Joan Koo

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EDUCATION

Ph.D. in Economics, American University, DC, USA 2026
M.A. in Applied Economics, American University, DC, USA 2021
M.S. in Development Economics and Policy, The University of Manchester, UK 2016
B.S. in Economics, Ewha University, ROK 2015

PUBLICATIONS

PEER-REVIEWED Koo, H. and Oh, J., "Crisis and Poverty: With Reference to Latin America," *International Area Studies Review*, 22/3, March 2019. [Link]

MASTER THESIS "Poverty and Crisis, the Relationship and Analysis"
(Supervisors: Pf. Yin-Fan Zhang, Pf. Osman Ouattara, and Pf. Katsushi Imai, The University of Manchester)

POLICY BRIEF "Review of Russia's Status as a Market Economy Country"
(with Leah Wils-Ownes, Economist at ITA)

IN PROGRESS **Papers:**
"Work Experience and Attitudes Toward Gender Role"
"Communication between Partially Migrated Households and Left-behind Women's Labor Market Participation"
"Infrastructure and Women's Occupational Sorting"

WORK EXPERIENCES

U.S. International Development Finance Corporation, International Economist
Dec, 2023 - current (full-time)

- Conducted industry analysis on DFC supporting development projects. Which includes a review of USITC investigations, Trade Adjustment Assistance, and employment trend data.
- Write Python code to aggregate data on Private Capital Mobilization for each DFC supporting project and report to OECD.
- Plan and manage overseas site visits and monitoring trips for development projects. Which includes inter-agency communication including the State Department and the U.S. Embassy. Engage with local community leaders and workers on the development impact of DFC supported projects.
- Brief via oral communication and written memo on findings to senior management and stakeholders. Especially on data transparency and managing business confidential data.
- Serve as steering committee for DFC's critical infrastructure evaluation projects. Including review and commenting of evaluation method and strategy.
- Hosted the DFC Speaker Series, featuring experts from academia, the OECD, and Innovations for Poverty Action. Discussions from the use of remote sensing data in artisanal mining to client protection principles for mobile money.

U.S. International Development Finance Corporation, Pathway Intern (Environment and Social Risk Impact Analyst)
Dec, 2022 - Dec, 2023 (part-time, 24hr/week)
• Conducted environment and social impact analysis for DFC supporting development projects. This includes a review of Environment and Social Policy and applying IFC performance standards.
• Plan and manage overseas site visits and monitoring trips for development projects.
• Brief via oral communication on findings to senior management and stakeholders.
• Write reports on risks associated with development projects.

International Trade Administration(Department of Commerce), International Trade Grad Student Fellow
May, 2021 - August, 2022 (part-time, 20hr/week)
• Conducted and supported macro and micro quantitative economics research on complex and contemporary issues in international trade including the United States. This has included the full spectrum of support, from problem identification to data collection, literature review, and analysis of issues and problem resolution.
• Conducted independent research on trade and labor conditions in China, such as rural-urban wage discrepancies and issues related to forced labor conditions.
• Presented research results to ITA economists and policymakers.

Knowledge and Management Dept. Intern, IEDC (Washington, DC)
May 2020 - August 2020 (full-time)
• Conducted qualitative and quantitative studies on Economic Development strategies.
• Supported case studies with business expansion and retention, workforce attraction, and sustainable development. Created infographics and data visualization for reports.
• Written blog posts and articles regarding various economic development issues.

UNHCR Korea Intern, Seoul, ROK 2017
• Public information and external relation team member assisted Korea Refugee Film Festival 2017, managed social media and UNHCR website, assisted schedule of representative.

Global Oversea Adoptee's Link Intern, Seoul, ROK 2014
• Assisting adoptees to search forthe birth family through email or in person, translating documents or verbally, producing events.

National Oceanic and Atmospheric Administration, HI, USA 2013
• Data organizing assistant: translation/collection of survey (first-hand data for annual report) for the project of long line fishery expenditure.

SKILLS

Computer:	STATA, Python, LaTeX, ArcGIS, R
Languages:	Korean (native), English (fluent)
Certification:	Investment Foundation Certificate (certification on comprehensive overview of the investment industry's structure, concepts, and ethical considerations), SA8000 (certification to audit fair and decent labor practice of workers and verify conformity to social standards issued by Social Accountability International), OHSHA 60 Construction (Workplace Health and Safety certification issued by OHSHA)

TEACHING EXPERIENCES

Lecturer, AU (Washington, DC)
Applied Econometrics I — Fall, 2022

Teaching Assistant, AU (Washington, DC) — Jan 2018 - May 2022
Pf. Mahmud Yesuf, Microeconomics and Economics of Environment Policy — Spring, 2022
Pf. Natalia Radchenko, Applied Econometrics 1 — Fall, 2021 - Spring, 2022
Pf. Dan Lin, Microeconomics — Fall, 2019 - Spring, 2021
Pf. Peter Spiegler, Economics for Business — Spring, 2020
Pf. Dan Lin, Economics for Business — Spring, 2018

LIST OF COMPLETED PHD COURSES

ECON 620 Economic Thought — Fall, 2018
ECON 705 Mathematical Economic Analysis — Fall, 2018
ECON 823 Econometric Methods — Fall, 2018
ECON 802 Macroeconomic Analysis I — Spring, 2019
ECON 803 Microeconomic Analysis I — Spring, 2019
ECON 824 Advanced Econometric Methods — Spring, 2019
ECON 619 Economic History: Microeconomic Aspects — Fall, 2019
ECON 662 Development Microeconomics — Fall, 2019
ECON 883 Seminar: Empirical Microeconomics — Fall, 2019
ECON 663 Development Macroeconomics — Spring, 2020
ECON 665 Economic Experiments and Empact Evaluation — Spring, 2020
ECON 696 GIS Application in Empirical Economics — Spring, 2020
ECON 650 Growing Artificial Societies — Fall, 2020
ECON 811 Marco Political Economy — Fall, 2020
ECON 897 Doctoral Dissertation Seminar — Fall, 2020
ECON 813 Microeconomic Analyusis II — Spring, 2021

GRANTS AND AWARDS

Doctoral Fellowship by AU for 4years, — 2018-2022
Amount Funded: $23,000 with credit.
Econometrics Prize, American University — 2021
ROK Government Study Aborad Grant, — 2015
Amount Funded: $31,000.
Graduation Thesis Award, Ewha University — 2015
Alumni Award for Outstanding Extra Curricular Activity, Ewha University — 2014
Scholarship for Outstanding Student, Ewha University — 2011-2014

PRESENTATION & WORKSHOP

The 2023 Bank-Fund Replication Games — July 17, 2023
Participation in the replication of published articles led by the Institute of Replication

and writing reports on the replication report.

Southern Economic Association November 18-20, 2023
Present paper on 'Communication between Partial Migrated Household and Left Behind Women's Labor Market Participation'.

International Association for Feminist Economics@ASSA January 5-7, 2024
Present paper on 'Communication between Partial Migrated Household and Left Behind Women's Labor Market Participation'. Part of a session titled 'Gendered Realities: Exploring the Dynamics of Social Norms'

Cover Letter

Joan Koo
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August 28, 2026

Pf. Emily Breza, Pf. Davide Viviano, and Pf. Arun Chandrasekhar
National Bureau of Economic Research
1050 Massachusetts Avenue Cambridge, MA 02138

Dear Program Committee for Workshop on Network and Development Economics,

I am writing to submit my paper, "Communication between Partially Migrated Households and Left-Behind Women's Labor Market Participation," for consideration at the workshop on network and development economics, to be held December 5, 2026.

The paper investigates how communication between left behind wives and their migrant husbands influences wives' labor market participation. Using a difference-in-difference design with multiple treatment periods, I find that improved monitoring environment leads conservative migrant husband to pressure progressive wives into dropping employment, reducing it by 29%. In nuclear households, progressive migrant husbands appear to encourage conservative wives to increase employment by 36%. This project speaks directly to the workshop's focus on using frontier empirical methods on development economics, and I believe it would generate productive discussion among participants working on related questions. The analysis draws on China Family Panel Survey, and identification relies on Callaway and Sant'Anna staggered difference in differences approach. I am an international economist at U.S. Development Finance Corporation, and this paper is part of my dissertation. I completed Ph.D. program in Summer of 2026.

The paper is attached, along with an abstract as requested. I would welcome the opportunity to present at the workshop and am happy to provide any additional materials the committee may need. Professor Nathan Larson, who chaired my dissertation committee, has agreed to provide a letter of recommendation on my behalf. He can be reached at the Department of Economics, American University, 4400 Massachusetts Avenue, NW, Washington, DC 20016, or at nlarson@american.edu.

Sincerely,
Joan Koo
U.S. Development Finance Corporation

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Motivational Statement

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August 28, 2026

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There are two items that I would like to focus on during the workshop. The first is the near separation problem, where I observe hard to believe coefficient values when including covariates with extreme values. I follow Cunningham (2026) suggestion on diagnosis and solution but would like to hear from other researchers who face similar problems. Second is the mechanism. I hypothesize that cell tower establishment in communities will increase the frequency of communication between separated couples, using phone ownership and cell expenditure as proxies. High cell ownership in the China context, and null effect findings on the cell expenditure proxy, weaken my mechanism. I want to explore alternative ways to test this hypothesis or explore other mechanisms which help me explain how communication between left-behind wives and their migrant husbands influences wives' labor market participation.

Reference

Cunningham, Scott. 2026. “Claude Code 31: Apple-to-Apple Audit of Six Callaway and Sant’Anna Packages.” Substack newsletter. *Scott’s Mixtape Substack*, March 12. https://causalinf.substack.com/p/claude-code-31-apple-to-apple-audit.

Communication between Partially Migrated Households and Left-Behind Women's Labor Market Participation

By Joan Koo*

This study investigates how communication between left-behind wives and their migrant husbands influences wives' labor market participation. Using a difference-in-differences design with multiple treatment periods, I estimate the effect of cell tower rollout on Chinese left-behind wives' employment. I find concrete evidence that an improved monitoring environment leads conservative migrant husbands to pressure progressive wives into dropping employment, reducing it by 29%. In nuclear households, progressive migrant husbands appear to encourage conservative wives to increase employment by 36%. I further examine the association between cell tower presence and cell phone ownership and expenditure, finding that tower establishment is positively associated with cell ownership among left behind women.

I. INTRODUCTION

The economic growth of China and many other developing countries has created a large gap between household income and available infrastructures in industrial regions and the rest of the country. As a result, men migrate to industrial hubs to earn higher incomes instead of participating in the local job market. This behavior has created a large population of partially migrated households in which wives have been left behind to care for children and elderly relatives while maintaining agricultural plots. This left-behind population has been growing since the start of China's industrialization. It was estimated that in 2015, there were approximately 17.17 million left-behind women in China (Wang and Tang, 2020). There is a perception that Chinese women are less responsive to labor market policy because of traditional gender roles that discourage them from participating in the labor market or starting businesses. Development policy often ignores left-behind women as a target population in national development projects (Wang and Tang, 2020). In this paper, I argue that it is essential to consider the communication between separated couples to better understand why left-behind women are less responsive to labor market policies.

This paper aims to understand the relationships among labor market policy, gender role preferences, and women's labor market participation (LMP) decisions. I am specifically interested in factor influencing women's less responsiveness in labor market policies, such as husband's gender role preference. I uilize the impact

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of communication between left-behind women and their migrant husbands. China is suitable context for studying the communication effect, as mobile phones have diffused widely throughout China even in most rural regions. The government-led cell tower rollout and the availability of affordable phones have increased the speed of diffusion (Liu, Wu and Chu, 2012). As a result, those without access to local cell service often own cell phones, as they can gain access to cell service when they travel to nearby neighborhoods. I seek to understand whether better communication encourages wives to choose outcomes that are more aligned with their husbands' preferences. Information communication technology (ICT)[1] infrastructure expansion has been considered a project that enhances local economic growth and job creation. Although the literature has investigated the impact of husbands' migration on left-behind women's LMP, there is little research on the effects of separated couples' communication and its influence on left-behind wives. I utilize the installation of infrastructure between 2010 and 2013 as a shock that alters the frequency of communication between men and women in separated couples; more frequent communication might influence left-behind women's choice set, especially in LMP.

I argue that the literature has found mixed results on left-behind women's LMP because it has not considered separated couples' communication and monitoring aspects. According to literature, the physical distance between separated husbands and wives creates information asymmetries, and it shifts the bargaining power of left-behind women (Ashraf et al., 2015; Castilla and Walker, 2013; Chen, 2006; Lundberg and Pollak, 1993). Also, migrant husbands send remittances that create an income effect for left-behind women (Binzel and Assaad, 2011; Mendola and Carletto, 2012; Bacud et al., 2021; Yang, 2008; Khanna et al., 2022). ICT expansions, however, reduce the constraints posed by physical distance on communication and monitoring, allowing men and women in separated couples to communicate with each other via ICT facilities and technologies. ICT infrastructure thus creates a potential channel of influence on the direction and magnitude of left-behind women's LMP (Williams et al., 2011). I hypothesize that more frequent communication and monitoring bring left-behind women's LMP into closer alignment with their husbands' preferences.

To empirically test this hypothesis, I focus on separated couples in which husbands and wives have different preferences regarding the wives' LMP. If improved communication changes left-behind women's preferences, the impact will be most significant among couples whose preferences are misaligned. I use the difference-in-difference (DID) approach with multiple treatment periods by subsamples to match the preferences between men and women in separated couples. The results show null effect for full sample and for average treatment effect across two different treatment periods for sub-sample. However, interesting result is revealed for

[1]ICTs include communication technologies such as the internet, cell phones, computers, and any other form of media application that accesses, retrieves, stores, transmits, and manipulates information in digital form (FAO, n.d.).

cohort treated by 2014, that the increased cell ownership of left-behind women, especially women who are progressive wives with conservative husbands, results in a decrease in LMP of 29% , which is 0.642 standard deviations among left-behind women. Among progressive husbands and conservative wives, I find suggestive evidence of a 36% increase in LMP only for nuclear households.

II. LITERATURE REVIEW

The literature review is structured around the mechanisms through which husbands' migration influences left-behind women's labor market participation(LMP). Two main channels of this influence have been explored in the literature. The first is the income effect, whereby remittances sent by migrant husbands increase household income, potentially altering the labor supply decisions of left-behind women. The second channel is bargaining power, whereby husbands' physical absence reduces their ability to monitor their wives, giving these women more freedom to decide whether to participate in the labor market. Regardless of the channel explored, empirical studies show a mixed relationship between husbands' absence and their left-behind wives' LMP.

This study contributes to the literature on the bargaining power channel (Datta and Mishra, 2011; Zhang, 2020; De Haas and van Rooij, 2010) by providing further evidence of how the introduction of cell towers, as an exogenous shock, affects the labor market behavior of left-behind women via a change in bargaining power. By controlling for the direct effect of cell towers on the local economy, I can isolate the effect of communication between men and women in separated couples. Although migrant husbands are physically absent, with cell services, they can readily monitor their wives' labor market activities (Wallis, 2011; Hannaford, 2015). By leveraging this exogenous shock in a DID design with multiple treatment periods, this study investigates the relationship between husbands' monitoring power and wives' labor market decisions, which may help explain the mixed findings between husband's migration and left behind women's labor market participation in the literature.

A. Motivation and Background

This study focuses on China, where, similar to other developing countries, there exists a significant wage gap between industrial and less developed areas. This gap incentivizes men to migrate to industrialized regions in search of higher wages. Most migrants are men who leave their families behind (Wang and Tang, 2020; Cook and Dong, 2011). This behavior creates a setting where the husband is physically absent, leaving the wife to manage household decisions, from resource allocation to LMP (Mu and van de Walle, 2011; Zhang, 2020; Cai, Guo and Huang, 2023; Meng, 2014). Researchers have utilized husbands' physical absence

as a key factor influencing left-behind women's decision-making. Absent husbands have been deemed unable to monitor their left behind wives' decision-making process (Koirala, 2023; Datta and Mishra, 2011; Zhang, 2020), and remittances have been considered the main factor influencing left-behind women's LMP (Binzel and Assaad, 2011; Mendola and Carletto, 2012; Bacud et al., 2021). However, this literature has not taken into account technological change, which has enabled communication in the face of physical distance. ICT infrastructure has expanded in remote regions, enabling remote monitoring by migrant husbands.

