CHAPTER 1

COMMUNICATION BETWEEN PARTIAL MIGRATED HOUSEHOLD AND LEFT BEHIND WOMEN'S LABOR MARKET PARTICIPATION

INTRODUCTION

The economic growth of China and many other developing countries has created a large gap between household income and available infrastructures in rural and urban areas. As a result, rural men migrate to urban areas to earn higher incomes rather than participate in the agriculture sector. This has created a large, partially migrated, rural household population characterized by wives left behind to care for their children and in-laws. The left-behind population has been growing since the start of China's urbanization. In 2015, it was estimated that there were approximately 17.17 million left-behind women in rural China. Although the population of rural women is significant, they are not considered the target population when establishing rural development policies because rural women are less responsive to government support and policy. This lack of responsiveness is due to traditional gender roles in rural China, discouraging women from participating in the labor market or starting businesses. Rural development policy often ignores the left-behind women as a target population of a national development project (Wang and Tang, 2020). I argue that because rural women refrain from working and have been left behind by their husbands, it is essential to consider the communication between separated couples to better understand why rural women are less responsive to rural development

policies.

This paper aims to understand the relationship between rural development policy, gender role preferences, and women's labor market participation (LMP) decisions. My specific interest is the impact of communication between left-behind women and migrant husbands. I want to understand if better communication between left-behind women and migrant husbands would encourage the wives to choose outcomes more aligned with their husbands' preferences. Information Community Technology (ICT)[1]infrastructure expansion has been considered a project that enhances rural economic growth and job creation. Previous literature has investigated the impact of the migration of husbands on left-behind women's LMP. However, there is little research on the effects of the separated couple's communication and its influence on left-behind wives. I utilize the installation of infrastructure as an impact that alters the communication frequency between separated couples; greater frequency of communication might influence left-behind women's choice set, especially in LMP.

I argue that previous literature found mixed results in left-behind women's LMP because they did not consider separated couples' communication and monitoring aspects. The physical distance between separated husbands and wives creates asymmetric information and shifts the bargaining power of left-behind women. Migrant husbands send remittances which create an income effect for left-behind women. Considering the expansion of ICT in rural areas, physical distance matters less in terms of communication and monitoring. Separated couples can communicate with each other via ICT facilities and technologies. As a result, ICT infrastructure creates a channel that influences the direction and magnitude of left-behind women's LMP. Increased frequency of communication and monitoring influence left-behind women's LMP to be better aligned with husbands'

[1]ICT includes communication technologies such as the internet, cell phone, computer, and any other form of media application that access, retrieve, store, transmit, and manipulate information in a digital form. (Food and Agriculture Organization, Food and Agriculture Organization)

preferences.

To empirically test this hypothesis, I focus on separated couples in which the husbands and wives have different preferences regarding the wives' LMP. If improved communication influences left-behind women to change their preferences, the impact will be most significant among couples whose preferences are misaligned. I use the difference-in-difference approach with multiple treatment periods by subsamples to match preferences between separated couples. The paper's main finding is that increased communication between separated couples with conservative husbands and progressive wives results in a decrease in LMP of 50% by the left-behind women.

LITERATURE REVIEW

Husband Migration Influence on Left-behind Women's Labor Market Participation

Several studies have investigated the effect of husbands' migration on the LMP of their wives who have remained behind. Research has produced mixed results. There is no agreement on whether the migration of husbands has a positive or negative effect (or any effect) on left-behind women's LMP. The findings range from a decreased effect, null effect, and an increase in left-behind women's LMP. I review the existing literature and identify the gap I will attempt to close in this study. I suggest migrant husband's monitoring is a factor that drives the mixed results of previous research. Isolating the impact of communication will clearly show the husband's influence on left-behind women's LMP.

Husband Migration Decreases Left-behind Women's LMP

As stated above, some literature finds that husbands' migration has harmed the LMP of the wives who stayed behind. These studies argue that the income effect of

remittances drives this negative effect. Some studies use the Instrument Variable (IV) method to correct the endogeneity problem of husbands' migration. Instruments used for each paper account for information on migration density and the history or drivers of migration, such as exchange rate or wage gap between rural and urban regions. The husband's migration creates an inflow of cash via remittances and the rural household experiences the absence of the husband's labor. Left-behind women substitute the absence of the husband's labor by reducing their wage-paying jobs and participating in nonwage labor such as household farm work or housework. As a result, the income effect from the husband's migration decreases left-behind women's LMP (Yang, 2008; Binzel and Assaad, 2011; Mendola and Carletto, 2012; Bacud et al., 2021; Khanna et al., 2022).

Unlike studies which focus on the income effect, Chen (2006) proposed a theoretical model that explains how partially migrated households face imperfect monitoring, which leads to noncooperative behavior of the left-behind wives, which affects the time and resource allocation of rural households. This study supports the theory using data in the context of China. The physical distance between husbands and wives creates an imperfect monitoring situation. Left-behind wives choose to act noncooperatively for goods that are difficult to monitor. The wife's time use is difficult to monitor compared to purchasing durable goods. Wives decrease their income-generating activities and increase time spent on leisure, while children spend more time on housework. Imperfect monitoring from the husband increases the wives' decision-making power on their time use.

Left-behind women's decision of LMP is not only related to monetary compensation but also to decision-making power. The husband's migration changes the wife's decision-making power. One may think that hypothetically, the physical distance between the migrant husband and the left-behind wife will increase the wife's decision-making power regarding her time use and LMP. However, several studies have found that husbands' migration does not always increase wives' decision-making power. Indeed, the literature

finds that in rural areas where extended family structures are common, in-laws take over the decision-making power while the husband is absent. Under this context, left-behind women's LMP decisions will depend on the in-laws' decision (Ahmed, 2020; Gartaula et al., 2012).

Husband Migration has Null-effect on Left-behind Women's LMP

Studies that found a null effect of husband's migration on left-behind wives' labor supply find that countervailing factors offset any income effect. Two factors strengthen the income effect. The first is the household labor shortage due to the husband's migration, which increases the shadow wage of housework, which, in turn, increases the opportunity cost of the left-behind wife's LMP. As a result, left-behind wives will decrease their labor supply. The second factor is constrained employment opportunities outside of the household, which reduces the chance of employment. Compared to urban areas, the demand for labor in rural areas is limited. There are two countervailing effects of income effects. The first is labor supply increasing factors such as lack of remittances from the migrant, whose income effect is minimized. The second factor is the high cost of migration, which creates an initial debt to a partially migrated household. Left-behind women are likely to increase their labor supply to offset the debt. Thus, the income and countervailing effects offset each other, resulting in no change in left-behind women's LMP (Kan and Aytimur, 2019).

Time-use studies have also found null effects. Xu (2017) investigate the impact of migration of household members on left-behind members' time use. The study uses the data context of China with the IV method to encounter endogenous factors of migration of family members. An instrument for the model is the wage gap of coastal cities, the common destination of migrant household members. The study finds an income effect that reduces working hours for left-behind members and, in contrast, a countervailing

effect that increases working hours for left-behind members. These opposite effects offset each other, resulting in no significant change in labor supply.

Some literature also finds a null effect on the decision-making power of left-behind women, after the migration of husbands. It finds that due to concern over maintaining cultural and social position, left-behind women follow conservative gender roles which often migrant husbands prefer, and avoid breaking norms even with their husbands' absence. As a result, there is no major change in women's decision-making power (de Haas and van Rooij, 2010).

Husband Migration Increases Left-behind Women's LMP

Some literature finds that migration of husbands increases LMP of left-behind women. Literature provides theoretical background on why women will not decrease LMP with factors that creates an income effect. According to the noncooperative household bargaining model, working outside the household increases women's bargaining power, producing gains other than income. This led to increased LMP of left-behind women (Heath and Tan, 2020). An empirical paper by Mu and van de Walle (2011) found that left-behind women do more paid farm work in rural China than their left-behind men counterparts.

Regarding decision-making power, the literature finds that the absence of a husband enables left-behind women to take responsibility for decisions within the household such as managing finance, and remittance. Left-behind women also increased mobility with the absence of their husbands (Datta and Mishra, 2011). According to Zhang (2020), in rural China, the migration of husbands creates better bargaining power for left-behind women, especially on income from food production. Left-behind women independently make decisions on labor supply for food production.

