpreting the results, we need to observe if the predicted values of the dependent variable are outside the interval of 0 and 1; the LPM model can give predictions outside this range, rendering them meaningless. The predicted probabilities of FLFP all lie in the interval (0.157, 0.958), hence the LPM is expected to be unbiased and consistent. Figure A1 in Appendix A graphs the values of the predicted probabilities and displays that they are bounded by the interval from 0 to 1. While the upper bound is close to 1, most observations are between 0.2 and 0.8, implying the linear model fits well.

Again, the independent variable has a negative coefficient in the OLS regressions. The OLS regression without covariates (column 1) seems biased, as the coefficient is of a larger magnitude than the subsequent regressions that include covariates and fixed effects. It also has a negative coefficient. As with Table 6, including the fixed effects makes the coefficient positive and statistically insignificant. The individual and year fixed effects likely control for most of the variation in the FLFP variable. As this regression is also performed with OLS, the endogeneity issues have not been solved for. In the regression the standard errors are clustered at the PSU, the village sampling level, to account for heteroskedasticity.

Table 7: OLS regression results appliance index

	(1) **OLS** No covariates	(2) **OLS** Covariates[1]	(3) **Fixed effects** Covariates
Assets (absolute index)	-0.091***	-0.019***	0.004
	(0.002)	(0.003)	(0.003)
Observations	67,872	67,558	67,558
R-squared	0.075	0.166	0.032 5
Indiv. fixed effects	No	No	Yes
Year fixed effects	No	No	Yes

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

Note: In columns 2 and 3 all covariates are included. Column 1 serves as a base regression to benchmark how the regression techniques from columns 2 and 3 can solve for the bias in this regression

Finding a negative coefficient for the main independent variable in the OLS regression, while not necessarily contradicting theories from previous literature, presents an unanticipated result. This study hypothesises that household appliances have a positive effect on the FLFP in India. The fact that we find a negative coefficient in the OLS regressions can be attributed to several explanations. From a context perspective, there could be a prevailing negative relationship between the appliance variable and the FLFP in the Indian case. This is not entirely strange: there is quite a strong negative relationship between household income and FLFP in India, and a strong relationship between income and household appliances. The income effect could outweigh the time-saving effect that appliances have. As this model has not previously been applied to the Indian case, there are no reliable benchmarks for the direction of the coefficient. Ejaz (2011) highlights a similar relationship in Pakistan, employing a cross-sectional dataset, but using a similar IV estimation. From a data perspective, there are severe limitations. The survey asks a woman if she works and if she owns appliances but does not record which one occurred before the other. If the majority of women in the dataset were in employment prior to acquiring the appliances, then no causal relationship can be established. More waves of the survey are necessary to accurately follow a woman's life. The negative coefficient can also be explained by the 'leisure option' that women encounter. While Indian households become wealthier and acquire more appliances, this does not necessarily translate into workforce participation. Although time may indeed be saved on their existing household tasks, the acquisition of new assets could lead to increased leisure time or to the assumption of different household tasks for which there was previously not sufficient time. While these explanations all seem valid, the negative coefficient is most likely caused by the large OVB and reverse causality and its interpretation is therefore invalid. The next section solves for these issues by using an IV approach.

7.2 IV regression results

Including fixed effects does not solve all the endogeneity issues this model specification faces, thus an IV is incorporated. Table 8 presents the first-stage regression (from equation (8)): the relationship between district-year mean appliance ownership of unmarried women and the household appliance ownership of the respective married woman. They are positively and significantly correlated, even after including individual and year fixed effects. These strong coefficients demonstrate that this instrument satisfies the relevance condition. In addition, the F-statistics are well above 10, a benchmark from Angrist and Pischke (2009) for strong instruments.

Table 8 presents the coefficient of the main independent variable for the IV regressions, which are performed using 2SLS. The IV coefficient from the specification in column 1 states that, holding everything else constant, an increase of one household appliance leads to a 4.4 percentage point decrease in the probability that a woman operates for more than 240 hours a year in the labour market, ceteris paribus. This result is contaminated by a large OVB as there is no control for individual and year unobserved characteristics. It is crucial that the fixed effects are included in the 2SLS regressions to obtain unbiased estimates.

Table 8: IV regression results appliance index

	(1) **2SLS**	(2) **2SLS with fixed effects**
Assets (absolute index)	-0.044***	0.072***
	(0.011)	(0.023)
First-stage regression		
District-year mean appliance ownership of **unmarried** women, Z	0.470***	0.501***
	(0.0121)	(0.0239)
First-stage F-statistic	1515.90	437.97
Observations	67,300	67,300
R-squared	0.163	0.015
Indiv. fixed effects	No	Yes
Year fixed effects	No	Yes
F-statistic	566.69	223.79

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

Note: In columns 1 and 2 all covariates are included.

When the model includes both individual and year fixed effects, in column 2, the coefficient becomes positive, implying a positive effect of household appliances on FLFP. The last column states that, holding everything else constant, an increase of one household appliance leads to a 7.2 percentage point increase in the probability that a woman operates for more than 240 hours a year in the labour market, ceteris paribus. This

is a coefficient of rather large magnitude and the change in sign compared to column 1 is unexpected but can be sufficiently explained. The OLS regressions produce biased estimates, as unobserved heterogeneity is large in this specification. The IV specification solves this. However, only when individual and year fixed effects are included, the unobserved heterogeneity bias from the OLS and 2SLS regressions fully disappears. The individual fixed effects account for each individual's unobserved characteristics that could affect her FLFP and household appliances, such as ideological and personal norms and values. As discussed before, a range of determinants heavily influences these two variables, thus controlling for these unobserved factors removes the large omitted variable bias. Furthermore, the year fixed effects are likely to have a substantial effect on reducing bias, as the period observed here spans over six years. India has rapidly developed both economically and socially in these years and including year fixed effects eradicates these unobserved factors. FLFP has been decreasing in India over this period; the time fixed effects control for this aggregate trend. FLFP and appliances are spuriously related as they are both affected by the positive economic growth in India: increasing income causes a decline in FLFP, but an increase in appliances. The OVB from failing to control for time was negative, due to the aggregate rising trend of household appliances and falling FLFP over this period of 2005 to 2011, putting downward pressure on the coefficient in the model specifications without fixed effects.