B. Income Effect

The first mechanism that connects husbands' migration and left-behind women's labor market participation (LMP) is the income effect. This effect refers to the change in one's labor market behavior due to a change in income. An increase in nonlabor income reduces one's labor supply (Killingsworth, 1983; Kan and Aytimur, 2019). The income effect explains how a husband's migration and, in particular, any associated remittances that he sends change a household's financial constraints and influence the wife's participation in the labor market. Remittances are nonlabor income for left-behind wives, and according to the neoclassical labor model, such income shifts the household budget constraint upward. A higher budget raises the reservation wage, the lowest wage that an individual is willing to accept for a job. As a result, left-behind women reduce their labor supply (Killingsworth, 1983).

Husbands' monitoring environment can influence the income effect via remittances. As remittances are an important factor that influences the income effect, if migrant husbands' monitoring environment changes, one can leverage remittances as a tool to negotiate the LMP of left-behind women. The literature reports that communication via cell phone is the main channel of migrant husbands' monitoring activities (Ur Rehman, 2023; Harper and Zubida, 2018; Mizanur Rahman, 2013). Ur Rehman (2023) studies the context of Filipino migrants located in United Arab Emirates (UAE) and their left-behind family member in the Philippines over the 2005–2019 period. Using the randomized controlled trial (RCT) method, the study finds that there are information asymmetry and strategic misreporting between migrant husbands and left-behind wives. The underreporting of left-behind wives' income is more distinctive when migrant husbands monitor less. The study does not further investigate whether migrant husbands decrease their remittances if they catch their left-behind wives underreporting their income. Both Harper and Zubida (2018) and Mizanur Rahman (2013) use qualitative methods, mainly interviews. Harper and Zubida (2018) study migrants from Pakistan and other countries located in Israel. Interviews were conducted in 2010. The research finds that remittances operate as a mechanism to gain visibility in left-behind households' economic behavior. When the visibility diminishes, migrant family members change the size of remittances or stop sending money to

left-behind families. Mizanur Rahman (2013) investigates Bangladeshi migrants in the UAE and uses a mixed-methods approach that includes conducting surveys and interviews. The paper finds that even though a migrant family member is married, remittances often go to the father of the migrant family member rather than the spouse. When the recipient is the spouse of the migrant family member, frequent communication between them functions as negotiation on managing remittances. As a result, literature confirms that remittance is crucial element in income effect while migrant husband communicate with left behind women on remittance.

C. Bargaining Power

Bargaining Power over Hard-to-Monitor Factors. — The second mechanism through which the absence of migrant husbands may influence their wives' LMP is bargaining power. When husbands migrate, the allocation of time and resources within left-behind households is monitored imperfectly. This allocation depends on husbands' ability to verify and monitor household decisions (Ashraf et al., 2015; Castilla and Walker, 2013). For instance, consider the allocations of two types of goods: one that is relatively easy to observe (e.g., children's nutrition) and another that is more difficult to monitor (e.g., the wife's allocation of time between housework and wage labor). In the husband's absence, allocations of the easily observed good are likely to align with the couple's prior agreement, as they can be verified remotely. However, for the harder-to-observe good, the wife may have more bargaining power, allowing its allocation to shift toward her preferences because of the monitoring barrier faced by her migrant husband (Chen, 2006; Lundberg and Pollak, 1993).

Chen (2006) utilizes time use data on China's rural migrant families to empirically demonstrate the relationship between husbands' migration and the allocation of hard-to-monitor goods. The study finds that remittance income is typically allocated to easily observable resources, such as children's nutrition, while less observable aspects, such as children's time use, are determined entirely by left-behind wives' preferences. In other words, for goods that are difficult for migrant husbands to monitor, their allocation aligns with the mothers'preferences. Although Chen (2006) does not differentiate between household chores and paid labor as the primary outputs for left-behind women, while this study provides valuable insights into the bargaining dynamics of men and women in separated couples and the critical role of monitoring.

Qualitative studies also confirm that the absence of husbands is strongly related to left-behind women's bargaining power. Interview studies in India and China have found that the absence of husbands allows women to make more independent decisions with more bargaining power (Datta and Mishra, 2011; Zhang, 2020). However, an increase in bargaining power does not necessarily translate

into a uniform response in LMP, as the outcomes depend on the individual preferences and priorities of the left-behind wives.

This study contributes to the literature on women's bargaining power (Datta and Mishra, 2011; Zhang, 2020; De Haas and van Rooij, 2010) and the monitoring of women's LMP (Wallis, 2011; Hannaford, 2015) by leveraging exogenous variations in ICT, specifically through the establishment of cell towers, as a source of change in migrant husbands' monitoring capacity. This approach makes it possible to empirically examine how shifts in this capacity affect the labor market activities of left-behind wives.

Limitations in the Literature on Bargaining Power. — One may argue that women's control over commodities whose allocations are easy to observe does not necessarily translate into greater bargaining power and that, rather, such control is simply a household burden shouldered by women. Mu and van de Walle (2011) use panel data to analyze the impact of men's migration on the time use of left-behind women in rural China. They find that while husbands' absence led to a reallocation of traditional farm labor, with women taking on more agricultural responsibilities, this shift did not translate into enhanced bargaining power over household decision-making or resource allocation. The increased participation in farm labor remained confined within the traditional responsibilities assumed by women, thereby limiting any potential gains in bargaining autonomy. While a few empirical studies have investigated this channel, several qualitative studies highlight the presence of structural and social constraints that undermine the bargaining position of left-behind women even in their husbands' absence. Factors such as surveillance by in-laws, strict adherence to patriarchal norms, and societal pressure from neighbors continue to restrict women's autonomy and diminish their influence over household decisions. Relevant studies conducted in Pakistan, Nepal, and Morocco—all regions characterized by patriarchal values—illustrate how the persistence of social norms and family dynamics can counteract any potential increase in bargaining power that might result from the physical absence of a spouse (Ahmed, 2020; Gartaula, Visser and Niehof, 2012; De Haas and van Rooij, 2010).

Monitoring Ability. — The literature confirms the importance of monitoring between men and women in separated couples. Migrants are often willing to sacrifice both time and financial resources to expand their monitoring capabilities to have better control over the left-behind household's resources (Ashraf et al., 2015; Castilla and Walker, 2013). This finding confirms that the ability to monitor left-behind household members is closely related to bargaining power. Studies also explore how separated couples exploit information asymmetries arising from physical separation to their advantage. Migrant husbands and left-behind women

share only observable information and conceal unobservable information (Ashraf et al., 2015; Castilla and Walker, 2013). This behavior aligns with Chen's (2006) finding that separated couples cooperate in the allocation of easily monitored goods but do not cooperate in the allocation of hard-to-monitor goods. The behavior disappears when information is fully shared. Experiments by Ambler (2015) and Ashraf (2009) find that when full information is shared between men and women in separated couples, wives adjust their choices to align more closely with their husbands' preferences than when information is not fully shared.

III. THEORETICAL FRAMEWORK

The goal of this section is to theoretically show how an increase in the strength of the monitoring environment shifts a wife's labor market participation (LMP) choices to be closer to what her migrant husband prefers. In other words, LMP falls if the migrant husband prefers less work than his wife's preference, or LMP rises if the migrant husband prefers more work than his wife's preference. I assume an exogenous factor, such as cell tower establishment, to be positively related to the monitoring environment. The framework shows that with an increase in the strength of the monitoring environment of a migrant husband, his left-behind wife's working hours converge to her husband's preferred level. In addition to the influence of monitoring by migrant husbands, monitoring within the household by maternal parents or parents-in-law may influence left-behind women's LMP. Depending on the parent's gender role preference, an increase in spousal communication via ICT may have weaker marginal effects on left-behind women's LMP.

A. Husbands Who Prefer That Their Wives Stay Home

A left-behind wife's labor hours are x, where $0 \leq x \leq 24$. The wife's wage rate is w. Let us assume that a migrant husband's preference for the labor hours of his wife is $X = 0$. The probability that the husband detects that his wife is working more than he prefers is composed of the strength of the monitoring environment (T) and the gap in desired working hours between the separated husband and wife ($x - X$). If the gap in desired working hours between them is large, the chance of detection of the left-behind wife's working hours increases.

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

The wife incurs disutility (c) from paid labor. The higher this parameter is, the more the wife does not prefer working regardless of her husband's influence.

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

We assume that remittance (R) is transferred from the migrant husband to his left-behind wife only when he does not detect that she is working more than his preferred number of hours. Therefore, the wife's total income is as follows:

$$\begin{cases} R + wx & \text{if the wife is not caught by her husband working } x > X \\ wx & \text{if the wife is caught by her husband} \end{cases} \tag{3}$$

The wife's utility is the expected income minus her disutility from working.

$$U_w(x) = E(income) - v(dis - utility) = wx + (1 - p(x))R - \frac{1}{2}cx^2 \tag{4}$$

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

$$\frac{\partial U_w}{\partial x} = w - (TR + c)x = 0 \quad x^* = \frac{w}{TR + c} \tag{5}$$

The wife's equilibrium number of labor hours (x^*) is positively related to her wage earned by working (w) and negatively related to the strength of the monitoring environment (T), the amount of remittances from her absent husband (R), and her own disutility from working (c).

$$\frac{\partial x^*}{\partial T} = -1 \cdot w(TR + c)^{-2} \cdot R = -\frac{Rw}{(TR + c)^2} < 0 \tag{6}$$

$$\frac{\partial x^*}{\partial c} = -1 \cdot w(TR + c)^{-2} \cdot 1 = -\frac{w}{(TR + c)^2} < 0 \tag{7}$$

B. Husbands Who Prefer That Their Wives' Working Hours Are Positive

I expand the model above by allowing the husband to prefer that his wife works a positive number of hours. The utility function of the left-behind wife is then as follows:

$$U_w(x) = wx + (1 - \frac{1}{2}T(x - X)^2)R - \frac{1}{2}cx^2 \tag{8}$$

The equilibrium working hours of the left-behind woman are as follows:

$$\frac{\partial U_w}{\partial x} = w + TRX - (TR + c)x = 0 \tag{9}$$

$$x^* = \frac{w + TRX}{TR + c} \tag{10}$$

If the husband's preferred number of working hours for his wife increases, then the wife's equilibrium working hours also increase; however, if her disutility increases, her working hours decrease.

$$\frac{\partial x^*}{\partial X} = \frac{TR}{TR + c} > 0 \tag{11}$$

$$\frac{\partial x^*}{\partial c} = -\frac{w + TRX}{(TR + c)^2} < 0 \tag{12}$$

The following equation shows the relationship between the strength of the monitoring environment (T) and the left-behind woman's equilibrium working hours (x^*).

$$\frac{\partial x^*}{\partial T} = -\frac{R(w - Xc)}{(TR + c)^2} \tag{13}$$

If $w - xc > 0$, then $w > xc$, and the relationship is negative. An increase in the strength of the monitoring technology decreases the wife's equilibrium working hours only when $\frac{w}{c} > x$ is satisfied.

C. Monitoring within Multigenerational Households

Coresident parents and/or in-laws can shield or block a migrant husband's remote monitoring by limiting the frequency or duration of phone calls or texts. To operationalize this multigenerational household aspect, I introduce $\gamma \in [0, 1]$, which is a monitoring restraining parameter. As a result, the monitoring environment is $\tilde{T}$.

$$\tilde{T} = T(1 - \gamma) \tag{14}$$

The probability of detection of left-behind women's LMP behavior is as follows:

$$\tilde{p} = \frac{1}{2}T(1-\gamma)(x-X)^2 \tag{15}$$

Left-behind women's utility function considering the household structure is as follows:

$$U_w(x) = wx + (1 - \frac{1}{2}T(1-\gamma)(x-X)^2)R - \frac{1}{2}cx^2 \tag{16}$$

$$\frac{\partial U_w}{\partial x} = w - TR(1-\gamma)(x-X) - cx = 0 \tag{17}$$

$$x^* = \frac{w + T(1-\gamma)RX}{T(1-\gamma)R + c} \tag{18}$$

$$\frac{\partial x^*}{\partial \gamma} = \frac{(w - cX)TR}{[T(1-\gamma)R + c]^2} > 0 \quad if\ w > cX \tag{19}$$

If $\gamma = 0$, which means that there is no influence of maternal parents and/or in-laws, then the equilibrium is the same as equation (2.10).
If $\gamma = 1$, which means that maternal parents and/or in-laws have the maximum influence, then the equilibrium is $\frac{w}{c}$. This case fits when the LMP preference of cohabiting parents and/or in-laws matches the left-behind wife's preference. The opposite case can be considered when the parents' gender role preference aligns with that of the migrant husband. If this is the case, it reverts to the 2.3.1 model or 2.3.2 model.

I can understand the role of maternal parents and/or in-laws as a principal–agent problem. Principal–agent theory explains that a principal delegates decision or actions to an agent but that the two parties have different information and interests. Additionally, the principal cannot perfectly monitor the agent's behavior (Eisenhardt, 1989). I can think of parents and a migrant husband as dual principals and a left-behind wife as an agent, where the left-behind wife has to serve two principals. If the principals cannot coordinate, the agent distorts her behavior toward whoever applies more pressure on the agent (Bernheim and Whinston, 1986). It is most likely that cohabiting parents and/or in-laws can apply stronger pressure than the migrant husband because they are cohabiting, and as a result, when the principals' preference is not aligned, the left-behind wife is likely to influenced by the LMP preference of the cohabiting parents and/or

in-laws.

D. Left-Behind Women's Equilibrium Working Hours

I can rewrite the left-behind wife's equilibrium working hours as a weighted average of her and her husband's preferences.

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

$$x^*|_{R=0} = \frac{w}{c} \tag{20}$$

When ($R = 0$) without the husband's remittance, the wife decides her working hours on the basis of the ratio between her hourly wage and hourly disutility from working.

I can rewrite the equilibrium working hours in terms of the weighted average between $x^*|_{R=0}$ and X.

(21)
$$x^* = \frac{w + TRX}{TR + c} = \left[\frac{c}{TR + c}\right] \cdot \frac{w}{c} + \left[\frac{TR}{TR + c}\right] \cdot X = \left[\frac{c}{TR + c}\right] \cdot x^*|_{R=0} + \left[\frac{TR}{TR + c}\right] \cdot X$$

$$= \underbrace{\left[\frac{c}{TR + c}\right] \cdot x^*|_{R=0}}_{\text{wife's LMP preference without husband's pref}} + \underbrace{\left[\frac{TR}{TR + c}\right] \cdot X}_{\text{husband's preference on wife's LMP}} \tag{22}$$

An increase in monitoring power has different implications for each weight.

$$\frac{\partial x^*}{\partial T} = \left[-\frac{Rc}{(RT + c)^2}\right] \cdot \frac{w}{c} + \left[\frac{Rc}{(RT + c)^2}\right] \cdot X \tag{23}$$

As monitoring power (T) increases, the weight on the husband's preference (X) also increases. In other words, an improvement in monitoring technology increases the influence of the husband's preference on his wife's working hours.

I can represent the relationship between $x^*|_{R=0}$, x^*, and X in graphical form with a change in monitoring power (T). In Figure 1, the bottom panel shows the case in which a left-behind wife prefers working while her migrant husband prefers that she does not work. With an increase in monitoring power, the equilibrium labor hours for the wife approaches her husband's preference. The top panel shows the opposite case.