Cell Tower Expansion in Rural China

My argument of the importance of communication between separated couples is supported by literature investigating how much migrants value the opportunity to communicate with family members who are left behind. Field experiments test how much migrant husbands are willing to pay or how much they value communication with family members left behind. Migrants want to maintain control over household decisions, especially regarding financial activities. Separated couples also choose to exploit asymmetric information to their advantage. They share only observable information and conceal unobservable information. As a result, partially migrated households' LMP and purchase of goods follow a noncooperative equilibrium (Ashraf et al., 2015; Castilla and Walker, 2013). When information is shared between separated couples, wives choose a set of outputs that their husbands prefer. However, husbands do not show the same behavior pattern, instead choosing the better output for them (Ambler, 2015; Ashraf, 2009). Chen (2022) find that in rural China, left-behind members frequently communicate with migrant members to determine childrearing decisions and the LMP of wives. Therefore, left-behind women's LMP decision-making relates to social norms, culture, relationships, and communication with migrant husbands.

ICT infrastructure includes cell towers, broadband, telephone lines, and other communication infrastructure. ICT infrastructure has expanded rapidly in rural China in the past ten years, increasing the frequency and quality of communication between separated couples.

ICT infrastructure expansion has several applications in rural economies, such as income diversification and SME startups. ICT positively impacts the off-farm income of rural households. The literature has used association models such as the linear model, endogenous switching model, probit and logit model, and propensity score matching, to

investigate the relationship between the expansion of ICT on the off-farm income of rural households. Studies use ownership of cell phones and access to the internet as a proxy for the expansion of ICT. They find that low-income farmer has the largest positive treatment effect from ICT infrastructure on off-farm income. Access to cell phone and the internet have increases the nonagriculture income of rural households (Leng et al., 2020; Min et al., 2020; Rajkhowa and Qaim, 2022; Khanal and Mishra, 2016). Access to ICT tools also created an additional income stream for rural households. Cell ownership and internet use positively impact starting SMEs for rural households (Barnett et al., 2019).

Increased Communication between Separated Couples and Left-behind Women's Choice of Labor Market Outcome

The paper's contribution is that it investigates the causal relationship between the increased communication between separated couples due to cell tower expansion and the LMP decisions of left-behind women. The causal method used for the paper is an improved difference-in-difference method correcting for multiple treatment periods developed by Callaway and Sant'Anna (2021).

This chapter has reviewed literature on the effect of husband migration and of ICT expansion on rural populations separately. However, to my knowledge, no previous studies have focused on the communication and monitoring aspect of partially migrated households using ICT as an exogenous variation.

The hypothesis is that increased communication between migrant husbands and left-behind wives as a result of ICT expansion influences the decisions of left-behind women's about their LMP so that they are closer to what the husbands' preferences. If the husband has a conservative gender role perspective and the wife has a progressive gender role, an increase in communication will likely make left-behind women hesitate to participate in the labor market. I argue that this heterogeneity of matching couples' preferences explains the mixed findings in previous studies.

DATA AND SUMMARY STATISTICS

Chinese Family Panel Survey (CFPS)

The CFPS provides information on the relationship between cell tower installation and left-behind women's LMP. CFPS draws the sample from 25 provinces, cities, and autonomous regions, which accounts for 95% of the population. The community questionnaire contains questions on infrastructure, population, and local economic conditions. CFPS provides panel information on the year of installation of the cell tower in each community, which determines which units are treated and when they are treated. CFPS covers the years between 2010 and 2018. I match community-level information with household and individual-level observations to determine the output of treated and controlled groups. CFPS's community unit is smaller than the district level. The output of interest is LMP which is binary employment status measured at the women's level.

The sample of interest is rural women in China with migrated husbands. I refer to this population as "left-behind women/wives." The CFPS provides information on cell ownership and expenditure, indicators to verify the change in communication frequency between separated couples. Mechanism section establishes the association between cell tower installation and cell ownership and usage. If the installation of cell towers had a meaningful effect on the communication between separated couples, the result will be positive and significant, suggesting that the husband's monitoring power increased. This is the main channel connecting the installation of the cell tower and the left-behind women's LMP. CFPS also provides information that is highly correlated with husbands' migration and left-behind women's LMP. It includes remittances received from migrated family members, in addition to household expenditures, community area size, labor composition

of the community, casual labor wage of the community, number of households, price of produce, GDP, and fiscal revenue of the local government.

Data on Gender Role Preference

A major contribution of this paper is its investigation of the gender role preference differences between the husbands and wives of separated couples. The hypothesis is that establishing a cell tower will increase the frequency of communication between left-behind women and migrated husbands, which will, in turn, put pressure on left-behind women to shift their positions to be closer to their husbands' preferences. As a result, the treatment effect of communication (cell towers) will be strongest for couples with misaligned preferences. The CFPS survey includes several questions that provide information regarding wives' and husbands' LMP preferences.

The questionnaire that used to assess gender role preferences is "men should focus on their careers, while women should focus on the family." Respondents indicate the degree to which they agrees with the statement on a scale of 1–5; the higher the number the greater the agreement with conventional gender roles. These questions are answered individually so I observe both the wife's and husband's preferences. In several cases, I only observe the wives' or husbands' preferences. When this occurs, these answers are not used in the subsample analysis. I observe the preferences of the remaining couples whose husbands migrated during the survey period of 2010–2018, for whom I can observe preferences before migrating.

Figure 1 shows the share of gender role preference matching for separated couples. I define preference-matched couples as those with the left-behind wife and migrated husband having the same gender role preferences. This includes both conservative and progressive preference-matched couples. These couples represent the majority of the sample, which

consists of 60%. The preference-misaligned couples represent the rest of the sample. The group that I assume will show the most elastic response to an increase in communication are couples comprising progressive wives and conservative husbands. They consist of 14% of the sample. The remaining 26% of the sample are couples with conservative wives and progressive husbands.

Summary Statistics

Table 1, Table 2 , and Table 3 provide summary statistic tables. Table 1 presents baseline summary statistics of left-behind women's employment. All information is before the cell towers were installed. Compared to rural women who are cohabiting with their husbands, left-behind wives are slightly more likely to be employed, by 0.02 percentage points. Supplementary Table A3, shows that when comparing partially migrated household wives and non-migrant household wives, left-behind women participate more in non-agricultural employment than their counterparts. The table also provides a baseline mean by left-behind wives' gender role preferences. Couples comprising conservative wives and progressive husbands show the highest probability of employment, while wives with matching preferences have the lowest probability of employment. Table 2 presents cell ownership and cell expenditure baseline mean, which are proxies for communication between separated couples. Cell ownership is measured as a binary variable assigned one if one owns a cell phone, and zero otherwise. The conditional mean of cell ownership is similar regardless of the cohabitation status of husbands at 74%. The conditional mean of cell phone expenditure is also similar between rural women with cohabiting husbands and with migrant husbands, which is about 45 yuan (6.53 US dollars) per month. Table 3 presents a summary of statistics of control variables, with two different unit levels. Individual-level controls include remittances received from migrant family members and a set of expenditures. Community-level controls include remittances and expenditures as well as community size, the existence of polluting factories nearby, the water source

of the community, whether or not the community is located in an ethnic minority area, the labor composition of the community, wage, population, food price, net income GDP, fiscal revenue of the local government, and road infrastructure.

Sample Selection and Attrition

The sample of interest is rural women with migrant husbands. To utilize cell tower installation to represent a change in communication, I only use left-behind women who are located in communities where cell towers were or were not installed between 2010 and 2018. For further analysis, separated couples that responded regarding gender role preference are considered. There is attrition on the gender role preference variable and cell tower information. This section aims to verify if the attrition is random.

Figure 2 depicts the sample selection process. The diagram is read from top to bottom with each row representing the sample selection stage. The blue box represents samples that are kept for the next stage. Red boxes are dropped samples that do not proceed to the next stage. The green box represents the attrition sample. They will be tested for balance and linear probability models predicting the probability of attrition. At the bottom of the diagram are left-behind women who gain cell service during the survey period (2010–2018) or were never treated. For the subset analysis, a total of 6,900 samples are further divided into those with and without gender role preference variables.