While the 2SLS regressions in Table 8 have larger standard errors than the OLS ones, the coefficients are still statistically significant. The loss of efficiency that 2SLS usually imposes is not an issue in this case.

The signs of the covariates are inconsistent with the theory in each case (these coefficients are reported in Table A2). Parallel to the appliance variable, they change signs across the different regression specifications. Noticeably, all variables are of rather small magnitude and thus there is not one main predictor of FLFP. This regression exemplifies the complex situation of FLFP and the myriad factors that either stimulate or deter an increase in this rate. All determinants included in these regressions are endogenous and one should be careful when interpreting the economic significance of the variables.

It is surprising that age has such a limited effect on FLFP. This demonstrates that other variables are more important for determining FLFP. Intuitively, education would be one of those variables. However, it is statistically insignificant and its value is rather small. If most women had completed their education before responding to the survey – this is likely as the dataset is trimmed to include women who are 15 years and older – the individual fixed effects control for this time-invariant variable and thus remove its explanatory power. The variable is significant if the fixed effects are not included. In these specifications, in columns 2 and 4, education has a negative effect on FLFP, contradicting theories on labour determinants. As expected, income has a negative effect on FLFP, and this is stable and significant across all specifications. In the next section, the robustness checks demonstrate that these variables are not linear determinants of FLFP, and thus their explanatory power increases when their squared version is included.

For married women, children have a modest positive effect on the FLFP. This is counterintuitive, as a woman is more likely to stay at home and care for her children than enter the workforce. Perhaps the effect of children is negligible as the regressions are performed on married women only. As explained in the *Literature Review* section, marriage and fertility are intertwined as they often go hand in hand can act as a barrier to FLFP. The effect of children could be internalised by the effect of marriage on FLFP, which is excluded as the sample group consist of married women. Another explanation can be found in the connection between age and children: the positive effect of the children coefficient might capture the positive effect that age has on both the number of children and the FLFP. When including an interaction term, as in column 6 in Table A2, the coefficient of children becomes negative. However, the coefficient of the interaction term is positive, suggesting that an additional child yields a higher increase in FLFP for older women. While seemingly contradictory at first, it is reasonable to assume the effect of children on FLFP is different for a woman who bears children at age thirty than a woman who bears them at age twenty. However, the overall effect of children is positive at the aggregate level, as the youngest woman in the dataset is fifteen and adding the *Children* and *Age * Children* coefficient for this age yields a positive coefficient.

Both the urban and the electricity variable are statistically insignificant when fixed effects are included. It is feasible most respondents lived in the same area – urban or rural – and did or did not have electricity during the two survey rounds, hence the individual effects control for these time-invariant variables, removing the effect from the urban and electricity covariate. In the specifications in columns 2 and 4, the urban variable is the strongest determinant of FLFP. Living in an urban area reduces the probability of working by almost thirty percent.

7.3 Robustness checks

This section presents several robustness checks that demonstrate the validity of the results from the previous section. They serve the purpose of finding a robust causal relationship between appliances and FLFP. This will give more insights into the hypothesis formulated in the beginning of the study. All regression results are documented in Appendix B.

7.3.1 Unmarried women

This robustness check aims to determine whether the instrument – district-year average appliance ownership of unmarried women – also explains changes in the FLFP of unmarried women. Column 4 in Table B1 shows that the instrument does not predict changes in the FLFP of unmarried women. In this column, unobservable state-year shocks that could potentially affect appliance ownership and FLFP are not controlled for. If this regression would have been significant, it would imply that the instrument operates through the mechanism of unobservable factors that influence FLFP. In this case the exclusion restriction does not hold. However, when individual and year fixed effects are included, the coefficient becomes significant and of relevant magnitude. Thus, when controlling for all bias arising from omitted variables of time and individuals, household appliances

positively affect the FLFP of unmarried women. This confirms the exclusion restriction: when the regression does not control for unobservable individual and year specific shocks – in column 4 – there is no significant coefficient, but when fixed effects are included it becomes significant. The former effect is the one we want to find, as it confirms the notion that there are no unobservable shocks that affect the FLFP of married and unmarried women, which could also affect their appliance ownership. If this would be the case, column 4 would display a significant coefficient. It is demonstrated that the appliance ownership of unmarried women only affects the FLFP of married women through its effect on this latter group's appliance ownership.

This robustness check only confirms the link between increasing FLFP and acquiring more appliances. It does not check if there are external factors that influence both the FLFP and appliance ownership. However, since the FLFP of unmarried women did not change significantly during this time, but their appliance ownership did, it is unlikely that there are other factors that simultaneously influence appliance ownership and FLFP.

7.3.2 Additional controls

Here additional controls are included to check the robustness of the results from the primary regressions. A labour force regression that uses age as a covariate should also contain an age squared variable to control for the diminishing effect that age has on FLFP. The same holds for years of education and income; theoretically both variables are not linearly related to FLFP. Ejaz (2011) also includes a squared variable of the household appliances. She finds a negative coefficient for appliances, but a positive one for the squared variable, indicating that "the likelihood of participation increases when the number of labour-saving appliances rises" beyond a certain threshold.