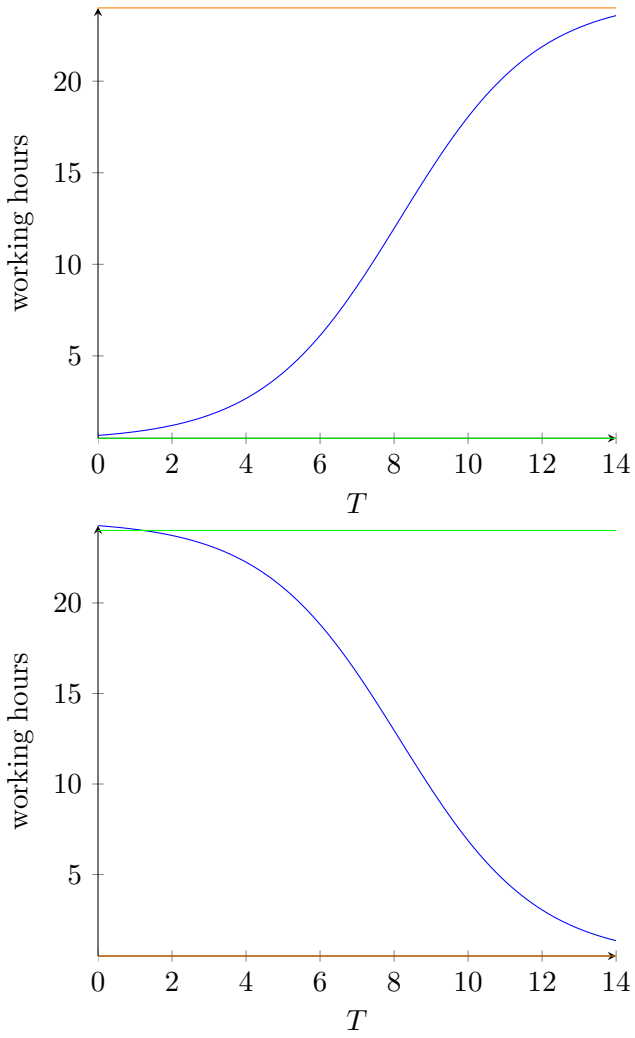


Figure 1. : Representation of Wives' Independent Working Hour Preference, Husbands' Preference, and Wives' Equilibrium Working Hours

Note: The y-axis represents the working hours of left-behind women, and the x-axis represents the strength of monitoring environment of migrant husbands. The top panel shows the case where the husband's preferred working hours for his wife (orange line) are higher than the left-behind woman's preferred working hours (green line). The bottom panel shows the case where the husband's preferred working hours for his wife (orange line) are smaller than the left-behind woman's preferred working hours (green line). Both panels show that as the strength of monitoring environment of migrant husbands increases (value of T increases), the actual working hours of left-behind women merge with their husband's preferred working hours.

IV. IDENTIFICATION STRATEGY

A. ICT Expansion as Exogenous Variation

The literature on the bargaining power channel and lab-in-the-field experiments highlight that the bargaining power of left-behind women is closely tied to their husbands' ability to monitor them. When opportunities arise to enhance monitoring, migrant family members are often willing to invest both financial resources and time to do so (Ashraf et al., 2015; Castilla and Walker, 2013). Improvements in ICT have made it easier for an absent husband to monitor his wife's decisions, potentially diminishing the wife's bargaining power (Williams et al., 2011).

One challenge in testing the hypothesis that better monitoring power via ICT changes a left-behind wife's LMP decision is that the communication between migrant husbands and their left-behind wives are not only difficult to measure but also endogenous in terms of frequency and direction. Focusing on exogenous events such as the rollout of ICT infrastructure helps address both of these problems. ICT infrastructure, which includes cell towers, broadband networks, telephone lines, and other communication systems, has undergone rapid and extensive development in China over the past decade (Williams et al., 2011). This technological progress has not only transformed local economic activities but also revolutionized communication patterns, enabling more frequent and higher-quality interactions between men and women in separated couples. Other studies that utilize ICT infrastructure penetration use cell phone ownership and internet access rather than community-based information on the availability of ICT infrastructure as a proxy for ICT expansion. One concern with this method is that the ownership and use of cell phones and broadband are inherently endogenous in terms of who uses cell or broadband to communicate.

Research has shown that low-income farmers experience the largest positive effect of ICT penetration on off-farm income. Specifically, access to cell phones and the internet has increased rural households' nonagricultural income (Leng et al., 2020; Min, Liu and Huang, 2020; Rajkhowa and Qaim, 2022; Khanal and Mishra, 2016). Access to ICT tools can create an additional income stream for households. For example, cell ownership and internet use positively impact startups of small and medium-sized enterprises (SMEs) in rural households (Barnett, Hu and Wang, 2019). This relationship between ICT and labor market activity could have hidden mechanism of communication between separated couple.

The identification strategy of this paper leverages the treatment timing, the year that a cell tower was installed within a community, assuming it to be unrelated to unit-specific trends in the outcomes. In other words, I assume that left-behind women's employment is unrelated to the timing of cell tower installation. However, a limitation of a strategy utilizing ICT infrastructure is that access to ICT infrastructure is itself likely to have a direct effect on household income through income diversification and the growth of SMEs in the local economy.

To isolate the effects of communication and monitoring on the labor market

decisions of left-behind women, it is crucial to isolate the communication effect of new ICT infrastructure from this other relationship. I do so by including proxy in communication frequency between left-behind women and their migrant husbands by means of cell tower installation. I leverage the staggered treatment timing of cell tower rollout using Callaway and Sant'Anna difference-in-differences (CSDID) estimation, as cell tower locations may not be random but the timing of ICT rollouts is somewhat random. By exploiting variation in treatment timing, I am able to mitigate endogeneity concerns related to cell phone ownership, which is likely correlated with individual choice and the capacity to acquire and use such technology. I conduct subgroup analysis by gender role preference match to further understand direction of impact. Additionally, the household structure, such as cohabiting with maternal parents and/or in-laws, influences left-behind women's LMP. Left-behind women who cohabit with parents operate as agents who receive pressure from both their migrant husbands and cohabiting parents and receive higher pressure from cohabiting parents, as they have a stronger monitoring ability than noncohabiting husbands. Therefore, I conduct a subgroup analysis for nuclear households. By limiting the sample to nuclear households, I may find that communication between migrant husbands and their left-behind wives is a stronger channel in nuclear households.

V. METHODOLOGY

This study presents both conventional two way fixed effect and staggered difference-in-difference in answering research question. This section first, explains each approach. Next, it compares pros and cons between two methodologies. Lastly, it presents specification for final model and steps leading to final specification.

A. Two-Way Fixed Effects

To understand the impact of cell towers on employment, I first run a conventional two-way fixed effects (TWFE) model.

$$Employment_{it} = \beta_0 + \beta_1 Cell\ Tower_c \times After_t + \delta_c + \gamma_t + \epsilon_{ict} \tag{24}$$

The TWFE model above contains community and year fixed effects. The community fixed effects absorb the cell tower establishment variable, and the year fixed effects absorb the time variable, and therefore, the equation is left with a single interaction term. I can interpret the coefficient β_1 as an overall treatment effect of cell tower establishment on left-behind women's employment. According to Goodman-Bacon (2021), β_1 represents a weighted average of all possible comparisons, which include the following: the treated group before treatment, the treated group after treatment, the comparison group before treatment, and the

comparison group after treatment. The TWFE approach fits best in a context in which there is only one treatment period. However, this research context has multiple treatment periods, which causes several problems in estimation.

B. DID with Staggered Treatment Timing

In settings where treatment occurs across multiple treatment periods, TWFE models may yield biased results by comparing already treated and not-yet-treated units. The correct comparison should instead be between already treated and never-treated groups and not-yet-treated and never-treated groups. In other words, when there is multiple treatment timing, the TWFE approach uses negative weights in calculating the aggregate average treatment effect on the treated (ATT), which biases the results. The method of Callaway and Sant'Anna (2021) (i.e., CSDID) addresses this problem by correcting the weights and specifying the groups that should be compared on the basis of their treatment timing to avoid comparing treated and not-yet-treated groups. I apply their approach to DID with staggered treatment timing for the main analysis.

$$ATT(g,t) = E[Y_t(g) - Y_t(0)|G_g = 1] \tag{25}$$

g: group treated time
t: particular time period

The notation presented above is a DID model with multiple treatment groups and treatment timing. The model estimates the *group-time average treatment effect*. It calculates the expectation over units on the difference between the potential outcome at time g and the counterfactual potential outcome of being never treated. The conditional term specifies that the average applies only to units that belong to g. For example, ATT(2014, 2016) means the average treatment effect for those treated in 2014, comparing between the treated and never-treated of the employment outcome in 2016. The CSDID approach can provide aggregated and disaggregated parameters. I am interested in both the aggregate ATT and ATT by treatment timing cohort among left-behind women in rural China, where I take cell tower installation as a staggered timing.

Apart from the limitation of TWFE models when used in a multiple treatment setting, TWFE models require the parallel trends assumption and a constant treatment effect over time (Goodman-Bacon, 2021). These requirements are restrictive even with a single treatment period. Meanwhile, the CSDID approach accommodates cases where the parallel trends assumption holds after conditioning on pretreatment covariates. Identification in such settings relies on a conditional

parallel trends assumption.[2] This conditional assumption applies when covariates show specific trend outcomes over time and differences in their distribution across groups. Because left-behind women's employment is correlated with covariates at the individual and community levels without cell installation, the conditional parallel trends assumption is more plausible for my model. This approach provides flexibility in the parallel trends assumption.

The China Family Panel Studies (CFPS) survey provides yearly information on when cell towers were installed within each community, while information on left-behind women's LMP is reported biannually. To structure the data in a way that satisfies the demands of the CSDID model, I group treatment timings into 2-year bins. Additionally, community-level surveys were collected twice (in the 2010 and 2014 waves) and asked for information on past years. Therefore, the 2016 and 2018 waves provide posttreatment information. The cohort of the "2012 treated" group represents left-behind women in whose communities cell towers were installed in 2010 or 2011; the cohort of the "2014 treated" group represents women in whose communities cell towers were established in 2012 or 2013. Each treatment indicator is constructed so that the same duration in years is considered.

I conduct several subsample analyses to specify the mechanism linking cell tower installation to women's LMP. I run the model for left-behind women whose preferences diverge from their husbands'. In my sample, women's preferences can either align with their husbands' (whether conservative or progressive) or be misaligned. The results for the group with misaligned preferences enable me to identify the impact of increased communication between men and women in separated couples that may shift left-behind women's LMP preferences closer to their migrant husbands'. If I can successfully isolate the impact of communication from other influences that cell towers have on local communities, the group with aligned preferences should show a null effect.

C. Near Separation in Callaway and Sant'Anna Difference-in-differences (CSDID)

Some researchers and users of the staggered DID approach have reported unstable weights when the sample size is relatively small and covariates with extreme values are used. This trend is called "near separation" (Cunningham, 2026). The unstable weights lead to unstable and extreme estimation results in the CSDID approach. According to Cunningham (2026), unstable estimation arises as certain covariates perfectly or near perfectly estimate treatment, which leads to large propensity scores. I follow the author's suggestions on investigating potential near

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

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

This notation explains that the covariates included in the CSDID model will be used when testing for pretreatment parallel trends.

separation problems. First I run a CSDID model without any covariates and observe all possible combinations of $ATT(g,t)$, which are a matrix of group-time treatments. If extreme weights are assigned, I will observe large $ATT(g,t)$ values. I also present a pretrend plot for the CSDID model without covariates. Next, I run a CSDID model with covariates and observe volatility among $ATT(g,t)$ values. Additionally, I check for common support of the propensity scores. Lastly, I check whether certain cohorts have small treated or comparison units. Once I detect a near separation problem, I troubleshoot the problem via three steps. First, I observe which covariates have extreme values and winsorize these values. Next, I standardize the covariates. Lastly, I explore different CSDID estimators, including the "reg" option. The results section will present the CSDID approach with standardized covariates along with the TWFE approach. The steps mentioned above are explained in detail in Appendix B section[3].

VI. DATA AND ATTRITION

A. Chinese Family Panel Survey

The CFPS, conducted by the Institute of Social Science Survey at Peking University, provides information on the relationship between cell tower installation and left-behind women's LMP. It draws its sample from 25 provinces, cities, and autonomous regions, which account for 95% of the country's population. The community questionnaire contains questions on infrastructure, population, and local economic conditions. The CFPS, which covers the 2010–2018 period, provides panel information on the year of installation of the cell tower in each community, which determines which units are treated and when. I match community-level information with household- and individual-level observations to determine the output of the treated and comparison groups, and the CFPS's community unit is smaller than the district level. The output of interest is LMP, which is binary employment status measured at the level of individual women. This variable includes holding a waged job, being self-employed, and running a business, that is, all activities that generate income.

The sample of interest is women in China with migrant husbands, and I refer to this population as *left-behind women/wives*. The CFPS provides information on cell ownership and expenditure, and these indicators are used as a proxy of the change in the frequency of communication between separated men and women. The mechanism section establishes the association between cell tower installation and cell ownership and usage. If cell tower installation has a meaningful effect on communication between separated men and women, the result will be positive and significant, suggesting that the husband's monitoring environment increased. This is the main channel connecting cell tower installation and left-

[3]See the "Near Separation Diagnosis and Solution" section

behind women's LMP. The CFPS also provides information that is highly correlated with husbands' migration and left-behind women's LMP across two different units—the individual and community levels. Table 1 provides a list of the definitions of the variables used in the paper.

Only separated couples, that is, migrant husbands and their left-behind wives,

Table 1—: Data Description for the Selected Variables

Variable	Description
Employment of left behind women	Dummy for whether left-behind women have paid work (wage employment, self-employment, or business ownership).
Wife gender role preference	1–5 scale of agreement with "the husband should work outside while the wife stays home and cares for the family"; higher = more conservative.
Husband gender role preference	Same 1–5 scale as above, reported for the husband; higher = more conservative.
Cell ownership	Dummy for whether left-behind women own a cell phone.
Cell fee (yuan)	Average monthly mobile phone fee.
Remittance (yuan)	Amount received from the migrant husband.
Food expenditure (1,000 yuan/month)	Monthly household food spending.
Age of wife (years)	Age of the left-behind woman.
Urban	Dummy for urban/rural status (census definition): urban = city districts (100,000+ residents) or townships; rural = village committees and areas outside urban/built-up/town zones.
Highest price of egg (yuan)	Highest price of eggs sold in the community.
Number of person	Number of people in the community.
Polluting Factory	Dummy for a polluting factory within 5km of the community.
Floating population	Number of residents without local household registration (Hukou).
Number of ICT infrastructure	Count of ICT infrastructure (telephone, radio, TV; excludes cell towers) established before cell tower installation.
Area size (km^2)	Geographical size of the community.
Extended family	Dummy: 0 = nuclear household (wife and/or children only); 1 = extended household (wife plus maternal parents and/or in-laws).

are included in the model. The best counterfactual for those treated will be left-behind wives without a cell tower, not those cohabiting with their husbands. Table 2 highlights the difference between left-behind women and women cohabiting with their husbands. Left-behind women are less likely to be located in urban areas, Which confirms the migration pattern discussed in the background

section, where rural men leave women behind and migrate to urban areas to earn higher incomes. Additionally, the rates of cell ownership are similar between the two groups, which confirms that due to central government-led cell adoption programs, even rural population have access to cell phones (Liu, Wu and Chu, 2012). The communication mechanism likely operates via a higher frequency and quality of access rather than cell ownership.

The CFPS household module provides information on family structure and

Table 2—: Selection on the Migration Status of Husbands

	(1) All	(2) Non-cohabit	(3) Always cohabit	(4) X^2 Value (df)
Employment	0.580	0.598	0.581	12.08*** (1)
Urban	0.440	0.326	0.481	1309.88*** (1)
Polluting factory	0.298	0.257	0.313	196.53*** (1)
Cell ownership	0.861	0.896	0.848	179.48*** (1)
Num ICT prior	2.132	2.185	2.112	135.19*** (4)
Gender role preference	4.102	4.115	4.099	14.99*** (4)
Husband gender role	4.101	4.146	4.088	32.24*** (1)
N	70,947	18,250	50,278	

Note: Sample consists of all observations in the dataset. As all observations included in models are household with migrated husband and left behind women, I do not limit the balance test to sample only included in the model. Reports means by group and chi-squared test statistics for categorical variables. Column 1 shows results for the full sample. Column 2 shows results restricted to observations where the husband has been non-cohabiting. Column 3 shows results restricted to observations where the husband has always been cohabiting. * indicates $p < 0.10$, ** indicates $p < 0.05$, *** indicates $p < 0.01$.
Source: China Family Panel Survey (CFPS).