Attrition of Cell Tower Information

The CFPS is collected at three levels: individual, household, and community. Information regarding cell tower installation is available in the community module. The community questionnaire is answered by community leaders or staff members of neighborhood committees who have access to administrative information and statistical data about the community. There is no attrition at the community level. However, attrition

of cell tower information occurs due to missing information and errors in the community identification at the individual level. The CFPS is the only available data source that provides community-level cell tower information and tracks more than two waves in China. The China Household Finance Survey (CHFS) and China Health and Nutrition Survey (CHNS) cover similar time periods, although they provide no information on community cell towers. Information on cell ownership and usage is available for CHFS or CHNS. However, these indicators are endogenous to individual and household characteristics. Therefore, CHFS or CHNS cannot be used for the causal relationship between communication and the labor market outcome of rural women. After merging the cell tower information with the individual-level units, the full sample is 297,571; approximately 1.3% of the sample is either missing or has an error in the community identification.

Table 4, shows a linear probability model using binary indicator variables for attrition of cell tower information. The control variables are aggregated individual information at the community level. If I use control variables collected at the community level, there is no variation between units with and without attrition. Therefore, I aggregated the individual-level characteristics of units within the same community. Out of 11 control variables, 6 significantly predict the probability of attrition. However, among 6 variables which show significance, 4 variables; remittances and expenditures on education, basic needs, and transportation make a negligible contribution to the attrition prediction. In contrast, employment and cell ownership significantly predict the probability of attrition.

Attrition of Gender Role Preference Variable

The individual and household response rates are higher for rural communities than urban communities. For rural communities, the response rate is 89.16% while in urban communities it is 69.35% (CFPS, 2018). The missing responses are due to a refusal to be interviewed, an incomplete survey due to other reasons, and not being eligible (not

passing the screening question). Attrition is a problem of panel surveys if there is a potential bias such that attrition is not random and is associated with potential outcomes (Hausman and Wise, 1979; Wooldridge, 2002). I thoroughly reviewed survey documents to determine the reason for the attrition. I also conducted a balance test on the main output of interest on attrition clustered at the community level and ran a probability model on attrition by control variables. The results indicate no bias in attrition, which is likely to have occurred randomly.

This study uses separated couples that answered the gender role preference question. The gender role preference questionnaire is part of the individual module, which is answered by adult family members. To answer the research question on the impact of the increase in communication between separated couples, it is necessary to observe both sides' gender role preferences, focusing on preference-misaligned couples. Therefore, one reason for the attrition is only observing the wife's gender role preference since the husband had already migrated before the survey period started in 2010. Additionally, gender role preferences were not asked in every survey wave, creating attrition for households which entered the later wave.

I ran a simple balance test to check the correlation between the main outcome, employment, and variable preference attrition. I conducted the balance test in community clusters allowing observation of left-behind women within same cluster to be correlated. To avoid the multiple testing problem, I standardized the test result using the z-score and normal distribution (Sarstedt and Mooi, 2014). Multiple testing problems occur when multiple statistical inferences are conducted simultaneously. That is, as the number of hypothesis tests increases, the two groups being compared are increasingly likely to differ. For example, if 60 tests are conducted at the 10% level, the expected number of incorrect rejects (type 1 error) of the null hypothesis is 6 out of 60.

According to Table 5,the concern about attrition bias is less prevalent. Out of 60 communities that installed cell towers between 2010 and 2018 or were never treated during this period, only 6 cases are rejected at the 10% level. The result shows that between units that are dropped due to missing and available gender preference variables, there is no significant difference in employment levels. The result supports that interpretation that the attrition due to the missing gender role preference variable occurred randomly.

I also conducted a probability model to show that individual- and community-level traits did not determine the probability of a unit being dropped from the main sample. Table 6 is a linear probability regression model using a binary variable of attrition as a dependent variable and a set of control variables for spending patterns, labor market conditions, local economy conditions, and the wealth of the community. The regression result shows significance on 4 out of 13 control variables. The F-value is also 12.51, which is less than 20. The model F-value is less than the benchmark of 20 in determining variables jointly explaining the dependent variable. Therefore, I conclude that the control variables do not jointly explain the probability of attrition. In other words, attrition on the preference variable does not create attrition bias.

METHODOLOGY

Difference in Difference with Multiple Treatment Timing

I conduct several subsample analyses to specify the mechanism between cell tower installation and LMP. I run the model for left-behind women whose preferences are different than those of their husbands. They can align (both conservative or progressive) or have a preference misalignment. The results of the preference-misalignment group enable me to find the impact of increased communication between separated couples that may lead to a shift in left-behind women's labor participation similar to what migrant

husbands prefer. If I successfully isolated the impact of communication from other influencing factors that cell towers have on rural communities, the preference-alignment group result will show a null effect.

Controlling remittances is important since remittances constitute a significant income source for the partially migrated household. Remittances alleviate rural SMEs' capital constraints and enable them to invest more. Additionally, remittances decrease the probability of seeking paid employment while increasing self-employment activities of the left-behind family members (Woodruff and Zenteno, 2007; Vadean et al., 2019). Models controlled for remittance and community-level factors to find a clear causal relationship. This enables isolating the communication between separated couples.

The problem with two-way fixed effects is that treated and untreated units are compared when there are multiple treatment periods. In other words, it uses negative weights in calculating aggregate ATT. As a result, ATT for two-way fixed effects is biased. The method by Callaway and Sant'Anna (2021) fixes this problem by correcting the weights and specifying the groups that the timing of the treatment should compare. This study uses difference-in-difference with multiple treatment model for the main analysis.

$$ATT(g,t) = E[Y_t(g) - Y_t(0)|G_g = 1] \tag{1.1}$$

g: specific group

t: particular time period

The notation presented above is a generalized version of the canonical difference in differences set up. It is generalized to fit multiple treatment groups and treatment timing. This is called *group-time average treatment effect*. It can provide aggregate causal parameters. I focus on the average effect of participating in the treatment across all groups that participated in the treatment by the time period t. I am interested in the aggregate ATT of left-behind women in rural China using the multiple treatment timing of cell installation.

THEORY MODEL

The goal of the theory section is to theoretically show how an increased husband's monitoring power decreases the equilibrium level of left behind wife's labor market participation. I assume an exogenous factor such as cell tower establishment which is positively related to the husband's monitoring power. The theory model shows that with an increase in the monitoring power of the migrated husband, the left-behind wife's working hours convert to the husband's preference.

Husbands' Prefer Their Wives to Stay Home

Left-behind wife's labor hours is x, which range $0 \leq x \leq 24$. The wife's wage rate is w. Let's assume a migrant husband's preferred labor hours by his wife is $X = 0$. The probability that a husband detects that his wife is working more than his desired working hour is composed of the strength of monitoring technology (T) and desired working hours gap between the separated couple ($x - X$).

$$p = \frac{1}{2}T(x - X)^2 = \frac{1}{2}Tx^2 \tag{1.2}$$

A wife has dis-utility (c) from paid labor. Higher the parameter, states that the wife does not prefer working regardless of her husband's influence.

$$\frac{1}{2}cx^2 \tag{1.3}$$

We assume that remittance (R) is only transferred from migrant husband to left-behind wife when the wife is not detected that she is exceeding the husband's preferred

labor hours. Therefore, the wife's total income is as follows,

$$\begin{cases} R + wx & \text{if wife is not caught by husband working } x > X \\ wx & \text{if wife is caught by husband} \end{cases} \tag{1.4}$$

The wife's utility is expected income minus dis-utility from working.

$$U_w(x) = E(income) - v(dis - utility) = wx + (1 - p(x))R - \frac{1}{2}cx^2 \tag{1.5}$$

The wife's best response will be to maximize her utility function.

$$\frac{\partial U_w}{\partial x} = w - (TR + c)x = 0x^* = \frac{w}{TR + c} \tag{1.6}$$

Equilibrium labor hour is positively related to wage earned by working(w), and negatively related to monitoring technology (T), remittance (R), and wife's dis-utility from working (c).