Table B2 presents the regression results when these additional covariates are included. Column 4 contains the preferred specification and will be used to calculate the turning point where the sign of the coefficient changes. Assets has a positive coefficient and a negative squared one, contradicting Ejaz' results, implying that FLFP decreases after the threshold of 2.7 appliances.[5] The positive effect of household assets on FLFP becomes five time as strong when its squared counterpart is included. There is an inverse U-shaped relationship between assets and FLFP. This is likely a cause of the income effect, where more appliances indicate a higher household income, thus decreasing participation. The income effect is completely captured in this trend, not in the income variable itself. The turning point for that variable is 2,342,353. Only 61 respondents have an income higher than that, representing 0.09 percent of the dataset. This implies that no squared relationship of income exists in this dataset and that income has a strong negative effect on FLFP. The maximum at which point income positively influences FLFP lies at the boundary of this dataset and can not be observed in this case. Age has a positive sign

[5] Calculate the threshold for each of the squared variables: (1) $Y = \beta_1 X + \beta_2 X^2$; (2) $\partial y/\partial x = \beta_1 + 2\beta_2 X$; (3) $\beta_1 + 2\beta_2 X = 0$ (optimisation); (4) $2\beta_2 X = -\beta_1$; (5) $X = -\beta_1/2\beta_2$
Applying this to our four squared variables, we calculate that X = 21.5 for age in years, X = 5 for years in education, X = 2.7 for the number of household appliances, and X = 2,342,353 for income.

while its squared version is negative: FLFP first increases when a woman ages, and after a certain threshold, 21.5 years old in this case, decreases. Education now has a negative sign – in the previous regression it had a positive one – while the squared education variable has a positive one, showing a U-shaped relationship. More education discourages a woman to enter the labour market until she has achieved around 5 years in education, after which attaining education increases the probability of participating in the labour market. This explains the trend that a woman who has acquired basic education is not necessarily pushed into the work force, but that acquiring more education – at high school and university level – does positive affect FLFP. This is in line with the theory from *Section 3.3*.

The explanatory power – demonstrated by their magnitude – of all variables that have a squared version increases immensely, as well as their statistical significance. The education variable, while not being significant in the main regression, becomes significant at the one percent level when the squared variable is included. In a realistic situation these variables portray a polynomial shape and including the squared variables allows them taking this form, thus increasing their statistical significance. They are more aligned with theory than the results of the regression in the previous section.

One should note that hitherto no variable of religion has been included, even though such a measure should act as a proxy for conservative cultural values. The reason for this being that 82 percent of the respondents is Hindu, 12 percent is Muslim, and the final 6 percent is of another religion. It would be instructive to compare religious and non-religious households in terms of FLFP, but such distinction is non-existent in the IHDS dataset. However, for this robustness check, a dummy variable for being Muslim is included. In Table B2, the Muslim dummy has a strong negative effect on FLFP in each specification. This effect is insignificant when individual fixed effects are included, as these control for such individual time-invariant characteristics. The reason this coefficient is not excluded from these two fixed effects regressions in column 2 and 4 is because a small number of women became Muslim in between the two survey rounds. However, this amount is too small for these estimates to have any economic relevance.

7.3.3 Unbalanced panel

The IHDS dataset had been trimmed to create a balanced panel. One of the robustness checks is to verify the previous main regression results with the same regressions performed on the unbalanced panel. As we observe some attrition, the balanced panel could have lost some important information. The results in Table B3 are in line with those from Table A2 in Appendix A. While the magnitude changes in some cases, the signs of the variables remain the same. It can be concluded that using the balanced dataset for the main regressions did not bias the results greatly. The previous findings hold, even compared to the larger dataset (there are 84,042 observations in the unbalanced panel dataset).

7.3.4 Income quintiles

Confirmed by both theory and the regression outputs, the income variable affects appliance ownership and FLFP simultaneously in opposing directions; it positively affects appliance ownership but has a downward pressure on FLFP. Dividing the data into quintiles of twenty percent each allows us to demonstrate the effect of appliances on FLFP across each income group: from the poorest (quintile one) to the most affluent one (quintile five). Table B4 shows the coefficient for the household appliance index for each of the five regression specifications. The preferred specification in column 5 has insignificant coefficients, except for the 1st income quintile, where appliance ownership is statistically significant at the 10 percent level and has a large magnitude. For almost each specification, the magnitude of the appliance coefficient increases the lower the income quintile: this presents suggestive evidence that household appliances have a stronger effect on the FLFP of poorer households. However, the signs are incoherent and no solid pattern can be detected. All coefficients are negative if the fixed effects are excluded; including them results in insignificant outcomes.

The negative explanatory power of the income coefficient on FLFP is 5 percent, 33 percent, 55 percent, 30 percent, and 6 percent for the 1st to 5th quintile respectively (for the IV regression with fixed effects): income is a stronger determinant for the middle-class. Dividing the dataset into income quintiles increases the negative effect income has on FLFP, especially for the 2nd to 4th quintile. This is evidence for the U-shaped education hypothesis outlined in *Section 2.1.* This robustness check exemplifies the importance of household income on a woman's decision to enter the work force.