	(1) All	(2) Non-cohabit	(3) Always cohabit	(4) Diff	(5) *t*-stat
Remittances	5,187.153	7,209.745	4,274.125	2,935.620***	−22.550
Food expenditure monthly	1,061.239	878.279	1,100.707	−222.428***	18.158
Highest egg price	6.223	6.294	6.192	0.102***	−4.473
Community population	4,226.054	3,558.716	4,459.965	−901.249***	23.084
Age	46.940	41.800	49.124	−7.325***	55.976
Floating population	830.676	665.315	890.935	−225.620***	13.085
Community area size	143.981	162.228	137.722	24.506***	−4.193
Cell fee	48.189	51.199	46.419	4.780***	−8.384
N	70,947	18,250	50,278		

Note: Sample consists of all observations in the data set. As all observations included in models are household with migrated husband and left behind women, I do not limit the balance test to sample only included in the model. Reports means by group, the difference between groups (Column 2 − Column 3), and the *t*-statistic from a two-sample *t*-test with unequal variances for continuous variables. Column 1 shows results for the full sample. Column 2 shows results restricted to observations where the husband has been non-cohabiting. Column 3 shows results restricted to observations where the husband has always been cohabiting. * indicates $p < 0.10$, ** indicates $p < 0.05$, *** indicates $p < 0.01$.
Source: China Family Panel Survey (CFPS).

makes it possible to create a variable for the household structure type. Using the

within-household code, I match couples and observe whether their parents are living with them. If couples report that their maternal parents and/or in-laws are cohabiting them, the household is an extended household. A total of 61% of left-behind women live in an extended household, while 39% of left-behind women live in a nuclear household. Among those who are living in extended family, 86% live with in-laws rather than maternal parents.

The CFPS also provides yearly data on cell tower establishment. The main output of interest, the employment variable, is reported biannually. I group the cell tower data in a binary manner and create a treatment timing cohort. Panel A of Table 3 shows the years of cell tower establishment, while Panel B shows the biannual treatment indicator.

Detailed summary statistics for each model are presented in the Results sec-

Table 3—: Cell Tower Rollout

Panel A: Cell Tower Est. Year

Year	Freq.	Percent	Cum.
2010	380	48.66	48.66
2011	177	22.66	71.32
2012	63	8.07	79.39
2013	161	20.61	100.00
Total	**781**	**100.00**	

Panel B: Treatment Year Identification

Treatment	Freq.	Percent	Cum.
0	1,219	60.95	60.95
2012	380	19.00	79.95
2014	401	20.05	100.00
Total	**2,000**	**100.00**	

Note: Sample limited to those included in final model. Panel A reports the distribution of cell establishment year. Panel B reports the distribution of first treatment timing for cell two across the full sample of 2,000 observations, where 0 indicates never-treated units.

tion, while a broader descriptive analysis is presented in this section. All information are based on raw data rather than standardized information. When comparing 2012 treated and 2014 treated groups, based on raw data, the increase in employment tends to show a spike with a delay[4]. The summary statistics of the Results section provides pre- and postperiod averages, which emphasize the raw differences in treatment. Regardless of treatment status or timing, the period between 2012 and 2014 shows the highest spike. Cohabiting wives and never-treated

[4]Figure A1 shows the biannual trend of employment for left-behind wives by treatment timing and cohabiting wives.

wives show a similar trend until 2014. The most distinctive pattern observed in employment trend for cohort treated by 2012, is that the employment variable shows a significant decrease in 2012 for pairs consisting of a conservative wife and a progressive husband [5]. This finding is likely due to the small sample size, and Appendix B presents a detailed description of the "near separation" problem exploring this problem. In case of the group with matching gender role preferences shows a different raw trend compared to the other groups. In case of raw trend of cell ownership, it decreases between 2010 and 2014 and increases after 2014. The trend of cohabiting wives is distinctly different from that of left-behind wives[6].

B. Data on Gender Role Preferences

A major contribution of this paper is its investigation of divergent gender role preferences between separated husbands and wives. The CFPS includes several questions that provide information regarding the LMP preferences of wives and husbands. I utilize gender role preference variable collected for 2014 wave. Therefore, I do not consider change in gender role preference across survey waves. The questionnaire item used to assess gender preferences is "Men should focus on their careers, while women should focus on the family." Respondents indicate the degree to which they agree with the statement on a scale of 1–5; the higher the number is, the greater the agreement with conventional gender roles. This question is answered individually; thus, I observe the preferences of both wives and husbands. In the several cases where I observe only wives' preferences or husbands' preferences, I exclude the answers from 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 migration. The gender role preference variables are not directly fed into model; rather, they are used to create subgroups. If a left-behind wife's gender role preference value is smaller than that of her husband, I consider her a more progressive wife. If a left-behind wife's gender role preference value is larger than that of her husband, I consider her a more conservative wife[7].

Figure 2 shows the share of separated couples with gender preferences pairs. I define *preference-matched couples* as those in which the left-behind wife and migrant husband share the same gender role preferences. These include both conservative and progressive preference-matched couples, who represent the largest share of the sample (42%). *Preference-misaligned couples* represent the rest of the sample. The group that I assume will show the most elastic response to an increase in cell ownership and/or expenditure is couples with misaligned prefer-

[5]Figure A2 presents the subgroup trend for employment across survey years. The top panel groups those treated by 2012, and the bottom panel groups those treated by 2014.

[6]Figure A3 shows the overall trend in cell ownership.

[7]See Table A1 for the distribution of the gender role preference variable for pairs.

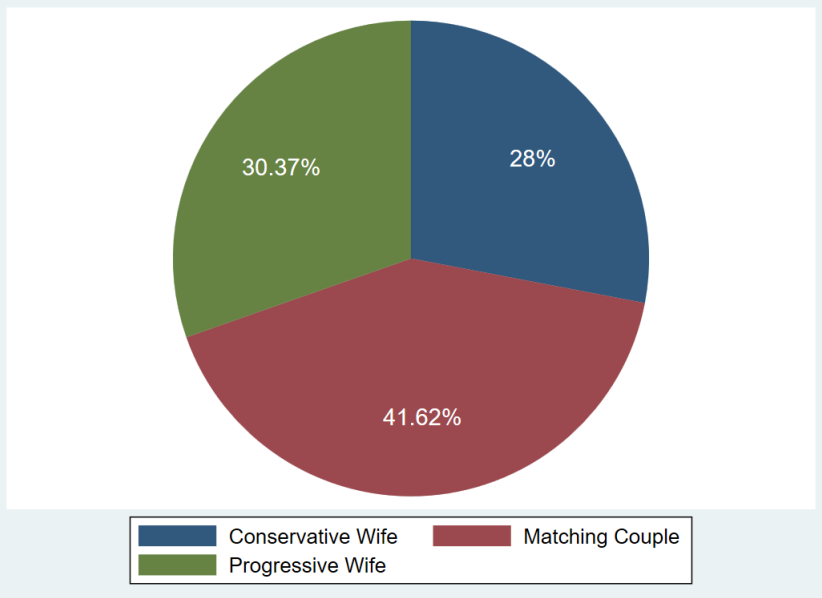


Figure 2. : Shares of Separated Couples By Alignment of Gender Preferences

Note: The questionnaire asked both husbands and wives, 'How much do you agree with the following statement? The husband should work outside, while the wife should stay home and take care of the family.' "5" indicates strong agreement with the statement, and "1" indicates strong disagreement. The most frequent pattern is that husband and wife share the same preference (41.62%); couples consisting of progressive wives and conservative husbands (30.37%) and conservative wives and progressive husbands (28%) appear at similar frequencies. In couples in which the wife is progressive and the husband conservative, the wife's gender role preference questionnaire value is lower than the husband's, and vice versa for couples consisting of a conservative wife and a progressive husband.
Source: CFPS.

ences. Couples consisting of progressive wives and conservative husbands account for 30% of the sample. The remaining 28% of the sample is couples consisting of conservative wives and progressive husbands. Table 4 shows the absolute differences between pairs of husbands and wives. Approximately 42% have no difference, which means that the gender role preferences match. Approximately 30% show a 1-scale difference, and approximately 19% show a 2-scale difference. The majority of differences in gender role preferences show less than a 2-scale difference. In conclusion, we should interpret misalignment in gender role preferences with a caveat. It is possible that the difference in gender role preferences is minimal. Additionally, the majority of gender role preference-matched couples are conservative couples. The estimation results for preference matching couples may reflect the labor market behavior of conservative couples.

I am also aware of limitation of using likert scale. The fundamental limitation is that while the 5-scale gender role attitude measurement categories has a clear rank older, the intervals between these cannot be assumed to be equal (Jamieson, 2004). Appendix section provide main model using absolute value

matching method. Progressive wife and conservative husband pair is defined as wife's response with 1 (progressive) to 2 (less progressive) scale while husband respond with 4 (less conservative) or 5 (conservative) and vise versa [8]. This approach limits the sample size significantly but for progressive wife and conservative husband pair, the result show same sign and slightly larger effect size as Table 14, which is the main CSDID model.

Table 4—: Absolute Difference in the Gender Preference Role Variable between Men and Women in Couples

Absolute Difference	Freq.	Percent	Cum.
0	492	41.62	41.62
1	350	29.61	71.24
2	228	19.29	90.52
3	63	5.33	95.85
4	49	4.15	100.00
Total	**1,182**	**100.00**	

C. Sample Selection and Attrition

The sample of interest is women with migrant husbands. To utilize cell tower installation to represent a change in communication, I use only left-behind women in communities where cell towers were or were never installed during the survey period. In further analysis, I consider men and women in separated couples who responded regarding their gender role preferences. There is attrition in the gender role preference variable and cell tower information. This section aims to verify whether that attrition is random.

Figure 3 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 observations retained for the next stage. Red boxes are dropped observations that do not proceed to the next stage. At the bottom of the diagram are left-behind women who gained cell service during the survey period (2010–2013) or were never treated. Accounting for control variable availability, I am left with 2,000 units, which are further divided into those with gender role preference information (1,182) and those without gender role preference information (818).

Attrition of Cell Tower Information. — The individual and household response rate of the CFPS is, on average, 79.26%. Missing responses are due to a

[8] See Table A10

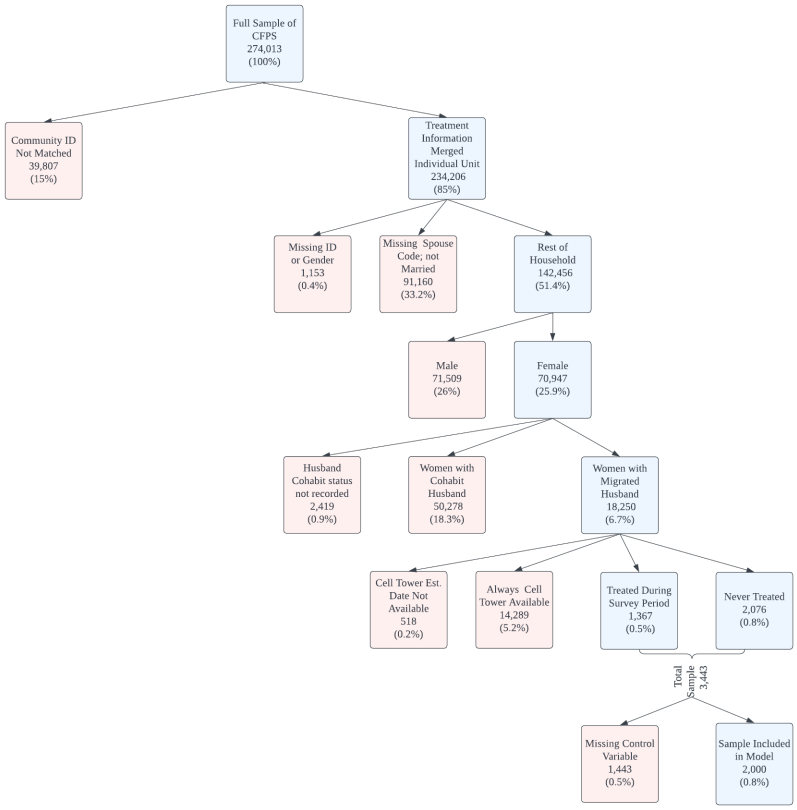


Figure 3. : Sample Selection Process

Note: The top of the diagram represents the full CFPS individual-level sample. Information on cell tower establishment is available at the community level. Information on cohabitation status is available at the individual level.
Source: CFPS.

refusal to be interviewed, survey incompleteness for other reasons, or ineligibility (failure to pass the screening question). Attrition is a problem in panel surveys if there is a potential bias such that the attrition is not random and is associated with potential outcomes (Hausman and Wise, 1979; Wooldridge, 2002). I thoroughly reviewed the survey documents to determine the reason for the attrition and conducted a balance test on the main output of interest.

CFPS data are collected at three levels: the individual, the household, and the 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 because of missing information and errors in the community information provided

at the individual level. The CFPS is the only available data source that provides community-level cell tower information over more than two waves in China. The China Household Finance Survey (CHFS) and China Health and Nutrition Survey (CHNS) cover similar time periods and record cell ownership and usage (indicators that are, however, endogenous to individual and household characteristics), but they provide no information on community cell towers. Therefore, neither the CHFS nor the CHNS can be used to evaluate the causal relationship between communication and the labor market outcomes of rural women. After I merge the cell tower information with the individual-level units, the full sample amounts to 234,206 observations; approximately 15% of the sample is either missing observations or has an error in the community identification for this variable.

Table 5 shows the results of a balance test, dividing continuous from categorical variables. There are some significant differences between the groups with missing and nonmissing cell tower information. Households in the latter group are likely to be less employed, receive less remittances and have a lower monthly food expenditure. They are also 2.4 years younger than those without cell information. The large difference for remittances and food expenditure seems to be due to the survey capturing a specific period or wave rather than a systemic difference. This explanation supports the idea that the missingness of cell tower information is due to omission created from the merging process. Although, there are differences in characteristics by cell tower information availability, it is still the best available information for detecting the change in frequency of communication between men and women in separated couples. As a result, when interpreting results, I need to account for characteristics of sample included in model, such as less likely to be employed and younger in age.

VII. RESULTS

This section demonstrates that cell tower establishment does not have an impact on the employment of left-behind women as a full group. It also shows that cell towers do not show a significant effect for subsamples with the gender role preference variable available for both the wife and her husband. However, the estimation results show a negative impact for subsamples without complete gender role preference information. The difference in the estimation results between the groups with and without the preference variable available can be explained via selection tables. There are some significant differences between those with full information and those without gender role preference information. According to Table 6, those with the gender role preference variable available are more likely to be employed, to receive more remittances from migrant husbands, and to be 1.7 year younger, on average, than those without complete gender role preference information.

Figure 4 presents a flowchart showing the mechanism that connects the treatment and outcome of interest. The Results section presents the second part of the

Table 5—: Selection on the Availability of Cell Tower Information for Households Where the Husband Migrates and the Wife is Left Behind

Panel A: Categorical Variables

	(1) All	(2) Has cell info	(3) No cell info	(4) X^2 Value (df)
Employment	0.599	0.507	0.633	174.94*** (1)
Urban	0.326	0.319	0.328	1.18 (1)
Polluting factory	0.258	0.255	0.259	0.31 (1)
Cell ownership	0.895	0.893	0.897	0.51 (1)
Num. ICT prior	2.187	2.227	2.173	24.65*** (4)
Gender role preference	4.108	4.102	4.109	1.17 (4)
Husband gender role	4.147	4.144	4.148	0.79 (4)
N	18,617	4,578	14,039	

Note: Sample restricted to household with non-cohabiting husband. Reports means by group and chi-squared test statistics for categorical variables. Column 1 shows results for the full sample. Column 2 shows results restricted to observations with cell tower information. Column 3 shows results restricted to observations without cell tower information. * indicates $p < 0.10$, ** indicates $p < 0.05$, *** indicates $p < 0.01$.
Source: China Family Panel Survey (CFPS).