Wife's working hour equilibrium (x^*) is negatively related with monitoring technology and dis-utility .

$$\frac{\partial x^*}{\partial T} = -1 \cdot w(TR + c)^{-2} \cdot R = -\frac{Rw}{(TR + c)^2} < 0 \tag{1.7}$$

$$\frac{\partial x^*}{\partial c} = -1 \cdot w(TR + c)^{-2} \cdot 1 = -\frac{w}{(TR + c)^2} < 0 \tag{1.8}$$

Husbands' Preferred Working Hour is Positive

We can expand this model by allowing a husband to prefer the positive working

hours of their wife. The utility function of left-behind wives is as following,

$$U_w(x) = x + (1 - \frac{1}{2}T(x - X)^2)R - \frac{1}{2}cx^2 \tag{1.9}$$

The working hour equilibrium of left behind women is

$$\frac{\partial U_w}{\partial x} = w + TRX - (TR + c)x = 0 \tag{1.10}$$

$$x^* = \frac{w + TRX}{TR + c} \tag{1.11}$$

If the husband's preference for women's working hours increases, then the wife's equilibrium working hour increases. Increase in the dis-utility of women, decrease women's working hours.

$$\frac{\partial x^*}{\partial X} = \frac{TR}{TR + c} > 0 \tag{1.12}$$

$$\frac{\partial x^*}{\partial c} = -\frac{w + TRX}{(TR + c)^2} < 0 \tag{1.13}$$

Following is equation showing the relationship between monitoring technology (T) and left-behind women's equilibrium working hour (x^*).

$$\frac{\partial x^*}{\partial T} = -\frac{R(w - Xc)}{(TR + c)^2} \tag{1.14}$$

if $w - xc > 0$, $w > xc$ then the relationship is negative. An increase in monitoring technology will decrease women's equilibrium working hours only when $\frac{w}{c} > x$ satisfies.

Left-Behind Women's Equilibrium Working Hour

We can re-write the left-behind wife's equilibrium working hour as a weighted av-

erage between the wife's preference and the husband's preference.

When there is no remittance from the migrant husband ($R = 0$), it shows left-behind women's independent decision on working hours.

$$x^*|_{R=0} = \frac{w}{c} \tag{1.15}$$

Therefore, regardless of the husband's remittance wife will decide their working hour via the ratio between hourly wage and hourly dis-utility of working.

I can re-write the equilibrium working hours by the weighted average between $x^*|_{R=0}$ and X.

$$x^* = \frac{w + TRX}{TR + c} = [\frac{c}{TR + c}] \cdot \frac{w}{c} + [\frac{TR}{TR + c}] \cdot X = [\frac{c}{TR + c}] \cdot x^*|_{R=0} + [\frac{TR}{TR + c}] \cdot X \tag{1.16}$$

$$= \underbrace{[\frac{c}{TR + c}] \cdot x^*|_{R=0}}_{\text{wife's preference of LMP without husband's pref}} + \underbrace{[\frac{TR}{TR + c}] \cdot X}_{\text{husband's wife's LMP pref}} \tag{1.17}$$

Increase of monitoring power has different implications on each weight.

$$\frac{\partial x^*}{\partial T} = [-\frac{Rc}{(RT + c)^2}] \cdot \frac{w}{c} + [\frac{Rc}{(RT + c)^2}] \cdot X \tag{1.18}$$

As monitoring power(T) increases, the weight on the husband's preference(X) goes up. In other words, improvement in its monitoring technology increases the influence of the husband's preference on women's working hours.

I can represent the relationship between $x^*_{R=0}$, x^*, and X in graphical form by change in monitoring power (T). According to Figure 3, the bottom panel is showing the case when a left-behind wife prefers working while a migrant husband does not. With an increase in monitoring power, the equilibrium labor hour for the wife gets closer to the husband's preference. The top panel shows the opposite case.

RESULT

Figure 4 is a flow chart showing the mechanism and the channel that connects the treatment and output of interest. The empirical model analysis follows the presented mechanism. First, I investigate the mechanism which is the treatment impact of cell tower installation in rural areas on cell ownership and expenditure. These two variables are proxies of frequency and strength of communication between separated couples. If cell tower installation had a meaningful impact on separated couples' communication, it would increase the probability of cell phone ownership of left-behind wives and increase their cell service expenditure. The association models found that installing cell towers increases communication between separated couples, increasing migrant husbands' power to monitor left-behind wives.

The main results show how increased monitoring power influences left-behind women's labor supply. I focus on separated couples with misaligned gender role preferences. I find that, among left-behind wives with progressive gender role preferences and migrant husbands with conservative gender role preferences, an increase in monitoring power shifts the left-behind women's decision to align with the preferences of their migrant husbands. This means that left-behind women who prefer to have a job are influenced by their conservative migrant husbands, and decide not to participate in the labor market.

Mechanism: Did Cell Towers Increased Communication between Separated Couples?

This chapter's goal is to identify the effect of cell tower installation on the ownership and use of cell phones. This is to determine if installing cell towers significantly impacts communication between separated couples. The relationship between the communication of partially migrated households and the labor supply of left-behind women makes sense only when there is a meaningful change in their communication due to cell tower instal-

lation. If left-behind women obtained cell phones due to the installation of a cell tower or increase the cell service expenditure, we would expect the communication frequency between separated couples to increase.

According to Table 7,the installation of cell towers during the survey periods, biannual surveys from 2010 through 2018, increased the probability of ownership of a cell phone among left-behind women. I used three different types of probability models: the linear probability model, logit, and probit model. Model (1) is a linear probability model showing an increase in the probability of ownership by 18.5% when the cell tower is installed. Model (2) is a logit model showing the marginal effect of a 19% increase in cell ownership. Model (3) is a probit model showing the marginal effect of an 18.4% increase in cell ownership. The estimated effect size is about a 24% increase from the baseline mean, which is the cell ownership level before the cell tower installation. It could be pointed out that impact is not large enough to influence left-behind women's labor market decisions or that the mean baseline, which is about 74%, is already high.

To refute the concern, I ran an association model on the relationship between the installation of a cell tower and expenditure on cell phone service on Table 8. I find suggestive evidence that cell service expenditure also increased. The association model captures the change in the use of cell phones with the installation of a cell tower. Table 8 shows that installing a cell tower increased the expenditure on cell service for the rural left-behind women by 8.9 yuan with time fixed effects. The magnitude of the increase is about 20.2% of the mean dependent variable. The increased cell service expenditure is a proxy for frequency in the use of cell phones. Therefore, I can conclude that the installation of a cell tower increased the use of cell phones for left-behind women. Both models on cell ownership and cell expenditure show a consistently positive result. The result ensures

that cell tower installation not only increases the probability of ownership of cell phone for left-behind women but also increase the usage of cell phone for left-behind women.

The summary statistics in Table 2, show the baseline mean of cell ownership is 74%. Some may be puzzled that the rural population would own cell phones without a cell signal available in the community. Since 2003, China has been engaged in a national-level project to expand its ICT infrastructure on an extensive scale (Zhang, 2019). Therefore, communities that established their first cell towers between 2010 and 2018 are among the most rural areas in China. China has good coverage, even in most rural areas. Because of this infrastructure situation, rural residents can travel to a nearby town that has a phone signal to use a cell phone. This is why cell ownership is high among rural left-behind women. Once the cell tower is established near the community, left-behind women have easier access to communication with their husbands who have migrated.

To verify factors other than monitoring power, such as remittances, I also checked major factors that can directly impact the output of interest rather than through treatment. Based on the literature investigating the relationship between remittances that left-behind family members receive and their LMP, I included remittances as a major control variable for the main models. Table A1 is the result of the association model, remittances on left-behind women's employment. Remittances are a major income source for left-behind women, creating an income effect and decreasing rural women's LMP. It also works as a negotiation tool for migrant husbands to pressure left-behind women to choose outcomes that their husbands prefer. According to Table A1, remittances have a significant direct impact on left-behind women's LMP controlling for year and community fixed effect. By controlling remittances for the main models, I isolated the impact of communication on left-behind women's LMP.

Main Result: Did Increased Monitoring of Husband Change Labor Market Participation of Left Behind Women?

After checking the mechanism, which shows a clear connection between cell tower installation and an increase in communication between the separated couple, the main chapter checks the impact of cell tower installation on left-behind women's LMP decisions. If an increase in communication between migrated husbands and left-behind wives increases pressure on wives to choose what the migrant husband prefers, the outcome will be close to what their migrant husbands prefer. Conservative migrant husbands with progressive wives will prefer less LMP of their wives, and progressive migrant husbands with conservative wives will prefer more LMP of their wives.

Cell Tower Establishment Impact on Labor Market Participation: Difference in Difference with Multiple Treatment

Notably, the treatment period of cell tower installation varies across communities. I am aware of negative weights and incorrect comparison groups created by the canonical TWFE model in case of multiple treatment timing. The estimation result is biased if the TWFE method is used for multiple treatment period analysis. The bias occurs by comparing untreated units with already treated units. Recent innovations by Callaway and Sant'Anna (2021); Goodman-Bacon (2021) correct for these biases by using bootstrapping, inverse probability weights, and matching. They also handle parallel trends by allowing conditional parallel trends using control variables. The parallel trend assumption[2] holds after conditioning on covariates. This assumption is essential in cases where covariates show specific trend outcomes over time and differences in the distribution of

[2]Assumption 4 (Conditional Parallel Trends Based on a "Never-Treated" Groups)
Let $\delta \geq 0$ for each $g \in G$ and $t \in \{2, ..., \tau\}$ such that $t \geq g - \delta$

$$E[Y_t(0) - Y_{t-1}(0)|X, G_g = 1] = E[Y_t(0) - Y_{t-1}(0)|X, C = 1]$$

covariates across groups. Left-behind women's employment is correlated with covariates at the individual and community levels without cell installation. Therefore, the conditional parallel trend is more plausible for my model.