7.3.5 Urban vs rural

One of the robustness checks is duplicating the regression model separately for the rural and urban respondents. As established before, appliance ownership differs greatly across these two areas, as does FLFP. Surprisingly, the FLFP is larger in rural areas, where 60 percent of the women work, compared to only 22 percent in the urban sample. Observing the output in Table B5, not one linear trend can be established when comparing the results for the urban and rural sets. The preferred specification in columns (5) and (10) displays an insignificant coefficient. For both groups most coefficients are rather similar, except for the education and electricity coefficient. Education is insignificant across all specifications in the urban group, implying that women decide to work or not irrespective of their educational attainment. Interestingly, the effect of appliances and income do not differ extensively between the two groups, even though the urban and rural areas are economically and culturally quite different. No sensible conclusion can be extracted from this robustness check as the regression results are incoherent. Perhaps living in either an urban or rural region has such strong explanatory power on the FLFP that it reduces that of the other variables.

7.3.6 Alternative measures FLFP

The IHDS dataset offers some, albeit not perfect, different measures of work participation, such as hours or days worked in a year. Unfortunately, some of these variables are

only included in the 2011 wave, but they are still used as a robustness check. The 1st column of Table B6 has a binary dependent variable of work participation on a farm. It is coded in a similar fashion to the dependent variable of the principal regression and is thus regressed as an LPM. The 2nd and 3rd column consist of a dependent variable that represents total working days and hours a year respectively. The 2nd column displays the working days of job 1[6] and this variable, while consisting of fewer observations, was asked during both rounds. The same holds for total working hours. The 4th and 5th columns present a dependent variable coded as the number of days and hours worked in a year respectively. These regression specifications do not include year fixed effects as the survey question related to these variables was only asked during the 2011 wave. Observing the data and the questionnaire, it becomes evident that the dependent variables of columns 4 and 5 consist of plenty observations of 'zero', meaning the respondent did not work any days. For both columns 4 and 5, 48 percent of the responses are 'zero'. The working days and hours for job 1 – column 2 and 3 – were only denoted if the respondent actually attended her job, hence the low number of observations.

Column 4 and 5 present the results for women both in and out of the workforce. Taking into account this group as a whole, household appliances have a negative effect on the work days and hours a year; the large group of women that works zero days or hours likely pushes the coefficient downward. This corresponds to the regression results of columns 1 and 2 in Table 7 and column 1 in Table 8. These regressions are biased as they do not consist of panel data, but rather cross-sectional observations. While they show significant results that can be interpreted in line with the literature, the OVB is too large in these specifications.

7.4 Limitations

LPM

The drawback of using an LPM is that the effect is always constant; it only provides average effects. This implies that in the model the effect of the appliance index on the FLFP of going from zero to one appliance is the same as going from four to five appliances. This is palpably an unrealistic assumption. It might be a relatively large step for a household to go from zero to one appliance; this could indicate a large increase in income or another socio-economic shock. If a household moves from four to five appliances, this is probably not a result of a significant change in household characteristics. Unfortunately, there is no available data on the order and date of acquisition of said appliances. The appliances included in this model will each have a different time-saving effect on the woman's household work. One could assume that a washing machine or refrigerator save a woman more time than a mixer or sewing machine. Another drawback of the LPM is that the error term is by definition heteroskedastic. This is controlled for by including robust clustered standard errors.

[6]Respondents were asked to note down how many days they worked in the last year for each separate job, where job 1 is the principal job.

External validity

Extrapolating the results from the study to the broader Indian population of married women is problematic. While the IHDS surveyed a representative sample of individuals, the trimmed balanced dataset used in this study – containing married women aged 15 – 65 – is not necessarily representative. Evidently there is also low external validity beyond the Indian context. The data used is very specific to India and is not indicative of current or historic trends in other countries. India has a distinct culture, with specific FLFP determinants and appliance diffusion trends. One should be careful when applying the results to different research audiences. Noted throughout the study, FLFP does not follow a rational worldwide course, and it is almost impossible to make claims on audiences beyond the scope of research on this topic.

Internal validity

Internal validity is compromised through the choice of instrument. The 'relevance' requirement is attained through the strong first-stage of the 2SLS regression. The 'exclusion restriction' poses a more strenuous concern, as this condition cannot be tested. The instrument selected had to be of such nature that it affects FLFP only through the endogenous variable, the household appliances. Intuitively, the instrument employed – the district-average rate of appliance ownership of unmarried women – should fulfil this restriction, as it is argued that factors influencing the district-average rate, such as sales tax and transportation costs, have no direct effect on labour supply decisions. However, the scarcity of research on this specific topic constrains the theoretical foundation of such claims. It is therefore not completely apparent that the 'exclusion restriction' is fully satisfied.

Range of appliances

All regressions are based on the five time-saving appliances in the IHDS: refrigerator, washing machine, sewing machine, mixer/grinder, and pressure cooker. There are many other time-saving appliances that could have a more direct (and perhaps positive) effect on the FLFP, such as dish washers, vacuum cleaners, clothes dryers, microwaves, ovens, and gas stoves. Making sense of the empirical results in this study is therefore restricted to the former five appliances due to data limitations. One should interpret the remarks on the relationship between household appliances and FLFP with caution, as they do not constitute the whole range of time-saving appliances. Respondents in the dataset could be in full employment and yet own none of the appliances surveyed in the IHDS but could possess a dish washer and a gas stove; both appliances with time-saving capabilities. In this case, the study would falsely conclude that appliances do not play a role in this respondent's decision to enter the labour market, even though the respondent owns time-saving appliances. No survey or dataset is perfect and working with one designed for different purposes limits the valuable information one can extract from such questionnaires.

Time assumption
This study assumes that time is deterring women from entering the workforce (the case, for example, in Latin America (Sanfeliú, Polanco, Vásquez, & Calderón, 2016)), which need not be true in this setting. Especially in a complicated environment like India, time is only one of the multiple impediments to a flourishing FLFP. Household appliances play a major role in relieving the time constraints confronting women when entering the labour market. This is the mechanism through which appliances could affect FLFP and on which this study is based. If these constraints are not relevant to the Indian female population, the mechanism through which our variable of interest affects the outcome of interest does not hold.