Panel B: Continuous Variables

	(1) All	(2) Has cell info	(3) No cell info	(4) Diff	(5) t-stat
Remittances	7,137.780	492.617	9,304.712	−8,812.095***	55.978
Food expenditure monthly	875.720	197.401	1,095.641	−898.240***	64.192
Highest egg price	6.289	6.304	6.285	0.019	−0.440
Community population	3,558.640	3,538.209	3,565.307	−27.098	0.377
Age	41.672	39.890	42.355	−2.465***	9.782
Floating population	665.748	670.312	664.258	6.054	−0.180
Community area size	160.588	154.022	162.742	−8.720	0.762
Cell fee	51.527	55.799	51.427	4.372	−1.294
N	18,617	4,578	14,039		

Note: Sample restricted to household with non-cohabiting husband. Reports means by group, the difference between groups (Column 2 − Column 3), and the t-statistic from a two-sample t-test with unequal variances for continuous variables. Column 1 shows results for the full sample. Column 2 shows results restricted to observations with cell tower information. Column 3 shows results restricted to observations without cell tower information. * indicates $p < 0.10$, ** indicates $p < 0.05$, *** indicates $p < 0.01$.
Source: China Family Panel Survey (CFPS).

Table 6—: Selection on the availability of gender role preference information in the estimation sample

Panel A: Categorical Variables

	(1) All	(2) Has gen. pref. info	(3) No gen. pref. info	(4) X^2 Value (df)
Employment	0.626	0.672	0.561	25.28*** (1)
Urban	0.327	0.327	0.326	0.002 (1)
Polluting factory	0.245	0.288	0.183	28.42*** (1)
Cell ownership	0.888	0.878	0.904	2.809* (1)
Num ICT prior	0.536	0.542	0.527	7.305* (4)
Gender role preference	4.093	4.051	4.229	12.68** (4)
Husband gender role	4.166	4.172	4.135	13.57*** (4)
N	2,000	1,182	818	

Note: Sample consists of married, left-behind women (women whose husbands are migrants living away from the household) in communities that got a cell tower during the study period or never got a cell tower. Reports means by group and chi-squared test statistics for categorical variables. Column 1 shows results for the full sample. Column 2 shows results restricted to observations with information on gender role preferences of both wives and husbands. Column 3 shows results restricted to observations that do not have information about gender role preferences for at least one spouse. * indicates $p < 0.10$, ** indicates $p < 0.05$, *** indicates $p < 0.01$.
Source: CFPS.

Panel B: Continuous Variables

	(1) All	(2) Has gen. pref. info	(3) No gen. pref. info	(4) Diff	(5) t-stat
Remittances	6,694.350	7,202.876	5,959.535	1,243.341*	−1.847
Food expenditure monthly	818.990	846.719	778.922	67.797	−0.903
Highest egg price	6.607	6.593	6.628	−0.035	0.266
Community population	2,787.729	2,770.281	2,812.943	−42.662	0.287
Age	43.490	42.772	44.528	−1.756***	2.788
Floating population	372.094	393.625	340.981	52.644	−1.442
Community area size	238.094	211.225	276.920	−65.694*	1.652
Cell fee	50.371	49.544	51.807	−2.263	0.773
N	2,000	1,182	818		

Note: Sample consists of married, left-behind women (women whose husbands are migrants living away from the household) in communities that got a cell tower during the study period or never got a cell tower. Reports means by group, the difference between groups (Column 2 − Column 3), and the t-statistic from a two-sample t-test with unequal variances for continuous variables. Column 1 shows results for the full sample. Column 2 shows results restricted to observations with information on gender role preferences of both wives and husbands. Column 3 shows results restricted to observations that do not have information about gender role preferences for at least one spouse. * indicates $p < 0.10$, ** indicates $p < 0.05$, *** indicates $p < 0.01$.
Source: CFPS.

mechanism first, and then, the Mechanism section presents the estimation results for whether cell tower establishment increases communication between men and women in separated couples. The empirical analysis follows. First, the Results section presents TWFE and CSDID models for three groups: the full sample, the group without the gender role preference variable, and the group with the gender role preference variable. Second, the TWFE and CSDID models of the subsample of the group with the gender role preference variable is disaggregated into three groups: the group with matching gender role preferences, the group consisting of progressive wives and conservative husbands, and the group consisting of conservative wives and progressive husbands. Groups with misaligned gender role preferences are further disaggregated into nuclear households to understand how the household structure influences the communication between men and women in separated couples. This main results show how increased monitoring power influences left-behind women's labor supply. I find that among left-behind wives whose gender preferences are misaligned with their husbands', an increase in monitoring power shifts their LMP decision into alignment with their husbands' preferences. This finding means that left-behind women who prefer to work or not to work are influenced by their migrant husbands into participating or not participating in the labor market.

A. Impact of the Construction of Cell Towers on the Full Estimation Sample

Table 7 presents the summary statistics of all observations, observations with gender role preference information available, and observations with gender role preference information not available. The main output of interest, employment, shows an upward trend regardless of groups being ever or never treated across panels. Treated groups tend to show a sharper increase in the probability of employment than never-treated women do. The women included in Panel B are notably higher in terms of their employment probability. Remittances from migrant family members roughly triple after treatment across all treated groups. Never-treated groups also show growth in remittances. Additionally, treated communities are more rural and smaller in size. The urban share is lower for treated communities than for never-treated communities. The population size is also half that of never-treated communities. It is likely that cell towers were rolled out in less-developed and remote communities, while never-treated communities were located relatively close to cities where rolling out cell towers was not a priority project. Cell ownership is already high in the pretreatment period across groups. Some may be puzzled about why left-behind women would own a cell phone without a cell signal available in the community. Since 2003, China has been engaged in a national-level project to expand its ICT infrastructure at an extensive scale (Zhang Chi, 2019). Therefore, the communities that established their first cell towers during the survey period are among the most underdeveloped neighborhoods in the country. China has good coverage even in its most underdeveloped

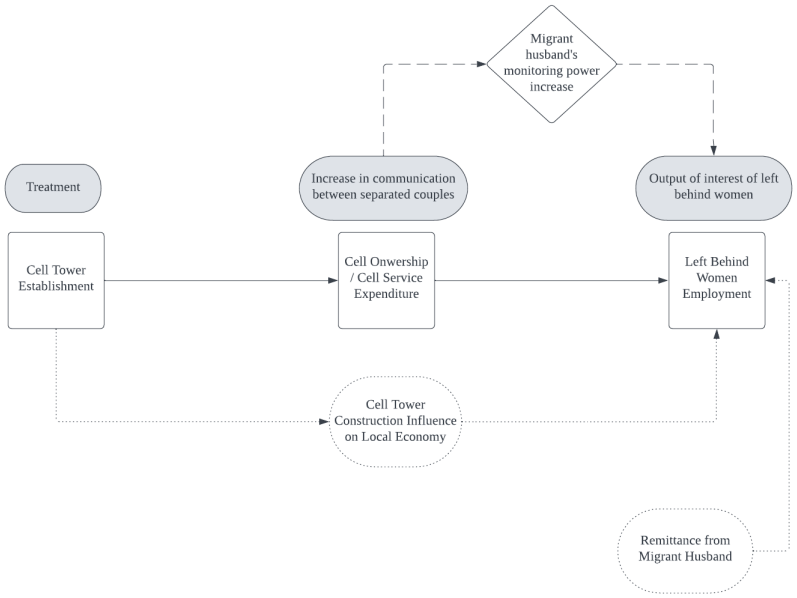


Figure 4. : Mechanism Diagram

Note: The diagram represents the mechanism of this study. The treatment is cell tower establishment in China, which represents a shock to communication between men and women in separated couples (left behind wives and husbands who migrated out). Left-behind wives' increase in cell ownership and/or expenditure, which are proxies for communication between men and women in separated couples, will increase husbands' monitoring environment strength over their wives. Increased monitoring by husbands changes the LMP of their left-behind wives. Factors other than communication between men and women in separated couples also influence left-behind women's LMP. The first main factor is remittances from migrant husbands. The second factor is how a new cell tower impacts the local economy, for example, by creating jobs and bringing workers to the community. Both factors are controlled for in the main model to isolate the impact of communication on LMP.

areas. Because of this infrastructure situation, residents can travel to a nearby town with a phone signal to use a cell phone, which is why cell ownership is high among left-behind women. Once a cell tower is established within the community, left-behind women have much easier access to communication with their migrant husbands. The gender role preferences of wives and husbands are close to 4, which is relatively conservative, and there is no dramatic change between the pre- and posttreatment periods. Lastly, the group of never-treated wives is older than the treated groups.

Figure 5 plots the event study style plot. Importantly, the presented plot is not a conventional event study plot. An event study is based on a TWFE model with relative time dummies and still suffers from negative weights and incorrect comparison when there is multiple treatment timing. In contrast, CSDID models calculate group-time average treatment effects for all cohort and aggregate to create pre- and posttrend effects. According to Figure 5, all three groups satisfy the parallel trends assumption condition on normalized covariates. As the group treated by 2012 has only one pretreatment period while the group treated by 2014 has two pretreatment periods, the CSDID approach uses both groups for collective testing and a simultaneous inference approach. The CSDID approach calculates the simultaneous confidence interval across disaggregated group-time average treatment effects and makes it possible to test the entire set of pseudo-group-time average treatment effects.

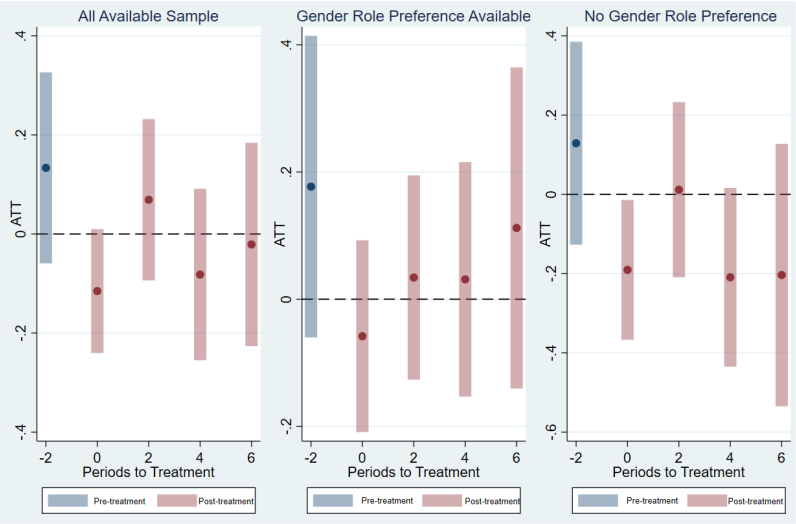


Figure 5. : Pre- and Posttreatment Trend: Full Sample

Table 7—: Summary Statistics, Full Sample

Panel A: All observations

		Ever Treated		Treated by 2012		Treated by 2014		Never Treated	
Variable	All	Pre	Post	Pre	Post	Pre	Post	2010–2014	2016–2018
Employment	Mean	0.578	0.760	0.559	0.698	0.589	0.836	0.530	0.684
	(Std)	(0.495)	(0.428)	(0.499)	(0.460)	(0.494)	(0.371)	(0.499)	(0.466)
Wife gender role pref.	Mean	3.965	3.966	3.874	3.904	4.016	4.042	4.146	4.235
	(Std)	(1.256)	(1.250)	(1.330)	(1.287)	(1.215)	(1.202)	(1.109)	(1.054)
Husb. gender role pref.	Mean	4.132	4.227	4.369	4.375	4.008	4.066	4.189	4.063
	(Std)	(1.015)	(0.931)	(0.858)	(0.841)	(1.071)	(0.998)	(1.099)	(1.149)
Cell ownership	Mean	0.967	0.914	0.956	0.936	0.973	0.887	0.853	0.876
	(Std)	(0.178)	(0.280)	(0.207)	(0.245)	(0.164)	(0.317)	(0.354)	(0.330)
Cell fee	Mean	37.171	53.729	39.185	54.596	33.900	52.989	48.009	53.433
	(Std)	(27.311)	(50.088)	(29.492)	(52.132)	(23.325)	(48.406)	(46.195)	(41.279)
Remittance	Mean	2,340.1	9,862.1	3,538.2	9,487.8	1,641.7	10,322.6	3,689.9	11,593.2
	(Std)	(7,177.8)	(13,893.8)	(5,323.7)	(13,474.1)	(7,996.1)	(14,410.1)	(10,386.0)	(22,092.5)
Food expenditure	Mean	306.9	814.8	459.7	674.7	217.8	987.1	719.8	1,359.6
	(Std)	(481.5)	(958.1)	(643.5)	(910.2)	(325.0)	(989.1)	(1,937.9)	(1,236.6)
Age	Mean	39.10	42.58	39.05	42.35	39.13	42.85	43.01	48.47
	(Std)	(12.05)	(11.49)	(11.35)	(10.71)	(12.47)	(12.40)	(14.49)	(14.18)
Urban	Mean	0.123	0.133	0.186	0.173	0.086	0.084	0.456	0.449
	(Std)	(0.329)	(0.340)	(0.391)	(0.379)	(0.281)	(0.278)	(0.498)	(0.498)
Highest Egg price	Mean	6.369	6.486	6.709	6.737	6.171	6.177	6.610	6.908
	(Std)	(3.518)	(3.558)	(2.702)	(2.767)	(3.909)	(4.325)	(2.473)	(2.557)
No. persons	Mean	1,687.2	1,643.1	1,813.3	1,767.5	1,613.7	1,490.0	3,622.4	3,294.6
	(Std)	(1,202.6)	(1,292.4)	(1,521.4)	(1,562.2)	(1,265.8)	(828.9)	(4,020.4)	(3,762.1)
Polluting factory	Mean	0.119	0.153	0.118	0.144	0.120	0.164	0.311	0.314
	(Std)	(0.325)	(0.360)	(0.324)	(0.352)	(0.326)	(0.371)	(0.463)	(0.465)
Float pop.	Mean	144.042	128.618	133.907	134.822	149.949	120.987	559.133	457.396
	(Std)	(276.932)	(283.759)	(314.841)	(332.490)	(253.012)	(209.286)	(1,140.792)	(926.032)
Num. ICT prior	Mean	1.007	0.893	0.637	0.568	1.223	1.292	0.294	0.256
	(Std)	(0.932)	(0.944)	(0.854)	(0.820)	(0.911)	(0.935)	(0.579)	(0.536)
Area size	Mean	268.0	188.6	127.7	121.3	349.9	271.5	240.1	274.3
	(Std)	(1,059.1)	(844.9)	(522.8)	(512.4)	(1,265.8)	(1,122.6)	(790.1)	(860.1)
Observations	2,000	277	504	102	278	175	226	805	414