For this chapter, I use a difference-in-difference approach with multiple treatment timing methods to use the correct weight and comparison group to calculate the aggregate average treatment in treated units (ATT). Callaway and Sant'Anna (2021) suggested a method to fix the bias of TWFE when there are multiple treatment periods. The difference in difference with multiple treatment timing is suitable for my research questions since the cell tower was not established in one year.

Table 9 presents a causal model that explores the relationship between cell tower installation and the employment status of left-behind women by gender preferences relative to their migrated husbands. While Table 9 explores the extensive margin, the intensive margin which is a working hour shows no effect due to the small sample size (Table A2). The daily time use portion of the survey contained several missing observations. The second row represents the pretrend test on a conditional parallel trend. If the null hypothesis cannot be rejected, the pretrend is parallel. In other words, considering community traits, treated units (left-behind wives who will have access to a cell tower), and control units (left-behind wives who never have access to a cell tower), the pretreatment trend of employment is parallel. Therefore, the estimation results which cannot reject null hypothesis, are interpreted as a causal relationship. The third row shows the p-value of the conditional pretrend test. All models except model (1) and model (2) control for potential direct channels that influence labor supply, which are remittances. Also, it controls for a set of community-specific characteristics, including local economic conditions such as the cost of durable goods, food, and necessity expenditure; community area size;

agricultural labor as a percentage of the total labor force; percent of the migrated workers out of the total labor force; casual labor wage; the existence of a polluting factory nearby; water source type; whether the community is in an ethnic minority area; and road access.

Model (1) is on total left-behind women without considering community control variables. The result shows a null effect. The conditional pretrend test cannot reject the null hypothesis, which tests that all pretreatment equals zero. Therefore, I interpret the result as a causal result. The result follows literature that found countervailing effects of the income effect. The null impact on left-behind women's labor market is also related to the sample size by preference match on separated couples. According to Figure 1, the total number of left-behind women who have matching preferences is about 60% (2,221 observations) of the total sample. In theory, these couples should show a null effect in increasing communication via cell towers as they have matching preferences. Left-behind wives with conservative gender role preferences and progressive migrant husbands represent about 26% (952 observations) of the sample of couples. Left-behind wives with progressive gender preferences and conservative migrant husbands represent about 14% (505 observations) of the sample of couples. The null effect results show preference-aligned couples hide the impact of communication between separated couples with misaligned gender role preferences.

Since about half of the sample out of the 6,900 observations are missing gender role preference information, I grouped the sample with and without availability of preference variables and compared these two groups to ensure they do not show different impacts. Model (2) is the left-behind women sample with preference variables available. The estimation result shows a null effect and, without considering covariates, it does not pass the parallel trend test. Therefore, to verify the difference between attrition of the gender preference group and the total left-behind women group, I need to consider the model with covariates, which is Model (4), and Model (3). Both models passed the conditional

parallel trend test and show a null impact. Model (3) is left-behind women regardless of availability of preference variables and model (4) is left-behind women with preference variables available. Regardless of the availability of gender role preference variables, the impact of cell towers on left-behind wives' LMP shows a null impact.

Model (5) comprises couples of progressive wives and conservative husbands. The estimated result is negative and significant at 1%. Installing a cell tower decreased left-behind women's labor participation by 50%. The conditional pretrend test cannot reject the null hypothesis which tests that all pretreatment is equal to zero. Therefore, I can interpret the result as a causal result. The installation of cell towers increases the communication between progressive wives and conservative husbands, which leads to a shift in left-behind wives' LMP outcomes to be similar to what migrant husbands prefer. Wives with progressive gender roles who prefer to work outside of the household decide to reduce their labor supply due to increased communication with their conservative migrant husbands.

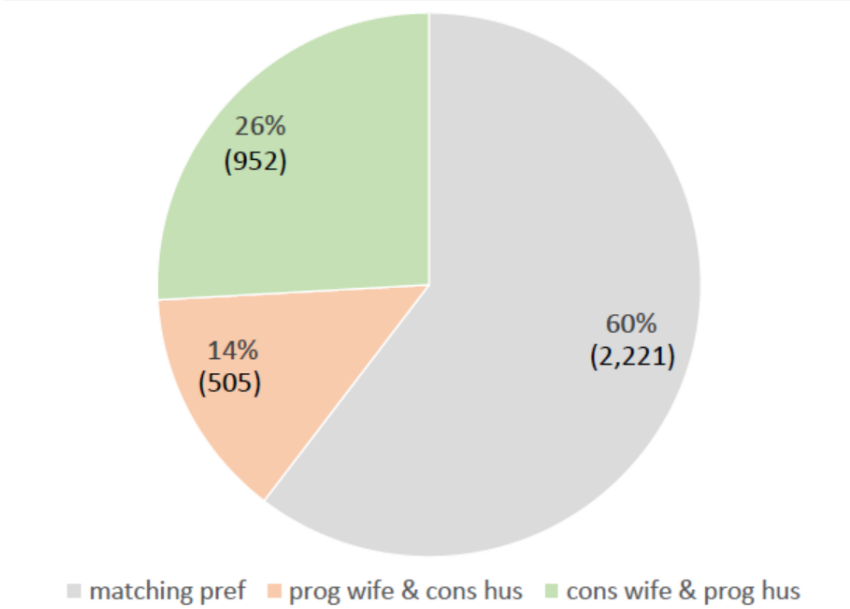
Couples with a matching preference on the model (6) do not show significant estimation results after correcting for multiple treatment timing. If the empirical model successfully isolated the impact of communication on left-behind women's LMP, then preference-matched couples would not shift their decision on labor supply. Therefore, the insignificant result on model (6) supports that the suggested empirical model is successful in isolating the communication element. For model (7), the sample of conservative wives and progressive husbands cannot be interpreted as a causal result because they do not satisfy the pretreatment parallel trend test.

CONCLUSION

The large income gap between urban and rural areas in China has created an incentive for rural married men to migrate to urban areas for higher income and leave their