Definition of LFP
The IHDS defines work participation as working in excess of 240 hours a year, which translates into, for example, thirty days of eight hours per day. This constitutes quite a high benchmark for a country such as India, where a lot of women are either not participating in the labour force or are performing small tasks. The other measures included in the dataset – such as days worked per year – offer deeper insight into the exact relationship between appliances and FLFP, as there is more variation in the dependent variable. Unfortunately, this data has only been sporadically collected and any future rounds of IHDS, if they indeed come to pass, should aim to collect more detailed data on female working hours. Lastly, there is ambiguity as to whether the data in the IHDS contains both formal and informal work, and how they define this. A respondent might, for example, be undertaking minor informal tasks for which she receives some remuneration, but which has not been documented in the survey due to the wording of the questions.

8 Summary and concluding remarks
The recent decline in FLFP in India has puzzled academics and policy makers, as the country's economy is growing rapidly and increasing numbers of girls obtain education. Numerous research pieces have analysed the long list of determinants of FLFP in this paradigm. This study complements this previous literature by scrutinising the link between time-saving household appliances and FLFP of married women, hypothesising the positive effect these appliances should have on women entering the labour force, through the mechanism of freeing up time in daily schedules of Indian females.

As the dependent variable is of a binary nature, an LPM model was implemented, along with a series of alternative specifications. The main endogenous variable was the sum of five relevant appliances, aggregated into an 'appliance index'. To solve the regression biases and to obtain causal results, an IV and fixed effects were included in the models. The results demonstrate a positive causal relationship between appliances and the FLFP. This outcome is prevalent across several robustness checks. The results are especially robust when squared variables are included; most covariates display a non-linear relationship to FLFP and accounting for this validates the suitability of the model.

The positive relationship between FLFP and appliances is also frequently found in some previous literature. However, as no predominant relationship between these two variables exists, it becomes problematic to interpret the results in a broader context. This is the first study that employs panel data to this specific research question and it is therefore somewhat difficult to compare the outcome to previous studies; especially as said studies did not examine India nor, indeed, any other emerging country. Including an IV and fixed effects results in a positive relationship between appliances and FLFP, but this result needs to be interpreted with caution and cannot be extrapolated to other contexts.

Comparing our result to previous studies that have employed OLS, this research actually finds a negative relationship between FLFP and appliances. Various factors can account for this result: (1) there exists a negative relationship between appliances and FLFP, as more appliances could encourage women to enjoy more leisure time or spend even more time in the household; (2) the income effect, which increases appliance possession but decreases FLFP, can be stronger than the direct link between appliances and FLFP; and (3) negative coefficient of appliances internalises other factors that could discourage women from entering the workforce. It is evident the OLS regressions without fixed effects in this study and in previous research are strongly biased and do not represent the real effect of time-saving appliances on FLFP.

Whilst FLFP in India is a profoundly complex issue and its drivers and deterrents difficult to disentangle, this paper does serve to underline that certain household appliances have produced time-saving effects which have expedited FLFP. Whether this will preface an innovative new area of policy design will depend upon culture and household dynamics which, as has been argued, continue to play a significant role in the FLFP decision, as each determinant is inextricably linked with others. Whilst policies that target poorer households and their lack of household appliances could influence the overall development of the country, only a multi-dimensional policy strategy, rooted in both cultural and economic logic, will eventually have an effect on women entering the labour market.

This study opens up a new and large field for further research. As the potential relationship between household appliances and FLFP has hardly been applied to the developing world context, this question should be applied to other developing countries with distinct cultures to that of India. Further research should endeavour to identify other time-saving appliances that could perhaps have stronger effects on the FLFP. Future surveys should aim to gather data on the whole range of time-saving appliances that households own. Furthermore, it would be interesting to include the labour demand-side factors in studies of this nature. This research neglects the market situation to focus solely on internal individual decisions to participate. In the case of India, the structure of the market plays a decisive role in determining FLFP. Simultaneously, these factors could be exploited to strengthen the 'exclusion restriction' of the instrument, by looking at the link between FLFP and market dynamics that influence household appliance acquisition. Lastly, a study using a panel consisting of more survey rounds will allow for a more complete image on the dynamics of FLFP.

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A Regression results

Table A1: Regression results individual appliances

	(1) OLS No covariates	(2) OLS Covariates	(3) Fixed effects Covariates
Refrigerator	-0.111***	-0.040***	0.005
	(0.008)	(0.008)	(0.010)
Washing machine	-0.079***	-0.001	-0.017
	(0.010)	(0.009)	(0.012)
Sewing machine	0.004	0.011	0.005
	(0.008)	(0.007)	(0.008)
Mixer/grinder	-0.082***	0.004	0.019*
	(0.009)	(0.008)	(0.009)
Pressure cooker	-0.160***	-0.062***	0.003
	(0.009)	(0.008)	(0.008)
Age		0.001***	-0.002**
		(0.000)	(0.001)
Education		-0.007***	0.002
		(0.001)	(0.002)
Urban		-0.285***	0.014
		(0.010)	(0.036)
Income (log)		-0.047***	-0.018***
		(0.003)	(0.003)
Children		0.019***	0.028***
		(0.002)	(0.002)
Electricity		0.036***	0.001
		(0.009)	(0.011)
Spouse's education		-0.003***	-0.001
		(0.001)	(0.001)
Survey dummy			-0.056***
			(0.010)
Constant	0.623***	1.063***	0.735***
	(0.006)	(0.027)	(0.053)
Observations	65,296	64,999	64,999
R-squared	0.083	0.165	0.033
Indiv. fixed effects	No	No	Yes
Year fixed effects	No	No	Yes