Panel B: Observations with gender role preference information

		Ever Treated		Treated by 2012		Treated by 2014		Never Treated	
Variable	All	Pre	Post	Pre	Post	Pre	Post	2010–2014[a]	2016–2018[a]
Employment	Mean	0.581	0.801	0.509	0.744	0.620	0.865	0.582	0.724
	(Std)	(0.495)	(0.400)	(0.505)	(0.437)	(0.488)	(0.342)	(0.494)	(0.448)
Wife gender role pref.	Mean	4.006	3.929	3.764	3.811	4.140	4.064	4.094	4.172
	(Std)	(1.241)	(1.284)	(1.374)	(1.340)	(1.146)	(1.206)	(1.117)	(1.067)
Husb. gender role pref.	Mean	4.103	4.202	4.309	4.322	3.990	4.064	4.200	4.116
	(Std)	(1.001)	(0.924)	(0.836)	(0.843)	(1.068)	(0.995)	(1.089)	(1.112)
Cell ownership	Mean	0.967	0.910	0.950	0.938	0.976	0.877	0.835	0.864
	(Std)	(0.179)	(0.287)	(0.221)	(0.242)	(0.155)	(0.329)	(0.372)	(0.344)
Cell fee	Mean	38.207	49.836	40.263	52.237	34.300	47.824	48.394	53.931
	(Std)	(25.225)	(43.994)	(25.200)	(44.623)	(25.450)	(43.523)	(39.412)	(44.302)
Remittance	Mean	2,559.4	10,302.7	3,830.9	10,017.2	1,860.0	10,632.1	4,535.7	11,092.7
	(Std)	(8,946.9)	(14,462.0)	(5,852.1)	(14,055.2)	(10,219.8)	(14,956.4)	(11,981.9)	(18,098.0)
Food expenditure	Mean	337.8	898.1	517.9	783.1	238.7	1,030.8	760.5	1,282.8
	(Std)	(534.4)	(1,004.4)	(740.5)	(1,046.1)	(342.4)	(939.8)	(932.8)	(1,144.7)
Age	Mean	37.27	41.01	35.89	40.50	38.03	41.59	43.30	47.97
	(Std)	(10.29)	(10.30)	(9.36)	(9.97)	(10.74)	(10.66)	(14.43)	(14.33)
Urban	Mean	0.129	0.146	0.200	0.189	0.090	0.096	0.468	0.444
	(Std)	(0.336)	(0.353)	(0.404)	(0.393)	(0.288)	(0.296)	(0.499)	(0.498)
Highest Egg price	Mean	6.496	6.681	6.833	6.755	6.311	6.595	6.500	6.713
	(Std)	(3.859)	(3.934)	(2.934)	(2.899)	(4.286)	(4.871)	(2.336)	(2.464)
No. persons	Mean	1,588.4	1,608.1	1,800.6	1,780.1	1,471.7	1,409.7	3,736.8	3,330.8
	(Std)	(1,276.8)	(1,392.8)	(1,773.6)	(1,746.4)	(883.9)	(772.4)	(4,200.5)	(3,779.6)
Polluting factory	Mean	0.155	0.161	0.127	0.139	0.170	0.186	0.370	0.397
	(Std)	(0.363)	(0.368)	(0.336)	(0.347)	(0.378)	(0.390)	(0.483)	(0.490)
Float pop.	Mean	126.774	126.034	151.255	148.444	113.310	100.176	623.036	505.575
	(Std)	(280.716)	(309.605)	(405.756)	(397.726)	(179.614)	(152.432)	(1,361.056)	(1,110.392)
Num. ICT prior	Mean	1.019	0.857	0.509	0.467	1.300	1.308	0.283	0.280
	(Std)	(0.936)	(0.932)	(0.791)	(0.772)	(0.893)	(0.899)	(0.578)	(0.591)
Area size	Mean	295.7	183.4	93.4	87.0	406.9	294.7	205.3	206.8
	(Std)	(1,129.4)	(851.9)	(416.9)	(394.9)	(1,361.7)	(1,168.4)	(729.2)	(723.6)
Observations	1,182	155	336	55	180	100	156	459	232

Note: Never treated group does not have a defined pre- and post-period; therefore 2010–2014 is considered pre-period and 2016–2018 is considered post-period. While summary statistics show raw data, covariates included in the model are Winsorized and normalized.
Source: CFPS.

Continued: Summary Statistics, Full Sample

Panel C: Observations without gender role preference information

		Ever Treated		Treated by 2012		Treated by 2014		Never Treated	
Variable	All	Pre	Post	Pre	Post	Pre	Post	2010–2014[a]	2016–2018[a]
Employment	Mean	0.574	0.679	0.617	0.612	0.547	0.771	0.462	0.632
	(Std)	(0.497)	(0.468)	(0.491)	(0.490)	(0.501)	(0.423)	(0.499)	(0.484)
Wife gender role pref.	Mean	3.814	4.123	4.250	4.250	3.556	3.939	4.301	4.410
	(Std)	(1.314)	(1.088)	(1.125)	(1.000)	(1.368)	(1.197)	(1.074)	(1.000)
Husb. gender role pref.	Mean	4.265	4.404	4.700	4.850	4.083	4.074	4.123	3.830
	(Std)	(1.082)	(0.970)	(0.949)	(0.671)	(1.100)	(1.035)	(1.155)	(1.282)
Cell ownership	Mean	0.967	0.925	0.964	0.933	0.969	0.914	0.879	0.893
	(Std)	(0.179)	(0.264)	(0.189)	(0.252)	(0.175)	(0.283)	(0.327)	(0.310)
Cell fee	Mean	35.894	63.460	37.667	60.319	33.500	66.245	47.341	52.755
	(Std)	(29.915)	(61.986)	(35.116)	(67.190)	(21.649)	(57.487)	(56.212)	(36.919)
Remittance	Mean	2,061.5	8,981.0	3,195.7	8,515.3	1,350.7	9,632.9	2,567.9	12,231.3
	(Std)	(3,937.0)	(12,676.8)	(4,669.5)	(12,346.1)	(3,234.3)	(13,188.0)	(7,653.7)	(26,361.6)
Food expenditure	Mean	267.6	648.1	391.6	475.6	189.9	889.6	665.8	1,457.4
	(Std)	(403.1)	(836.4)	(506.7)	(533.3)	(300.3)	(1,091.8)	(2,755.3)	(1,341.7)
Age	Mean	41.43	45.71	42.74	45.76	40.60	45.66	42.64	49.10
	(Std)	(13.67)	(13.05)	(12.42)	(11.24)	(14.41)	(15.31)	(14.58)	(14.00)
Urban	Mean	0.115	0.107	0.170	0.143	0.080	0.057	0.439	0.456
	(Std)	(0.320)	(0.310)	(0.380)	(0.352)	(0.273)	(0.234)	(0.497)	(0.499)
Highest Egg price	Mean	6.208	6.096	6.565	6.705	5.984	5.244	6.756	7.157
	(Std)	(3.038)	(2.620)	(2.427)	(2.522)	(3.362)	(2.532)	(2.640)	(2.657)
No. persons	Mean	1,812.7	1,713.0	1,828.1	1,744.4	1,803.0	1,669.0	3,470.7	3,248.4
	(Std)	(1,093.4)	(1,064.1)	(1,178.6)	(1,157.6)	(1,044.6)	(923.8)	(3,768.9)	(3,749.5)
Polluting factory	Mean	0.074	0.137	0.106	0.153	0.053	0.114	0.231	0.209
	(Std)	(0.262)	(0.345)	(0.312)	(0.362)	(0.226)	(0.320)	(0.422)	(0.408)
Float pop.	Mean	165.980	133.786	113.606	109.801	198.800	167.364	474.360	395.981
	(Std)	(271.611)	(224.047)	(153.597)	(151.012)	(321.137)	(295.756)	(748.985)	(613.480)
Num. ICT prior	Mean	0.992	0.964	0.787	0.755	1.120	1.257	0.309	0.225
	(Std)	(0.932)	(0.966)	(0.907)	(0.874)	(0.929)	(1.017)	(0.580)	(0.457)
Area size	Mean	232.9	199.1	167.8	184.2	273.7	219.8	286.3	360.4
	(Std)	(965.7)	(833.2)	(626.8)	(675.2)	(1,129.8)	(1,019.2)	(863.3)	(1,003.2)
Observations	818	122	168	47	98	75	70	346	182

Note: Never treated group does not have a defined pre- and post-period; therefore 2010–2014 is considered pre-period and 2016–2018 is considered post-period. While summary statistics show raw data, covariates included in the model are Winsorized and normalized. See "Near Separation in CSDID" for reason of normalization and detailed steps.
Source: CFPS.

The blue bar of each figure in Figure 5 shows the result from a test of the conditional parallel trends assumption. If the null hypothesis cannot be rejected (touches the horizontal zero line), the result provides suggestive evidence that the pretrends may be parallel, in other words, considering community and individual traits, the pretreatment employment trends of treated units (left-behind wives who ever have access to a cell tower) and comparison units (left-behind wives who never have access to a cell tower) are likely to be parallel.

Table 9—: Canonical Difference-in-Differences: Full Sample

	(1)	(2)	(3)
	All observation	Has gen. role pref. info	No gen. role pref. info
Cell tower × after	0.207***	0.209***	0.203***
	(0.0303)	(0.0426)	(0.0430)
Cell tower	0.122***	0.127**	0.101*
	(0.0288)	(0.0370)	(0.0458)
Constant	0.471***	0.502***	0.442***
	(0.0227)	(0.0325)	(0.0315)
Individual Controls	No	No	No
Community Controls	No	No	No
Pre-treatment Mean	0.471	0.502	0.442
N	1,404	732	672

Note: Estimated by OLS using difference-in-difference model specification. The dependent variable is a binary employment variable. Sample consisted of married, left-behind women (women whose husbands are migrants living away from the household) in communities that got a cell tower during the study period (2010–2013) or never got a cell tower. All models only include 2010 (pre-treatment), 2016, and 2018 (post-treatment) observations. There is only one treatment period which is between 2010–2013. Column 1 shows results for the full sample. Column 2 shows results restricted to observations with information on gender role preferences of both wives and husbands. Column 3 shows results restricted to observations that do not have information about gender role preferences for at least one spouse. No individual or community controls included. Robust standard errors in parentheses. * indicates $p < 0.10$, ** indicates $p < 0.05$, *** indicates $p < 0.01$.
Source: China Family Panel Survey (CFPS).

The Impact of Cell Tower Establishment on LMP: TWFE and the Full Sample. — The first step in exploring the model is checking the canonical TWFE results. Importantly, the treatment period of cell tower establishment varies by time. I am aware of negative weights and incorrect comparison groups created by the canonical TWFE model in the case of multiple treatment timing. If the TWFE method is used for multiple treatment period analysis, the estimation results will be biased. This bias will occur as a result of comparing not-yet-treated units with already-treated units. A recent innovation developed by Callaway

and Sant'Anna (2021); Goodman-Bacon (2021) corrects for this bias by using bootstrapping, inverse probability weights, and matching. However, it is useful to check the canonical TWFE results to understand the conventional results. To minimize potential bias, I include only three waves: one pretreatment wave (2010) and two posttreatment waves (2016 and 2018). Multiple treatment timings are merged into a single period (2010 to 2013) in canonical TWFE model.

Table 9 is the TWFE model results for the relationship between cell tower establishment and the employment status of left-behind women. The dependent variable is a binary variable indicating employment status. Model (1) shows the results for the full sample without any controls. The "after" variable is missing for the control group, which does not have a cell tower established in its community. The control group does not have a postperiod, and therefore, the interaction term absorbs the "after" variable. According to the estimation results, the establishment of a cell tower increases the probability of LMP by 20.7%. Model (2) presents the results for the sample with gender role preference information. There is a 20.9% increase in the probability of LMP, and this finding is positive and significant. Additionally, this result is consistent with that of Model (3) which is run for the group in which the gender role preference variable is missing. The positive and significant result follows the literature reporting a positive relationship between cell tower establishment and LMP, enterprise performance, and growth, mostly using association methods (Leng et al., 2020; Min, Liu and Huang, 2020; Rajkhowa and Qaim, 2022; Khanal and Mishra, 2016; Barnett, Hu and Wang, 2019).

Impact of Cell Tower Establishment on LMP: CSDID and the Full Sample. — Notably, the treatment period of cell tower installation varies across communities. To avoid the problems with negative weights and incorrect comparison groups created by the canonical TWFE model in the presence of staggered treatment timing, I turn to the recent innovations by Callaway and Sant'Anna (2021) and Goodman-Bacon (2021) to correct for these biases.

In this section, I apply the CSDID approach. The method of Callaway and Sant'Anna (2021) is suitable for my research setting because not all cell towers were established in one year. The CFPS community survey allows me to aggregate biannual information on the timing of tower installation. The main result is used to compare the "2012 treated" cohort and the never-treated group as well as the "2014 treated" cohort and the never-treated group.

Table 10 presents the results from a model with standardized covariates that explores the relationship between cell tower installation and the employment status of left-behind women. Each model includes a set of standardized controls (See the "Near Separation in CSDID" section of the Methodology section) that pass the conditional parallel trends test. The recommended interpretation of the coef-

Table 10—: CSDID: Full Sample, with Standardized Covariates

	(1)	(2)	(3)
	All observations	Has gen. pref. info	No gen. role pref. info
ATT (Treated by 2012)	0.0076	0.0877	-0.1335
	(0.0721)	(0.0854)	(0.0958)
ATT (Treated by 2014)	-0.0984	-0.0807	-0.1365
	(0.0912)	(0.0982)	(0.1139)
ATT (Ever treated)	-0.0399	0.0095	-0.1347*
	(0.0589)	(0.0642)	(0.0740)
Individual Controls	Yes	Yes	Yes
Community Controls	Yes	Yes	Yes
Pre-treatment mean	0.582	0.630	0.521
N	2,000	1,182	818

Note: Estimated using the Callaway and Sant'Anna (2021) difference-in-differences estimator with regression adjustment (RA) method. The dependent variable is a binary employment variable. Sample consists of married, left-behind women (women whose husbands are migrants living away from the household) in communities that got a cell tower during the study period or never got a cell tower. ATT (Treated by 2012) and ATT (Treated by 2014) report the average treatment effect on the treated for cohorts treated by 2012 and 2014, respectively. ATT (Ever treated) reports the overall average treatment effect on the treated across all cohorts. Column 1 shows results for the full sample. Column 2 shows results restricted to observations with information on gender role preferences of both wives and husbands. Column 3 shows results restricted to observations that do not have information about gender role preferences for at least one spouse. Individual controls include urban residence, standardized remittances, and standardized age. Community controls include standardized highest egg price, standardized monthly food expenditure, standardized floating population (without household registration), standardized polluting factory (within 5km), standardized community area size, and standardized prior ICT availability. Pre-treatment mean refers to the mean employment rate of the never-treated control group and outcome before cell tower establishment for treated group. Robust standard errors in parentheses. * indicates $p < 0.10$, ** indicates $p < 0.05$, *** indicates $p < 0.01$.
Source: China Family Panel Survey (CFPS).

ficients is not across models but, rather, between the treated and not-yet-treated groups for each subsample.

Model (1) is a CSDID model estimated for all observations regardless of the availability of the gender role preference variable. Model (2) is run for the sample of observations with the gender role preference variable available. Both results shows a null effect. In other words, cell tower establishment is not related with left behind women's employment. The conditional pretrends test cannot reject the null hypothesis that the estimates on all pretreatment trends equal zero. The null impact on left-behind women's LMP can be related to the size of the subsample of separated couples with matching preferences. According to Figure 2, the total number of left-behind women whose preferences match their husbands' is approximately 41.62% of the sample. In theory, these couples should show a null effect of an increase in communication via cell towers, as they already have matching preferences. Preference-misaligned couples account for an almost equal share: 30.37% of the sample consists of progressive wives with conservative husbands, and 28% consists of couples with conservative wives and progressive husbands. If communication with their migrant husbands sways women's LMP away from what these women prefer, then the impact should be the opposite between these groups. Such opposite impacts and similar share could hide an impact of communication between men and women in separated couples with misaligned gender role preferences.

Model (3) on the sample of left-behind women for whom the gender role preference variable is unavailable. The estimation results show a negative impact for the aggregated ATT and the level of significance is close to 10% (6.9%). In other words, cell tower establishment reduce left behind women's employment only for those who did not report both party's gender role preference. Additionally, the the conditional parallel trends assumption holds. The model includes both individual and community controls, including an urban/rural binary indicator, standardized remittances from migrant husbands, the standardized highest price of eggs, the standardized area size, standardized age, and the number of ICT infrastructures available before cell tower establishment. The difference among Model (1), (2), and (3) are likely due to differences in underlying covariates shown in Table 6. It weakens the external validity of the estimation result.

B. Impact of Cell Tower Construction by Subgroup

This section divides the sample into subgroups to further understand how cell tower establishment influences left-behind women's LMP. Cell towers increase the monitoring environment, and therefore, the influence of migrant husbands on their left-behind wives is strengthened among those in communities with new cell towers. As a result, I expect that for the group consisting of husbands and wives with matching gender role preferences, there is no effect. Although the frequency of communication between men and women in separated couples increases, because

the gender role preferences of husbands and wives match, left-behind women will not change their labor market behavior. In the case of pairs consisting of progressives wives and conservative husbands, the husbands will not want their wives to work. The increased monitoring environment will put pressure on left-behind women who prefer to work to stay home. I expect a negative ATT. In the case of pairs consisting of conservative wives and progressive husbands, the husbands will want their left-behind wives to work, and via the increased monitoring environment, left-behind wives will increase their LMP. I expect a positive ATT. The impact of cell tower construction is expected to have heterogeneous effects depending on the household structure. Left-behind women living in an extended household, that is, those living with maternal parents and/or in-laws, may receive higher pressure regarding their labor market behavior compared to those living in a nuclear household.