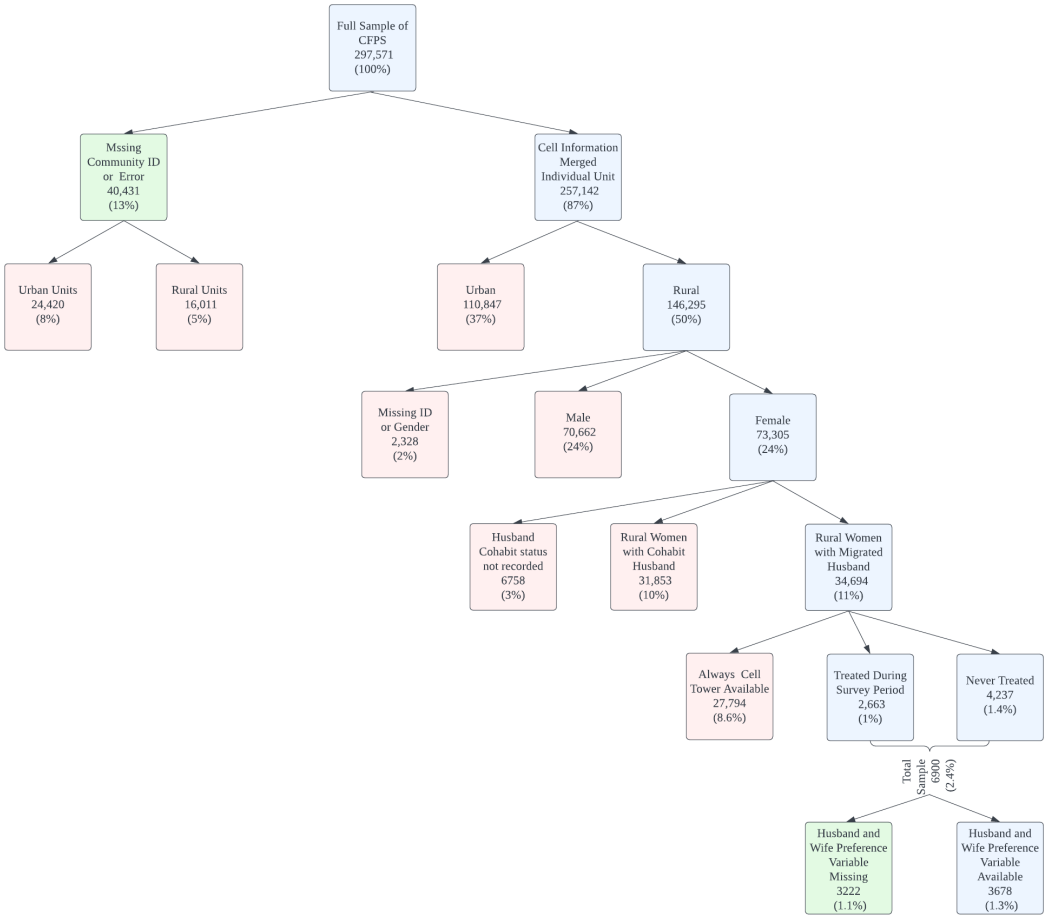
wives behind. The literature shows mixed results on the impact of husband's migration on left-behind women's LMP. To fill this gap in the literature, this paper focuses on communication between separated couples and its impact on the LMP of left-behind wives. The research uses cell tower installation as an impact that changes communication between separated couples. It contributes to the literature by investigating partially migrated households' communication and the decision-making power of the left-behind women. The study utilizes a difference-in-difference approach with multiple treatment periods to take into consideration the multiple treatment periods of cell tower installation. By using CFPS data and the gender role preference variables that measure how much women's LMP is preferred, the study results show that an increase in communication between separated couples decreases LMP left-behind women. This impact holds for migrated husbands with conservative gender role preferences and left-behind wives with progressive gender role preferences. However, for preference-matched couples, there is no change in LMP for left-behind women. The result implies that increased monitoring by migrated husbands with conservative gender role preferences shifted the progressive gender role preferences of left-behind women's about LMP to more closely align with their husbands' priorities. Therefore, policymakers should consider the family structure and their preference toward LMP in development policy on rural women, especially on LMP. Without considering these factors, development policies that intend to bring left-behind women into the labor market will be ineffective. For further analysis, household finance and saving management for a partially migrated household is worth investigating. It will contribute to partially migrated household finance behaviors.

Figure 1. Share of different types of gender role preferences of separated couples.[2]



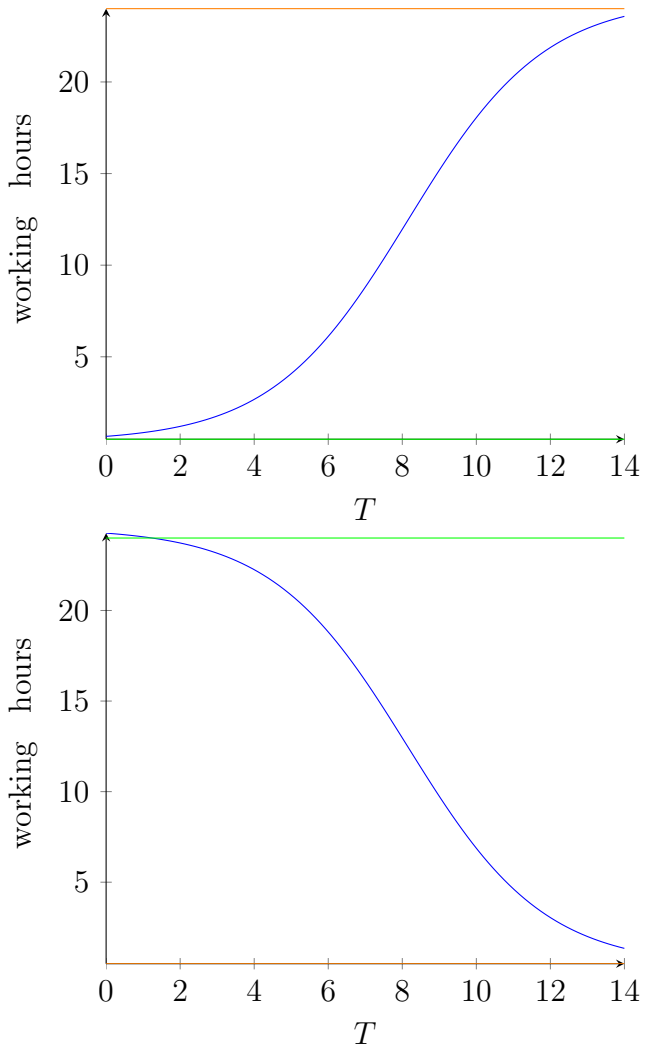
[2] Questionnaire asked both sides (husbands and wives) 'how much do you agree with the following statement: "Husband should work outside while wife should stay home and take care of family."' '5' indicates strongly agree with the statement while '1' indicates strongly disagree. The most frequent pattern is that both husband and wife has a conservative perspective on gender role. If a couple is considered as a progressive wife and a conservative husband, the wife's gender role preference questionnaire value is lower than the husband's value. The values in the parenthesis represent the sample size. *Source:CFPS*

Figure 2. Sample Selection Process[3]



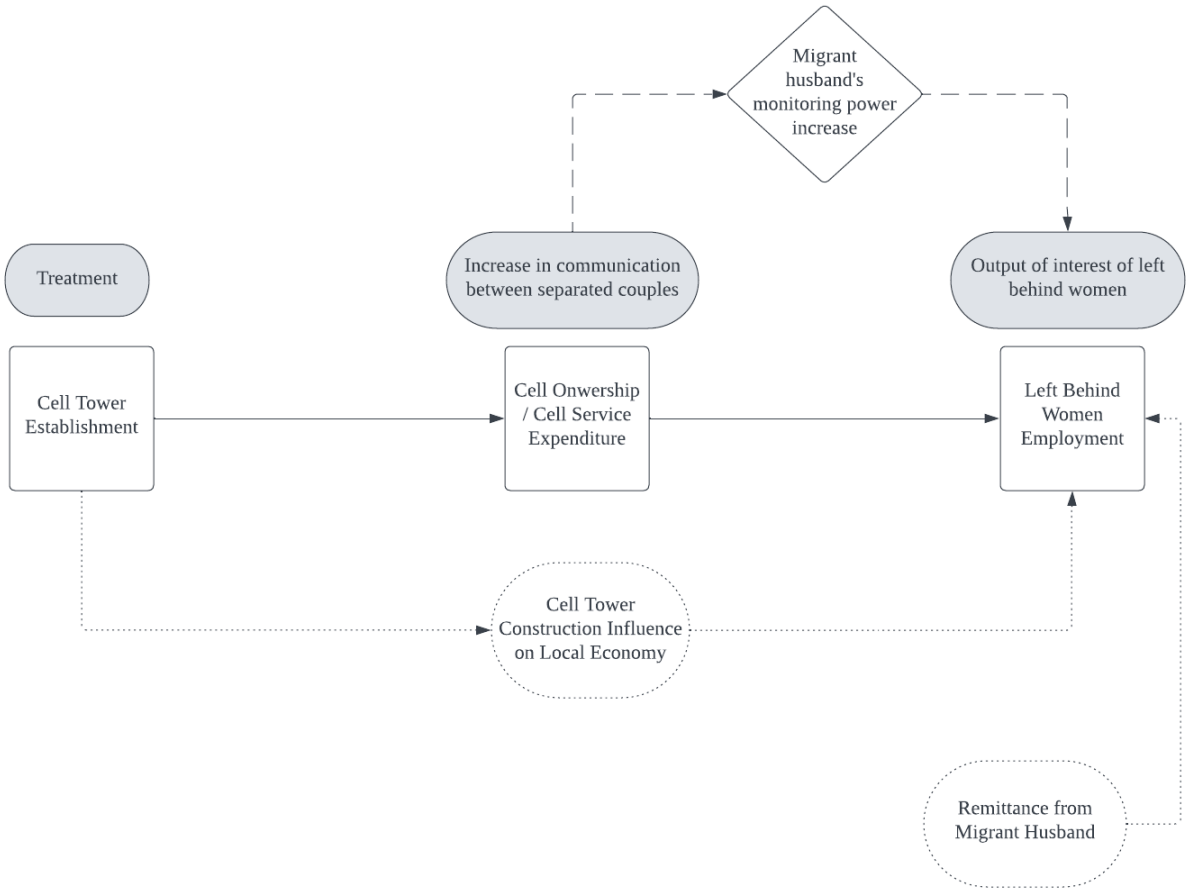
[3] Top of the diagram represents the full CFPS individual level sample. Information on cell tower establishment is available at the community level, therefore, I first drop individuals who were not able to match with community-level information due to missing or error in community ID. Next, I cut the units that are located in urban areas. And keep only rural women who have husbands. Therefore, per household, I observe one person who is left behind women. Among these left-behind women, located in communities that always had cell towers are not my sample of interest. Lastly, the final sample includes both left-behind women with preference variables available and unavailable. *Source:CFPS*