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

Figure A1: Distribution of the predicted values of FLFP

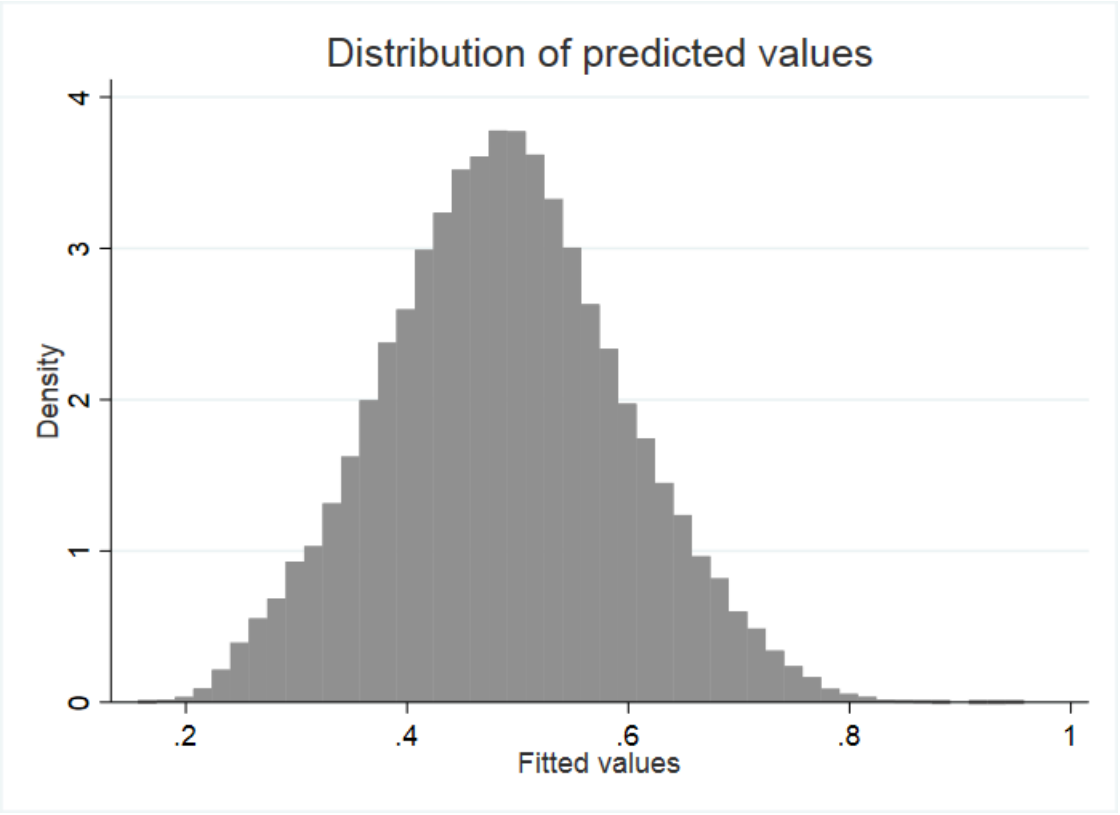

Table A2: Regression results appliance index

	(1) OLS No covariates	(2) OLS Covariates	(3) Fixed effects	(4) 2SLS	(5) 2SLS with fixed effects	(6) 2SLS with fixed effects
Assets (absolute	-0.091***	-0.019***	0.004	-0.044***	0.072***	0.073***
index)	(0.002)	(0.003)	(0.003)	(0.011)	(0.023)	(0.023)
Age		0.001***	-0.003**	0.002***	-0.002**	-0.004***
		(0.000)	(0.001)	(0.000)	(0.001)	(0.001)
Education		-0.007***	0.002	-0.005***	0.001	0.001
		(0.001)	(0.002)	(0.001)	(0.002)	(0.002)
Urban		-0.296***	-0.002	-0.284***	-0.020	-0.021
		(0.009)	(0.035)	(0.011)	(0.035)	(0.034)
Income (log)		-0.049***	-0.019***	-0.039***	-0.032***	-0.033***
		(0.003)	(0.003)	(0.005)	(0.005)	(0.005)
Children		0.020***	0.029***	0.019***	0.030***	-0.013*
		(0.002)	(0.002)	(0.002)	(0.002)	(0.007)
Electricity		0.032***	-0.004	0.042***	-0.003	-0.004
		(0.009)	(0.011)	(0.009)	(0.011)	(0.011)
Spouse's education		-0.003***	-0.001	-0.002***	-0.002*	-0.002*
		(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Age * children						0.001***
						(0.000)
Survey dummy			-0.049***		-0.068***	-0.063***
			(0.009)		(0.011)	(0.012)
Constant	0.616***	1.080***	0.767***	0.961***	0.811***	0.895***
	(0.006)	(0.027)	(0.052)	(0.055)	(0.054)	(0.055)
Observations	67,872	67,558	67,558	67,300	67,300	67,300
R-squared	0.075	0.166	0.032	0.163	0.015	0.016
Indiv. fixed effects	No	No	Yes	No	Yes	Yes
Year fixed effects	No	No	Yes	No	Yes	Yes