Table 11 presents summary statistics by subsample: preference-matched couples, couples consisting of progressive wives and conservative husbands, and couples consisting of conservative wives and progressive husbands. The main output of interest, employment, jump sharply from pre- to posttreatment regardless of subgroup. The group consisting of progressive wives and conservative husbands has the lowest pretreatment employment, which is 72.5% for the ever-treated group. The remittance size triples across all panels in the posttreatment period. Never-treated communities had a larger floating population and a higher urban share. These results confirm that a treated region is likely to be a remote area. In Panel C, area size is unusually small. In particular, for the cohort treated by 2014, the posttreated value is far smaller than those for other groups and panels. This result is likely due to the small sample size. Lastly, food expenditure grows faster between the pre- and postperiods for never-treated communities. This finding may reflect the high baseline wealth of the never-treated group.

The blue bar of each figure in Figure 6 shows the result of a conditional parallel trends test. For all three groups, the null hypothesis cannot be rejected. As a result, the pretrends may be parallel. In other words, controlling for community and individual traits, ever-treated and never-treated groups show parallel trends for the period before treatment.

Impact of Cell Tower Establishment Impact on LMP: TWFE and Subgroups. — Before presenting the CSDID model, I present the TWFE results. According to Table 13, the treatment effect of cell tower establishment is higher for the group with matching preferences and the group consisting of conservative wives and progressive husbands, while progressive wife and conservative husband group show null effect. Model (1) presents the results for the group with matching preferences, and Model (3) presents the results for the group consisting of conservative wives and progressive husbands. In both models, cell tower establishment

Table 11—: Summary Statistics, Subsamples

Panel A: Gender Role Preference Match

		Ever Treated		Treated by 2012		Treated by 2014		Never Treated	
Variable		Pre	Post	Pre	Post	Pre	Post	2010–2014	2016–2018
Employment	Mean	0.396	0.809	0.545	0.812	0.269	0.805	0.569	0.723
	(Std)	(0.494)	(0.395)	(0.510)	(0.394)	(0.452)	(0.401)	(0.496)	(0.449)
Wife gender role pref.	Mean	4.625	4.627	4.591	4.638	4.654	4.610	4.641	4.589
	(Std)	(0.672)	(0.662)	(0.666)	(0.618)	(0.689)	(0.737)	(0.692)	(0.730)
Husb. gender role pref.	Mean	4.625	4.627	4.591	4.638	4.654	4.610	4.641	4.589
	(Std)	(0.672)	(0.662)	(0.666)	(0.618)	(0.689)	(0.737)	(0.692)	(0.730)
Cell ownership	Mean	0.941	0.935	0.923	0.941	0.952	0.925	0.847	0.837
	(Std)	(0.239)	(0.247)	(0.277)	(0.237)	(0.218)	(0.267)	(0.361)	(0.372)
Cell fee	Mean	50.938	44.475	57.917	50.349	30.000	37.649	42.333	58.140
	(Std)	(33.077)	(33.143)	(34.737)	(36.813)	(16.330)	(27.209)	(30.433)	(49.713)
Remittance	Mean	1,977.1	11,397.3	3,404.5	11,102.9	769.2	11,892.7	3,984.1	13,906.3
	(Std)	(4,145.3)	(14,178.4)	(5,137.4)	(14,842.6)	(2,612.4)	(13,148.6)	(9,845.1)	(20,379.6)
Food expenditure	Mean	271.8	733.2	355.7	677.4	200.8	827.1	626.0	1,207.4
	(Std)	(293.0)	(758.0)	(310.7)	(793.5)	(262.4)	(693.5)	(711.1)	(939.7)
Age	Mean	36.813	41.791	37.045	41.594	36.615	42.122	43.031	47.098
	(Std)	(10.229)	(10.116)	(9.010)	(8.969)	(11.332)	(11.913)	(14.750)	(14.756)
Urban	Mean	0.146	0.127	0.136	0.101	0.154	0.171	0.451	0.420
	(Std)	(0.357)	(0.335)	(0.351)	(0.304)	(0.368)	(0.381)	(0.499)	(0.496)
Highest egg price	Mean	7.103	7.321	7.400	7.259	6.852	7.427	6.433	6.521
	(Std)	(4.176)	(4.315)	(3.283)	(3.242)	(4.857)	(5.732)	(2.366)	(2.471)
No. persons	Mean	1,312.6	1,360.0	1,387.8	1,409.2	1,248.9	1,277.2	3,694.5	3,571.5
	(Std)	(768.5)	(847.5)	(941.2)	(968.2)	(597.5)	(593.8)	(4,299.8)	(4,208.0)
Polluting factory	Mean	0.188	0.182	0.136	0.145	0.231	0.244	0.451	0.482
	(Std)	(0.394)	(0.387)	(0.351)	(0.355)	(0.430)	(0.435)	(0.499)	(0.502)
Float pop.	Mean	39.927	42.314	45.682	40.246	35.058	45.793	578.046	549.933
	(Std)	(51.464)	(49.288)	(55.414)	(48.638)	(48.436)	(50.777)	(1,380.422)	(1,321.183)
Num. ICT prior	Mean	1.000	0.855	0.636	0.565	1.308	1.341	0.292	0.321
	(Std)	(0.875)	(0.855)	(0.790)	(0.757)	(0.838)	(0.794)	(0.602)	(0.633)
Area size	Mean	549.342	305.552	57.187	49.700	965.781	736.132	273.496	288.917
	(Std)	(1,537.632)	(1,137.422)	(148.046)	(122.743)	(2,008.231)	(1,787.973)	(851.960)	(872.561)
Household type	Mean	0.875	0.435	0.955	0.353	0.808	0.575	0.698	0.566
	(Std)	(0.334)	(0.498)	(0.213)	(0.481)	(0.402)	(0.501)	(0.460)	(0.498)
Observations	465	48	110	22	69	26	41	195	112

Panel B: Progressive Wife and Conservative Husband

		Ever Treated		Treated by 2012		Treated by 2014		Never Treated	
Variable		Pre	Post	Pre	Post	Pre	Post	2010–2014	2016–2018
Employment	Mean	0.725	0.798	0.524	0.762	0.867	0.848	0.607	0.678
	(Std)	(0.451)	(0.403)	(0.512)	(0.429)	(0.346)	(0.363)	(0.490)	(0.471)
Wife gender role pref.	Mean	2.725	2.550	2.381	2.381	2.967	2.783	2.917	2.881
	(Std)	(1.115)	(1.101)	(1.071)	(1.038)	(1.098)	(1.153)	(0.909)	(0.873)
Husb. gender role pref.	Mean	4.569	4.578	4.524	4.587	4.600	4.565	4.710	4.559
	(Std)	(0.671)	(0.657)	(0.750)	(0.663)	(0.621)	(0.655)	(0.526)	(0.623)
Cell ownership	Mean	0.977	0.898	1.000	0.968	0.962	0.804	0.842	0.947
	(Std)	(0.152)	(0.304)	(0.000)	(0.178)	(0.196)	(0.401)	(0.366)	(0.225)
Cell fee	Mean	36.250	59.481	34.706	55.833	40.000	63.622	53.928	55.630
	(Std)	(18.430)	(57.288)	(13.401)	(51.489)	(28.284)	(63.705)	(45.377)	(42.116)
Remittance	Mean	2,211.8	8,848.6	4,990.5	8,952.4	266.7	8,706.5	3,682.8	8,864.4
	(Std)	(4,838.9)	(13,989.7)	(6,569.8)	(14,130.1)	(1,048.3)	(13,949.3)	(10,796.7)	(18,661.7)
Food expenditure	Mean	449.6	1,034.9	693.3	886.2	279.0	1,243.1	932.3	1,666.3
	(Std)	(645.6)	(1,161.7)	(798.0)	(1,188.6)	(454.1)	(1,102.3)	(1,138.7)	(1,591.7)
Age	Mean	36.373	40.174	34.095	39.254	37.967	41.435	44.428	47.797
	(Std)	(11.144)	(10.948)	(10.207)	(11.183)	(11.657)	(10.607)	(13.833)	(13.359)
Urban	Mean	0.196	0.257	0.333	0.349	0.100	0.130	0.469	0.525
	(Std)	(0.401)	(0.439)	(0.483)	(0.481)	(0.305)	(0.341)	(0.501)	(0.504)
Highest egg price	Mean	5.884	5.979	6.238	6.183	5.637	5.700	6.495	6.525
	(Std)	(3.170)	(3.154)	(2.752)	(2.610)	(3.456)	(3.788)	(2.088)	(2.049)
No. persons	Mean	1,972.9	1,973.4	2,167.5	2,165.9	1,836.7	1,709.8	4,090.4	3,500.8
	(Std)	(1,815.2)	(2,011.2)	(2,511.1)	(2,488.0)	(1,133.7)	(1,027.6)	(4,409.2)	(3,678.0)
Polluting factory	Mean	0.196	0.202	0.143	0.175	0.233	0.239	0.262	0.237
	(Std)	(0.401)	(0.403)	(0.359)	(0.383)	(0.430)	(0.431)	(0.441)	(0.429)
Float pop.	Mean	213.922	228.578	265.905	286.484	177.533	149.272	720.617	517.169
	(Std)	(448.988)	(505.310)	(628.505)	(631.240)	(267.987)	(229.550)	(1,487.361)	(890.190)
Num. ICT prior	Mean	0.784	0.688	0.429	0.444	1.033	1.022	0.297	0.237
	(Std)	(0.966)	(0.950)	(0.870)	(0.894)	(0.964)	(0.931)	(0.567)	(0.536)
Area size	Mean	17.099	20.084	28.402	28.903	9.187	8.005	272.727	233.718
	(Std)	(37.508)	(43.373)	(56.034)	(55.040)	(10.148)	(9.111)	(841.519)	(784.092)
Household type	Mean	0.843	0.495	0.952	0.410	0.767	0.609	0.741	0.526
	(Std)	(0.367)	(0.502)	(0.218)	(0.496)	(0.430)	(0.493)	(0.439)	(0.504)
Observations	364	51	109	21	63	30	46	145	59

Note: Never treated group does not have a defined pre- and post-period; therefore 2010–2014 is considered pre-period and 2016–2018 is considered post-period.
Source: CFPS.

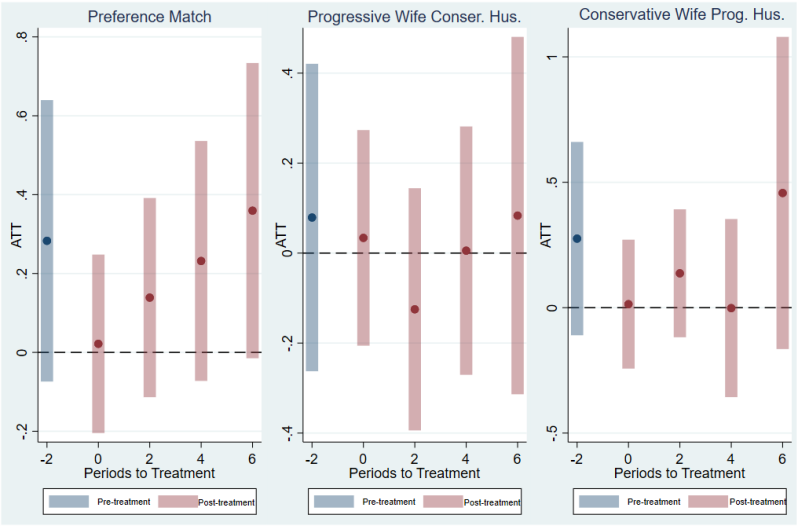
Continued: Summary Statistics, Subsamples

Panel C: Conservative Wife and Progressive Husband

		Ever Treated		Treated by 2012		Treated by 2014		Never Treated	
Variable		Pre	Post	Pre	Post	Pre	Post	2010–2014	2016–2018
Employment	Mean	0.615	0.819	0.417	0.650	0.675	0.944	0.550	0.754
	(Std)	(0.491)	(0.387)	(0.515)	(0.483)	(0.474)	(0.231)	(0.500)	(0.434)
Wife gender role pref.	Mean	4.731	4.681	4.667	4.650	4.750	4.704	4.596	4.574
	(Std)	(0.528)	(0.572)	(0.651)	(0.622)	(0.493)	(0.537)	(0.795)	(0.763)
Husb. gender role pref.	Mean	3.269	3.362	3.417	3.425	3.225	3.315	2.826	2.869
	(Std)	(0.770)	(0.653)	(0.669)	(0.636)	(0.800)	(0.668)	(1.035)	(1.024)
Cell ownership	Mean	0.976	0.903	0.900	0.897	1.000	0.907	0.773	0.847
	(Std)	(0.154)	(0.297)	(0.316)	(0.307)	(0.000)	(0.293)	(0.421)	(0.363)
Cell fee	Mean	30.059	39.194	27.222	44.565	33.250	36.673	45.813	44.780
	(Std)	(22.222)	(29.580)	(13.944)	(39.107)	(29.741)	(23.938)	(38.257)	(36.157)
Remittance	Mean	3,346.2	11,271.3	2,583.3	8,950.0	3,575.0	12,990.7	6,660.6	9,278.7
	(Std)	(14,161.4)	(15,825.1)	(5,884.6)	(12,689.5)	(15,882.4)	(17,716.5)	(15,882.6)	(12,699.3)
Food expenditure	Mean	290.0	825.8	508.3	687.6	224.5	928.1	722.9	1,068.5
	(Std)	(594.7)	(1,007.2)	(1,112.7)	(1,183.9)	(306.8)	(850.6)	(899.1)	(852.5)
Age	Mean	39.019	42.298	36.917	40.950	39.650	43.296	45.083	48.787
	(Std)	(9.591)	(8.932)	(8.712)	(8.590)	(9.854)	(9.127)	(14.098)	(14.640)
Urban	Mean	0.058	0.074	0.083	0.125	0.050	0.037	0.468	0.361
	(Std)	(0.235)	(0.264)	(0.289)	(0.335)	(0.221)	(0.191)	(0.501)	(0.484)
Highest egg price	Mean	6.265	6.160	6.833	6.575	6.095	5.853	6.753	6.969
	(Std)	(3.669)	(3.073)	(2.566)	(2.294)	(3.952)	(3.532)	(2.581)	(2.736)
No. persons	Mean	1,463.9	1,561.9	1,915.3	1,966.2	1,328.5	1,262.4	3,179.9	2,671.1
	(Std)	(915.7)	(1,006.1)	(1,293.8)	(1,340.5)	(736.8)	(489.1)	(3,242.3)	(2,956.8)
Polluting factory	Mean	0.096	0.117	0.083	0.100	0.100	0.130	0.339	0.393
	(Std)	(0.298)	(0.323)	(0.289)	(0.304)	(0.304)	(0.339)	(0.476)	(0.493)
Float pop.	Mean	114.404	113.016	144.167	138.188	105.475	94.370	438.459	396.033
	(Std)	(137.113)	(139.324)	(191.584)	(184.101)	(117.803)	(91.040)	(784.541)	(864.507)
Num. ICT prior	Mean	1.231	1.021	0.417	0.375	1.475	1.500	0.229	0.246
	(Std)	(0.921)	(0.973)	(0.669)	(0.628)	(0.847)	(0.906)	(0.521)	(0.567)
Area size	Mean	260.827	110.155	273.606	250.798	256.993	5.975	28.138	38.806
	(Std)	(1,045.554)	(535.398)	(871.696)	(805.118)	(1,102.345)	(4.063)	(82.519)	(99.157)
Household type	Mean	0.765	0.527	1.000	0.564	0.692	0.500	0.579	0.525
	(Std)	(0.428)	(0.502)	(0.000)	(0.502)	(0.468)	(0.505)	(0.496)	(0.504)
Observations	316	52	94	12	40	40	54	109	61

Note: Never treated group does not have a defined pre- and post-period; therefore 2010–2014 is considered pre-period and 2016–2018 is considered post-period. Standard deviations in parentheses.
Source: CFPS.

Figure 6. : Pre- and Posttreatment Trend: Subsamples



is associated with a 26% increase in left-behind women's LMP. In Model (2), which is run for the group consisting of progressive wives and conservative husbands, the results are not significant. I interpret this effect as reflecting positive economic spillovers from cell tower construction (namely, increased local labor demand) rather than an isolated monitoring mechanism. The CSDID subgroup analysis show different trend than TWFE results. None of the TWFE models include covariates controlling for community- or individual-level characteristics that might absorb these spillover effects. The monitoring mechanism, in addition to the positive economic spillover, would have an upward impact in all three models.