Figure 3. Representation of Wife's Independent Working Hour Preference, Husband's Preference, and Wife's Equilibrium Working Hours [1]



[1] y-axis represents the working hours of left behind women while the x-axis represents the monitoring power of migrant husbands. The top panel is the case where what husband's preferred working hours(orange line) are larger than left-behind women's preferred working hours(green line). The bottom panel is the case where what husband's preferred working hours(orange line) are smaller than left-behind women's preferred working hours(green line). Both cases show as the monitoring power of migrant husbands increases (value of T increases) actual working hours of left-behind women merge with the husband's preferred working hours.

Figure 4. Mechansim Diagram[4]



[4] The diagram represents the mechanism of this study. The treatment is cell tower establishment in rural China. This will increase communication between separated couples, wives in rural areas, and husbands who migrated out. The increase in communication between separated couples will increase the husband's monitoring power over wives. The increased monitoring of husbands changes the labor market participation of left behind women.
There are other factors other than communication between separated couples that influence left behind's labor market participation. The first main factor is remittance from migrant husbands. The second factor is the cell tower establishment's impact on the local economy such as creating jobs and bringing workers to the community. A set of community-level control variables is a proxy for local economic conditions. Both factors are controlled on the main causal model to isolate the impact of communication on labor market participation.

Table 1. Baseline Mean of Employment[5]

employment	mean	sd	min	max	count
husband migrate& before cell tower	0.68	0.466	0	1	3,764
husband cohabit& before cell tower	0.66	0.474	0	1	2,689
husband migrate& before cell tower& progressive match	0.75	0.432	0	1	263
husband migrate& before cell tower& conservative match	0.70	0.458	0	1	1,118
husband migrate& before cell tower& gender pref match	0.71	0.454	0	1	1,381
husband migrate& before cell tower& progressive wife	0.754	0.431	0	1	309
husband migrate& before cell tower& conservative wife	0.781	0.414	0	1	543

[5] The table includes summary statistics of the main output variable (left behind women's employment). It is showing baseline summary statistics of employment of different subset samples. All information is collected before the establishment of cell towers. The top two rows compare rural women with migrant husbands and cohabit husbands. The bottom three rows are comparing among left-behind women with different gender role preferences.

Table 2. Baseline Mean of Cell Ownership and Expenditure[6]

cell ownership	mean	sd	min	max	count
husband migrate& before cell tower	0.748	0.434	0	1	3,179
husband cohabit& before cell tower	0.743	0.437	0	1	2,011
cell expenditure	mean	sd	min	max	count
husband migrate& before cell tower	44.24	34.94	0	450	2,327
husband cohabit& before cell tower	45.61	41.77	0	450	1,477

[6] The table includes the main mechanism variable (mobile phone ownership and expenditure). It is showing baseline summary statistics of cell ownership and expenditure of different subset samples. All information is collected before the establishment of cell towers. The top two rows are on cell ownership comparing rural women with migrant husbands and cohabit husbands. The bottom two rows are cell expenditure in yuan comparing rural women with migrant husbands and cohabit husbands.

Table 3. Summary Statistics[7]

unit in individual level					
	mean	sd	min	max	count
remittance (yuan)	13076.07	19265.27	0	300000	2943
durable expenditure (yuan)	68.42329	319.6489	0	12666.67	5370
food expenditure (yuan)	431.7177	527.7996	0	6000	6841
necessity expenditure (yuan)	71.80088	113.3482	0	3000	6845
family support expenditure (yuan)	275.7123	1796.377	0	66666.66	6889
medical expenditure (yuan)	353.9736	935.7598	0	16666.67	6787
clothing expenditure (yuan)	139.3453	192.1489	0	2500	6766
commercial insurance expenditure (yuan)	497.6656	2775.496	0	100000	6850
transportation expenditure (yuan)	24.30566	180.2285	0	5012.5	6862
unit in community level					
remittance (yuan)	12408.83	5593.326	0	33461.54	6869
durable expenditure (yuan)	69.19959	65.38848	0	617.9487	6900
food expenditure (yuan)	446.7851	200.2854	131.125	1957.109	6900
necessity expenditure (yuan)	74.24599	33.40712	21.31061	250.1692	6900
community area size (km^2)	7.002588	9.00601	.001347	38	4384
polluting factory nearby	0.1172522	0.3217565	0	1	4469
water source	2.682479	1.048557	1	6	4469
ethnic minority area	0.2224211	0.415919	0	1	4469
pct agriculture labor (%)	56.23534	21.86161	15	100	4262
pct labor migration (%)	33.82058	20.48612	1	100	4353
casual labor wage (yuan)	61.60373	28.58995	30	200	4290
number of households	435.7991	335.0166	67	2000	4469
highest price of egg (yuan)	6.200856	5.700144	2.8	38	4438
lowest price of egg (yuan)	4.090172	1.645605	2.1	8	4355
net income GDP (yuan)	2229.34	1624.526	300	8600	4048
fiscal revenue (yuan)	369.7495	1374.104	0	7000	3953
access to road within community	0.4895652	0.4999273	0	1	6900
Max N					6900

[7] The table includes control variables included in the model estimation. The control variables are at an individual level and community level. Among control variables, 'Water source' is a categorical variable ('1' River/Lake water '2' Well/Spring water '3' Tap water '4' Mineral/Purified/Filtered water '5' Rainwater '6' Cellar water '7' Pond water)

Table 4. Predictors of Cell Tower Information Attrition[8]

	(1) attrition of cell tower information
remittance (1,000 yuan)	-0.000917**
	(0.000359)
employment (%)	-0.161***
	(0.0444)
total edu expenditure (1,000 yuan)	-0.0131***
	(0.00415)
cell ownership (%)	0.354**
	(0.142)
cell service expenditure (1,000 yuan)	-1.312
	(0.921)
food expenditure (1,000 yuan)	-0.0291
	(0.0593)
necessity expenditure (1,000 yuan)	0.778*
	(0.449)
family support expenditure (1,000 yuan)	-0.0231
	(0.0239)
medical expenditure (1,000 yuan)	-0.00900
	(0.0275)
clothing expenditure (1,000 yuan)	0.0157
	(0.149)
commercial expenditure (1,000 yuan)	-0.0118
	(0.00750)
transportation expenditure (1,000 yuan)	-0.0699**
	(0.0324)
constant	-0.0631
	(0.114)
F-value	4.23
Unit	community level
N	155572

Standard errors in parentheses
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

[8] The dependent variable is a binary variable that indicates attrition of the cell tower information which is at the community level. The error term is clustered at the province level. All of the control variables are aggregated at the community level. Units are displayed in parentheses. *Source:CFPS*

Table 5. Balance Test on Gender Role Preference Attrition[9]