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

B Robustness checks

Table B1: Unmarried women

	(1) OLS No covariates	(2) OLS Covariates	(3) Fixed effects	(4) 2SLS	(5) 2SLS with fixed effects
Assets (absolute index)	-0.072***	-0.013***	0.007	0.003	0.069***
	(0.004)	(0.004)	(0.007)	(0.012)	(0.020)
Age		0.004***	-0.001	0.003***	-0.001
		(0.000)	(0.002)	(0.000)	(0.002)
Education		-0.004***	0.019***	-0.006***	0.017***
		(0.001)	(0.003)	(0.002)	(0.003)
Urban		-0.128***	-0.040	-0.137***	-0.046
		(0.013)	(0.047)	(0.015)	(0.048)
Income (log)		-0.060***	-0.015**	-0.066***	-0.027***
		(0.004)	(0.007)	(0.006)	(0.008)
Children		-0.006**	-0.008*	-0.006**	-0.007
		(0.003)	(0.005)	(0.003)	(0.005)
Electricity		-0.024	-0.031	-0.032**	-0.026
		(0.015)	(0.023)	(0.016)	(0.023)
Survey dummy			-0.020		-0.033
			(0.021)		(0.021)
Constant	0.497***	1.020***	0.501***	1.096***	0.543***
	(0.009)	(0.050)	(0.106)	(0.072)	(0.108)
Observations	12,234	11,875	11,875	11,875	11,875
R-squared	0.051	0.112	0.013	0.111	0.091
Indiv. fixed effects	No	No	Yes	No	Yes
Year fixed effects	No	No	Yes	No	Yes

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

Table B2: Additional controls

	(1) OLS Covariates	(2) Fixed effects	(3) 2SLS	(4) 2SLS with fixed effects
Assets (absolute index)	-0.035***	0.004	-0.133***	0.351***
	(0.006)	(0.007)	(0.044)	(0.099)
Assets squared	0.003***	-0.000	0.023***	-0.066***
	(0.001)	(0.001)	(0.009)	(0.019)
Age	0.041***	0.044***	0.042***	0.043***
	(0.001)	(0.002)	(0.001)	(0.002)
Age squared	-0.001***	-0.001***	-0.001***	-0.001***
	(0.000)	(0.000)	(0.000)	(0.000)
Education	-0.027***	-0.009***	-0.023***	-0.010***
	(0.002)	(0.003)	(0.003)	(0.003)
Education squared	0.002***	0.001***	0.001***	0.001***
	(0.000)	(0.000)	(0.000)	(0.000)
Urban	-0.286***	-0.000	-0.275***	0.010
	(0.009)	(0.035)	(0.011)	(0.033)
Income (log)	-0.102***	-0.016	-0.073***	-0.088***
	(0.021)	(0.024)	(0.024)	(0.034)
Income squared (log)	0.003**	-0.000	0.002	0.003*
	(0.001)	(0.001)	(0.001)	(0.001)
Children	0.006***	0.007***	0.005***	0.009***
	(0.002)	(0.002)	(0.002)	(0.003)
Electricity	0.032***	-0.007	0.060***	-0.033**
	(0.008)	(0.011)	(0.014)	(0.014)
Spouse's education	-0.004***	-0.001	-0.003***	-0.002*
	(0.001)	(0.001)	(0.001)	(0.001)
Muslim	-0.157***	-0.057	-0.150***	-0.055
	(0.010)	(0.048)	(0.011)	(0.054)
Survey dummy		-0.089***		-0.108***
		(0.010)		(0.011)
Constant	0.716***	-0.113	0.512***	0.205
	(0.113)	(0.134)	(0.144)	(0.175)
Observations	67,558	67,558	67,300	67,300
R-squared	0.198	0.052	0.191	0.025
Indiv. fixed effects	No	Yes	No	Yes
Year fixed effects	No	Yes	No	Yes

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

Table B3: Unbalanced panel

	(1) OLS No covariates	(2) OLS Covariates	(3) Fixed effects	(4) 2SLS	(5) 2SLS with fixed effects
Assets (absolute	-0.091***	-0.018***	0.004	-0.026***	0.109***
index)	(0.002)	(0.003)	(0.003)	(0.010)	(0.022)
Age		0.001***	-0.003**	0.001***	-0.002**
		(0.000)	(0.001)	(0.000)	(0.001)
Education		-0.007***	0.002	-0.007***	0.000
		(0.001)	(0.002)	(0.001)	(0.002)
Urban		-0.302***	-0.002	-0.298***	-0.029
		(0.009)	(0.035)	(0.010)	(0.034)
Income (log)		-0.044***	-0.019***	-0.041***	-0.038***
		(0.002)	(0.003)	(0.004)	(0.005)
Children		0.019***	0.029***	0.019***	0.030***
		(0.001)	(0.002)	(0.001)	(0.002)
Electricity		0.026***	-0.004	0.029***	-0.001
		(0.008)	(0.011)	(0.008)	(0.011)
Spouse's education		-0.003***	-0.001	-0.003***	-0.002**
		(0.001)	(0.001)	(0.001)	(0.001)
Survey dummy			-0.049***		-0.076***
			(0.009)		(0.011)
Constant	0.598***	1.042***	0.748***	1.006***	0.820***
	(0.006)	(0.025)	(0.052)	(0.048)	(0.055)
Observations	84,042	83,592	83,592	83,591	83,591
R-squared	0.074	0.168	0.032	0.168	0.049
Indiv. fixed effects	No	No	Yes	No	Yes
Year fixed effects	No	No	Yes	No	Yes