Community ID	Obs(group 0 & 1)	Mean Diff	s.e.	p-value
1	86	0.314	0.223	0.1597
2	94	0.115	0.218	0.5975
3	102	0.019	0.2	0.9255
4	125	0.191	0.181	0.2910
5	96	0.124	0.206	0.5456
6	95	0.182	0.21	0.3877
7	78	0.106	0.236	0.6542
8	94	-0.044	0.207	0.8308
9	79	-0.025	0.235	0.9146
10	69	0.187	0.244	0.4431
11	85	-0.152	0.218	0.4851
12	68	0.365	0.245	0.1364
13	76	-0.106	0.242	0.6606
14	162	0.332	0.157	0.0350**
15	101	-0.005	0.333	0.9868
16	84	-0.105	0.337	0.7544
17	66	-0.058	0.359	0.8705
18	73	0.152	0.272	0.5769
19	97	0.197	0.256	0.4412
20	81	0.353	0.25	0.1578
21	122	0.053	0.182	0.7719
22	95	-0.036	0.213	0.8667
23	85	0.051	0.251	0.8406
24	113	0.331	0.19	0.0819*
25	99	0.369	0.217	0.0890*
26	118	0.132	0.209	0.5280
27	31	0.357	0.43	0.4057
28	105	0.33	0.196	0.0925*
29	86	0.188	0.218	0.3892
30	57	0.489	0.325	0.1324
31	77	0.179	0.229	0.4349
32	79	-0.049	0.226	0.8280
33	117	0.202	0.202	0.3177
34	110	0.112	0.192	0.5594
35	75	0.09	0.261	0.7277
36	103	-0.133	0.198	0.5027
37	93	0.439	0.217	0.0426**
38	135	0.266	0.173	0.1233
39	90	0.155	0.212	0.4650
40	155	-0.041	0.161	0.7986
41	109	0.24	0.2	0.2350
42	78	0.182	0.243	0.4535
43	103	0.077	0.205	0.7078
44	114	0.162	0.201	0.4203
45	143	0.385	0.217	0.0761*
46	46	-0.163	0.295	0.5811
47	19	0.5	0.476	0.2931
48	52	0.436	0.283	0.1227
49	23	0.211	0.55	0.7019
50	81	-0.076	0.223	0.7328
51	54	0.08	0.338	0.8121
52	14	0.25	0.592	0.6726
53	67	0.284	0.428	0.5066
54	31	0.425	0.359	0.2370
55	62	0.376	0.275	0.1726
56	13	0.818	0.769	0.2872
57	47	0.092	0.293	0.7549
58	22	0.133	0.428	0.7555
59	23	0.317	0.619	0.6090
60	42	0.486	0.309	0.1154
Total observation	6155			

[9] Z-test is conducted for two groups which are gender preference variable is available (group 0) and not available (group 1) on employment. The z-test is conducted by clustering at the community level. The table presents the combined number of observations between groups 0 & 1 and the mean difference and p-value of the estimation. The total observation is 6155, 745 observation is missing out of 6900. These units are missing since they are missing employment information. These units reported that they are involved in business rather than employed. *Source: Author calculation from CFPS*

Table 6. Predictors of Gender Role Preference Attrition[10]

	(1) attrition of gender preference variable
remittance (1,000 yuan)	-0.00131
	(0.00443)
durable expenditure (1,000 yuan)	0.596**
	(0.232)
food expenditure (1,000 yuan)	0.0360
	(0.216)
necessity expenditure (1,000 yuan)	-1.515**
	(0.706)
community area size (km^2)	0.00336
	(0.00221)
pct agriculture labor (%)	0.000776
	(0.000681)
pct labor migration (%)	-0.000977
	(0.000921)
casual labor wage (1,000 yuan)	0.585
	(0.532)
num of household	-0.000191
	(0.000116)
the highest price of egg (1,000 yuan)	-0.611
	(1.437)
the lowest price of egg (1,000 yuan)	29.56**
	(13.52)
net income GDP (1,000 yuan)	-0.0218
	(0.0162)
fiscal revenue (1,000 yuan)	0.0144*
	(0.00768)
constant	0.489***
	(0.100)
F-value	12.51
Unit	community and individual level
N	3716

Standard errors in parentheses
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

[10] The dependent variable is a binary variable that indicates attrition of the gender preference variable which is at the individual level. The error term is clustered at the community level. Among the control variables, remittance, durable, food, and necessity expenditure are individual level. The rest of the control variables are community level. *Source: CFPS*

Table 7. Mechanism: Cell Ownership Increase[11]

	(1) cell ownership	(2) cell ownership	(3) cell ownership
probability model	linear	logit	probit
access to cell tower	0.185**	1.182*	0.666**
	(0.0695)	(0.463)	(0.256)
marginal effect		0.19**	0.184***
constant	0.782***	1.542***	0.893***
	(0.0637)	(0.422)	(0.235)
time fixed effect	Yes	Yes	Yes
community fixed effect	Yes	Yes	Yes
N	4887	4863	4863

Standard errors in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

[11] The binary dependent variable represents ownership of a cell phone by left behind women. The first row of the table represents the probability model used for each column. For the logit and probit models, the marginal effect result is provided. Out of 6900 samples of interest, there are about 2013 units missing information on cell ownership.

Table 8. Mechanism: Cell Expenditure Increase[12]

	(1) cell expenditure	(2) cell expenditure	(3) cell expenditure	(4) cell expenditure
access to cell tower	8.765***	8.925***	2.672	3.969
	(1.307)	(1.305)	(7.166)	(7.147)
constant	44.24***	31.66***	47.50***	33.14***
	(0.795)	(4.038)	(5.351)	(6.629)
time fixed effect	No	Yes	No	Yes
community fixed effect	No	No	Yes	Yes
N	3690	3690	3690	3690

Standard errors in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

[12] The dependent variable is a continuous variable, which represents cell expenditure. The unit is in yuan. The baseline mean is 45 yuan.

Table 9. Main Results: CSDID[13]

	(1) wife's employment	(2) wife's employment	(3) wife's employment
agg ATT of cell tower	-0.014	0.004	-0.092
	(0.045)	(0.065)	(0.102)
conditional parallel trend test	fail to reject null	reject null 5%	fail to reject null
p-value	0.1106	0.0349	0.5287
sample	migrant husband	gender role pref available	migrant husband
community fixed effect	No	No	Yes
N	6155	3609	3785

Standard errors in parentheses
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$
Conditional Pretrend Test: H0 All Pre-treatment are equal to 0

	(4) wife's employment	(5) wife's employment	(6) wife's employment	(7) wife's employment
agg ATT of cell tower	0.258	-0.50***	-0.109	-1.14***
	(0.159)	(0.172)	(0.179)	(0.218)
conditional parallel trend test	fail to reject null	fail to reject null	fail to reject null	reject null 1%
p-value	0.1334	0.4710	0.5128	0.0038
sample	gender role pref available	progressive wife	pref match	conservative wife
community fixed effect	Yes	Yes	Yes	Yes
N	2117	325	1230	562

Standard errors in parentheses
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$
Conditional Pretrend Test: H0 All Pre-treatment are equal to 0

[13] Aggregated ATT coefficient with rejected conditional parallel trend test cannot interpret as a causal effect. Therefore, Model (2) and Model (7) ATT estimation results are biased.

APPENDIX A

SUPPLEMENTARY MATERIAL FOR CHAPTER 1

Table A1. Remittance and Left behind Wife's Employment[a]

	(1) wife's employment	(2) wife's employment	(3) wife's employment	(4) wife's employment
remittance (1,000 yuan)	-0.000933***	-0.00105***	-0.000512*	-0.000578**
	(0.000201)	(0.000199)	(0.000222)	(0.000219)
constant	0.727***	0.565***	0.761***	0.603***
	(0.00506)	(0.0146)	(0.0650)	(0.0659)
time fixed effect	No	Yes	No	Yes
community fixed effect	No	No	Yes	Yes
N	13003	13003	13003	13003

Standard errors in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

[a] The sample of this model is rural women with migrant husbands regardless of treatment status. The unit of remittance is 1,000 yuan.

Table A2. Left Behind Wife's Working Hour: CSDID[b]

	(1) wife's hour of work	(2) wife's hour of work	(3) wife's hour of work
agg ATT of cell tower	-6.311	-2.285	-1.046
	(5.302)	(1.600)	(2.614)
conditional parallel trend test	fail to reject null	fail to reject the null	reject null 1%
p-value	0.3826	0.1152	0.0052
sample	progressive wife	pref match	conservative wife
community fixed effect	Yes	Yes	Yes
N	115	389	144

Standard errors in parentheses
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$
Conditional Pretrend Test: H0 All Pre-treatment are equal to 0

[b] Hour of work is defined as weekday daily time used for work. Those who are unemployed at the time of the survey are entered and 0 hours of work.

Table A3. Type of Work Left-Behind Women Participates [c]

type of work	mean	sd	min	max	count
ag-employment & partially migrated household wife	0.710	0.454	0	1	24,764
ag-employment & non-migrant household wife	0.732	0.443	0	1	20,186
non-ag employment & partially migrated household wife	0.243	0.429	0	1	23,813
non-ag employment & non-migrant household wife	0.208	0.406	0	1	18,612

[c] Non-agricultural employment indicates that the wife is currently engaged in paid non-agricultural work. Agricultural employment indicates that the wife is currently primarily engaged in agricultural work.

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