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

Table B4: Income quintiles

Assets (absolute index	(1) OLS No covariates	(2) OLS Covariates	(3) Fixed effects	(4) 2SLS	(5) 2SLS with fixed effects	Observations
1st quintile	-0.106***	-0.041***	-0.003	-0.117***	0.271*	13,239
	(0.006)	(0.006)	(0.021)	(0.021)	(0.159)	
2nd quintile	-0.094***	-0.015***	0.033*	-0.076***	0.100	13,500
	(0.005)	(0.006)	(0.018)	(0.021)	(0.127)	
3rd quintile	-0.089***	-0.015***	0.002	-0.046***	-0.034	13,491
	(0.004)	(0.005)	(0.014)	(0.017)	(0.075)	
4th quintile	-0.086***	-0.019***	-0.020	-0.027**	-0.017	13,550
	(0.004)	(0.004)	(0.013)	(0.014)	(0.067)	
5th quintile	-0.065***	-0.022***	0.003	-0.014	0.008	13,520
	(0.004)	(0.004)	(0.011)	(0.013)	(0.066)	
Indiv. fixed effects	No	No	Yes	No	Yes	
Year fixed effects	No	No	Yes	No	Yes	

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

Table B5: Urban vs rural

	(1) OLS No cov.	(2) OLS Covariates	(3) Fixed effects	(4) 2SLS	(5) 2SLS with fixed effects	(6) OLS No cov.	(7) OLS Covariates	(8) Fixed effects	(9) 2SLS	(10) 2SLS with fixed effects
	Urban					Rural				
Assets (absolute	-0.038***	-0.016***	0.007*	-0.040***	0.046	-0.063***	-0.023***	-0.004	-0.044***	0.047
index)	(0.003)	(0.003)	(0.004)	(0.012)	(0.030)	(0.004)	(0.004)	(0.005)	(0.016)	(0.030)
Age		0.002***	-0.001	0.003***	-0.001		0.000	-0.003**	0.001**	-0.003**
		(0.000)	(0.002)	(0.000)	(0.002)		(0.000)	(0.001)	(0.000)	(0.001)
Education		0.001	0.002	0.003**	0.002		-0.013***	0.002	-0.012***	0.002
		(0.001)	(0.002)	(0.001)	(0.002)		(0.001)	(0.002)	(0.002)	(0.002)
Income (log)		-0.041***	-0.027***	-0.029***	-0.036***		-0.051***	-0.015***	-0.043***	-0.023***
		(0.004)	(0.005)	(0.007)	(0.009)		(0.003)	(0.004)	(0.006)	(0.006)
Children		0.017***	0.034***	0.017***	0.034***		0.021***	0.025***	0.020***	0.026***
		(0.002)	(0.004)	(0.002)	(0.004)		(0.002)	(0.003)	(0.002)	(0.003)
Electricity		-0.051***	-0.003	-0.036*	-0.009		0.054***	0.013	0.062***	0.013
		(0.020)	(0.026)	(0.020)	(0.026)		(0.009)	(0.012)	(0.011)	(0.012)
Spouse's education		-0.007***	-0.005***	-0.006***	-0.005***		-0.002**	-0.000	-0.001	-0.001
		(0.001)	(0.002)	(0.001)	(0.002)		(0.001)	(0.002)	(0.001)	(0.002)
Survey dummy			0.027**		0.017			-0.086***		-0.100***
			(0.014)		(0.016)			(0.012)		(0.015)
Constant	0.311***	0.700***	0.498***	0.557***	0.531***	0.668***	1.127***	0.864***	1.034***	0.894***
	(0.010)	(0.045)	(0.087)	(0.074)	(0.093)	(0.007)	(0.034)	(0.060)	(0.070)	(0.063)
Observations	20,937	20,784	20,784	20,722	20,722	46,935	46,774	46,774	46,578	46,578
R-squared	0.020	0.040	0.012	0.035	0.003	0.027	0.055	0.051	0.054	0.05
Indiv. fixed effects	No	No	Yes	No	Yes	No	No	Yes	No	Yes
Year fixed effects	No	No	Yes	No	Yes	No	No	Yes	No	Yes

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

Table B6: Alternative measures FLFP

	(1) Work farm	(2) Working days job 1	(3) Work hrs/year job 1	(4) Working days total	(5) Work hrs/year total
			2SLS		
Assets (absolute index)	-0.018	-5.130	77.872	-6.731**	-69.185***
	(0.018)	(13.778)	(130.203)	(2.938)	(19.643)
Age	-0.001	0.537	1.502	-0.378***	-3.395***
	(0.001)	(0.511)	(4.479)	(0.090)	(0.596)
Education	-0.002	1.233	8.650	0.311	6.884***
	(0.001)	(1.179)	(10.427)	(0.353)	(2.371)
Urban	-0.018	1.840	38.946	-38.807***	-187.309***
	(0.020)	(14.485)	(104.828)	(3.014)	(19.660)
Income (log)	0.004	11.288***	81.948***	-2.554*	-11.881
	(0.004)	(2.087)	(17.874)	(1.517)	(10.282)
Children	0.009***	1.287	15.521*	1.541***	3.533
	(0.002)	(1.003)	(8.437)	(0.522)	(3.554)
Electricity	0.041***	-8.225**	-52.446*	19.828***	162.638***
	(0.010)	(3.426)	(29.699)	(3.269)	(22.034)
Spouse's education	0.002*	-0.232	-0.911	-0.960***	-8.337***
	(0.001)	(0.710)	(6.254)	(0.225)	(1.525)
Survey dummy	0.010	-14.740***	-174.881***		
	(0.010)	(5.373)	(48.733)		
Constant	0.210***	31.214	261.597	142.889***	866.701***
	(0.047)	(24.415)	(206.430)	(17.753)	(119.411)
Observations	67,300	16,320	16,307	33,663	33,663
R-squared	0.002	0.017	0.017	0.051	0.040
Indiv. fixed effects	Yes	Yes	Yes	No	No
Year fixed effects	Yes	Yes	Yes	No	No

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