Impact of Cell Tower Establishment on LMP: CSDID and Subgroups. — Table 14 presents the results of a model with standardized covariates with the household structure type. Model (1) shows nonsignificant effects for couples with matching preferences after correction for staggered treatment timing. In other words, if we believe that cell tower installation is associated with monitoring strength of migrant husband, gender role preference matching couples will not change one's labor market behavior with cell tower establishment. If I observe null effect for gender role preference matching couple, I can consider the estimation result successfully isolates the impact of communication on left-behind women's LMP. Therefore, the nonsignificant result from Model (1) supports the idea that the suggested empirical model is successful in isolating the communication element.

Table 13—: Canonical Difference-in-Differences: Subsamples

	(1) Preferences match	(2) Progressive wife	(3) Conservative wife
Cell tower × after	0.260***	0.0872	0.266**
	(0.0650)	(0.0810)	(0.0806)
Cell tower	0.0995	0.120	0.182**
	(0.0583)	(0.0750)	(0.0623)
Constant	0.457***	0.590***	0.462***
	(0.0516)	(0.0561)	(0.0623)
Individual Controls	No	No	No
Community Controls	No	No	No
Pre-treatment Mean	0.457	0.590	0.462
N	307	217	208

Note: Estimated by OLS using difference-in-difference model specification. The dependent variable is a binary employment variable. Sample consisted of married, left-behind women (women whose husbands are migrants living away from the household) in communities that got a cell tower during the study period (2010–2013) or never got a cell tower. All models only include 2010 (pre-treatment), 2016, and 2018 (post-treatment) observations. There is only one treatment period which is between 2010–2013. Column 1 shows results for preference matching couple (progressive or conservative). Column 2 shows results restricted to sample with progressive wife and conservative husband. Column 3 shows results restricted to sample with conservative wife and progressive husband. No individual or community controls included. Robust standard errors in parentheses. * indicates $p < 0.10$, ** indicates $p < 0.05$, *** indicates $p < 0.01$.
Source: China Family Panel Survey (CFPS).

Table 14—: CSDID: Subsamples, with Standardized Covariates

	(1) Prefer. match	(2) Prog. wife	(3) Prog. wife, nuclear HH	(4) Conser. wife	(5) Conser. wife, nuclear HH
ATT (Treated by 2012)	0.1115	0.1816		0.0921	
	(0.1304)	(0.1390)		(0.2051)	
ATT (Treated by 2014)	0.2053	-0.2897*	-0.4028	0.0685	0.3601*
	(0.1713)	(0.1523)	(0.2488)	(0.1371)	(0.2070)
ATT (Ever treated)	0.1465	-0.0173	-0.4028	0.0785	0.3601*
	(0.1013)	(0.1063)	(0.2488)	(0.1166)	(0.2070)
Individual Controls	Yes	Yes	Yes	Yes	Yes
Community Controls	Yes	Yes	Yes	Yes	Yes
Pre-treatment mean	0.625	0.627		0.624	
N	465	364	62	316	90

Note: Estimated using the Callaway and Sant'Anna (2021) difference-in-differences estimator with regression adjustment (RA) method. The dependent variable is a binary employment variable. Sample consists of married, left-behind women (women whose husbands are migrants living away from the household) in communities that got a cell tower during the study period or never got a cell tower. ATT (Treated by 2012) and ATT (Treated by 2014) report the average treatment effect on the treated for cohorts treated by 2012 and 2014, respectively. ATT (Ever treated) reports the overall average treatment effect on the treated across all cohorts. Columns 1–2 and 4 use the full subsample by gender norm combination. Columns 3 and 5 further restrict to nuclear households. Only one treatment cohort (G2014) exists in columns 3 and 5 due to data limitation; ATT (Treated by 2012) is therefore omitted and ATT (Ever treated) equals ATT (Treated by 2014). Individual controls include urban residence, standardized remittances, and standardized age. Community controls include standardized highest egg price, standardized monthly food expenditure, standardized community area size, standardized number of persons, and standardized polluting factory (within 5km). Pre-treatment mean refers to the mean employment rate of the never-treated control group and outcome before cell tower establishment for treated group. Robust standard errors in parentheses. * indicates $p < 0.10$, ** indicates $p < 0.05$, *** indicates $p < 0.01$.
Source: CFPS.

Model (2) is on the group consisting of progressive wives and conservative husbands. Aggregating the ATT shows a null effect, and the estimated result is negative and significant at the 10% level for the "2014 treated" cohort, but there is a null effect for the "2012 treated" cohort. The difference between these two cohorts may due to the number of communities treated. Table 3 shows that 21 more communities were treated by 2014 compared to the group treated by 2012. In case of 2014 cohort, installation of a cell tower decreased left-behind women's LMP by 29%—in other words, there was a decrease of 0.835[9] standard deviations from the baseline mean. The conditional pretrends test cannot reject the

[9] 0.289 / 0.346 = 0.835, which is the effect size divided by the standard deviation of the baseline mean of the dependent variable.

null hypothesis that all pretreatment trend estimates are equal to zero. If we believe, new cell towers increase the communication between progressive wives and conservative husbands, it may shifts left-behind wives' LMP outcomes toward what their migrant husbands prefer, especially among the group treated in 2014. Compared to progressive wives never treated with cell towers within their communities, wives with progressive gender role preferences who prefer to work outside the household may decide to reduce their labor supply when monitoring by their conservative migrant husbands increases.

Model (4) is estimated for the sample of conservative wives with progressive husbands. The estimation result shows a null effect, and the parallel pretrends assumption cannot be rejected. The overall pattern show that the installation of cell towers increases the commnication between conservative wives and progressive husbands, which does not influence left-behind wives' LMP. This result weakens the monitoring via communication mechanism. However, further limiting the subsample to those living in a nuclear household provides suggestive evidence that the communication mechanism may operate for the group consisting of conservative wives and progressive husbands.

One may argue that the presence of in-laws or the co-residence of multiple generations in households could limit left-behind women's autonomy in their choice of LMP independent of their husbands' monitoring. I constructed a household type variable that partitions between households with a nuclear structure and those with an extended family structure. I can identify matched couple's parents. Among left-behind women living in an extended family household, the majority live with their in-laws. Due to data limitations, I am able to conduct the postperiod estimation for only the 2014 treated cohort. As a result, parallel pretrends cannot be computed, and therefore, the estimation findings cannot be interpretated as a causal result. I find suggestive evidence that husbands' monitoring power via communication is more visible for nuclear households. Model (5) is estimated for the sample of conservative left-behind wives with progressive migrant husbands and with a nuclear household structure. The results show that the installation of a cell tower increased progressive husbands' monitoring power over their conservative left-behind wives' LMP and increased their employment by 36%, an effect that is significant at the 10% level. The impact constitutes a significant result compared with Model (4). However, Model (3) does not show a significant result even when limited the sample to those living in a nuclear household. This estimation result weakens that extended household structure is interfering migrant husband's monitoring activities.

It is thus valid to be concerned that the inability to control for the coresidence of multiple generations may hide the impact of migrant husbands' monitoring power. However, one study reports that the coresidence of adult children and parents has declined throughout the first two decades of the 21st century in China, reaching a level comparable to that in Western countries (Huang, Li and Clark, 2022). According to Luo et al. (2024), by 2020, the national average household size had

fallen to 2.92 people. In place of the coresidence of adult children with parents, they choose to live apart but in proximity, for example, in the same city or county, has become the more common arrangement (Huang, Li and Clark, 2022). Since 2010, the majority of Chinese families live in a nuclear family setting rather than in a multigenerational household. As a result, monitoring by migrant husbands via communication maybe a more important factor to consider in the model than the presence of in-laws. Additionally, studies on the relationship between a multigenerational household structure and women's LMP present nuanced results. In particular, studies of China after 2010 show that the presence of grandparents can increase (Wang et al., 2022) or decrease (Yang, Fu and Li, 2016; Bai, Li and Hong, 2024; Zhou and Wang, 2023) women's LMP. Those that find a negative relationship point to housework burdens as the reason, while the papers reporting a positive relationship find that housework and childcare support from grandparents are the drivers of the relationship. In the case of Bai, Li and Hong (2024), their study uses the same dataset, the CFPS, and finds a positive relationship between multigenerational coresidence and women's LMP. As a result, without information on in-laws' preferences, it is unclear whether their presence supports or jeopardizes left-behind women's LMP.

VIII. MECHANISM

In this section, I investigate the mechanism behind the impact of cell tower installation on communication, namely, the cell ownership and expenditure of left-behind women. These two variables are proxies for the frequency and strength of communication between men and women in separated couples. The mechanism section tests the first leg of the mechanism described in Figure 4. If cell tower installation meaningfully impacts separated couples' communication, it should increase left-behind wives' probability of cell phone ownership and cell service expenditure. The association models should reveal that cell tower installation increases communication between men and women in separated couples, increasing migrant husbands' monitoring environment with respect to their left-behind wives.

A. Mechanism: Do Cell Towers Increase Communication between Men and Women in Separated Couples?

The goal of this chapter is to suggest potential channel that connects cell tower installation and cell phone ownership/usage to understand whether new cell towers increase communication between men and women in 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 couples' communication due to cell tower installation. CFPS dataset

does not provide information that measures frequency of communication such as administrative call and text information. However, I can use cell ownership and usage as a proxy of frequency of communication. If left-behind women obtained cell phones or increased their cell service expenditure because of the installation of a cell tower, I may assume the frequency of communication between men and women in separated couples to increase. However, I cannot rule out possibility of increase in communication influencing effects factors not related to monitoring of migrant husband. The communication can provide information regarding labor market information, economy, or business opportunities. The mechanism model provide mixed evidence that monitoring channel is the main channel influencing left behind women's labor market behavior.

Table 15—: Cell Ownership and Expenditure by Treatment by Subgroup and Treatment Status

Panel A: Progressive Wife and Conservative Husband

		Ever Treated		Never Treated	
Variable		Pre	Post	2010–2014	2016–2018
Cell ownership	Mean	0.977	0.898	0.842	0.947
	(Std)	(0.152)	(0.304)	(0.366)	(0.225)
Cell expenditure	Mean	36.250	59.481	53.928	55.630
	(Std)	(18.430)	(57.288)	(45.377)	(42.116)
Observations		51	109	145	59

Panel B: Conservative Wife and Progressive Husband

		Ever Treated		Never Treated	
Variable		Pre	Post	2010–2014	2016–2018
Cell ownership	Mean	0.976	0.903	0.773	0.847
	(Std)	(0.154)	(0.297)	(0.421)	(0.363)
Cell expenditure	Mean	30.059	39.194	45.813	44.780
	(Std)	(22.222)	(29.580)	(38.257)	(36.157)
Observations		52	94	109	61

Note: Never treated group does not have a defined pre- and post-period; therefore 2010–2014 is considered pre-period and 2016–2018 is considered post-period. Standard deviations in parentheses. Sample consists of married, left-behind women (women whose husbands are migrants living away from the household) in communities that got a cell tower during the study period or never got a cell tower in which observations have complete information on gender role preferences and family structure. The cell phone ownership variable in the 2010 wave differs from other waves in its response structure, offering three options: 'Yes,' 'No—parents' phone,' and 'No—other's phone.' As a result, a 'No' response indicates that the individual does not own a personal cell phone, but may still have access to one belonging to a parent or another household member. This distinction is important: 'No' reflects non-ownership rather than a lack of access to a cell phone.
Source: CFPS.

Table 15 presents the summary statistics for the pre- and posttreatment periods for the ever-treated and never-treated groups. In both Panel A and Panel B, cell ownership is high in the pretreatment period. The central government-led cell infrastructure rollout triggered people to own a cell phone, even when there was no signal in the community, as they could travel to a nearby neighboring town for connection. As a result, communication between men and women in separated couples was initiated by left-behind wives before cell tower establishment within community; however, after treatment, both sides could initiate communication. In terms of cell expenditure, the never-treated group shows stable cell expenditure. While, in Panel B, conservative wives show a much smaller increase in the posttreatment period. They show an increase of 30%, while progressive wives show an increase in cell expenditure of approximately 64%.

Based on Table 16, the installation of cell towers during the survey period did increase left-behind women's probability of owning a cell phone but null effect on cell fee. All models are OLS with year and province fixed effects and binary variables for an extended family and urban status. Model (1) is on all samples, but the sample size is smaller than that included in the main model due to the inclusion of the extended family variable and dropping 2010 wave information. According to Panel A, cell tower establishment increases cell phone ownership by 10.4%, and this result is significant at the 1% level. However, in Panel B, the result for cell phone service expenditure is not significant. Model (2) is on sample consisting of migrant husbands and left-behind wives with matching gender role preferences. Cell tower establishment increases cell ownership by 17%, but no significant effect for cell expenditure is observed. In case of Model (3) and model (4), which shows group for progressive wife and conservative husband pair and conservative wife and progressive husband pair show null effect for both cell ownership and expenditure. Considering high baseline cell ownership and null effect on cell expenditure, further study is needed to understand monitoring channel by focusing on other alternative measure of frequency of communication and considering other potential channels that could be connecting cell tower establishment and left behind women's labor market behavior.

B. Mechanism: Remittance

I also evaluate a major factor that could directly impact the outcome of interest through a means other than the treatment. Remittances are a major income source for left-behind women, shifting their LMP. Remittances can influence LMP positively by providing capital for small businesses or negatively by supplying enough income for a left-behind wife to focus on unpaid care for other left-behind family members. They may serve as a negotiation tool that lets migrant husbands pressure their left-behind wives into choosing outcomes that the husbands prefer. The theoretical section of this paper explored how remittance can oper-

Table 16—: Mechanisms

	(1) All	(2) Preference match	(3) Progressive wife	(4) Conservative wife
Panel A: Cell phone ownership				
Treated	0.1039***	0.1717***	0.0204	0.1025
	(0.0228)	(0.0526)	(0.0488)	(0.0662)
Extended family	0.0248	0.0433	-0.0174	0.0743
	(0.0165)	(0.0376)	(0.0381)	(0.0538)
Urban	0.1034***	0.0733*	0.1660***	0.2018***
	(0.0214)	(0.0423)	(0.0486)	(0.0733)
Year FE	Yes	Yes	Yes	Yes
Province FE	Yes	Yes	Yes	Yes
R-squared	0.0628	0.0872	0.1626	0.1861
N	1,452	362	282	250
Panel B: Cell phone expenditure (log)				
Treated	0.0685	-0.1018	0.0349	0.0078
	(0.0759)	(0.1637)	(0.1343)	(0.1596)
Extended family	0.0390	0.1322	0.1295	0.2059*
	(0.0529)	(0.1057)	(0.1153)	(0.1155)
Urban	0.0599	-0.0920	0.1807	0.0770
	(0.0614)	(0.1309)	(0.1292)	(0.2165)
Year FE	Yes	Yes	Yes	Yes
Province FE	Yes	Yes	Yes	Yes
R-squared	0.1105	0.2090	0.3508	0.3929
N	836	216	170	151

Note: Estimated by OLS. In all specifications, the dependent variable is indicated in each panel header. Panel B uses log-transformed cell phone expenditure. Sample consists of married, left-behind women. The 2010 wave is excluded from all specifications because its questionnaire differs from that used in subsequent waves. Column 1 shows results for all observations. Column 2 sample restricted to wives whose gender role preferences match their husbands. Column 3 restricted to wives with progressive gender role preferences. Column 4 restricted to wives with conservative gender role preferences. Robust standard errors in parentheses. * indicates $p < 0.10$, ** indicates $p < 0.05$, *** indicates $p < 0.01$.
Source: China Family Panel Survey (CFPS).

Table 17—: Communication Influence on Remittances

	(1) All observations	(2) Has gen. pref. info	(3) No gen. pref. info
ATT (Treated by 2012)	0.2080	0.1154	0.3528*
	(0.1277)	(0.1611)	(0.2105)
ATT (Treated by 2014)	0.2645***	0.3207***	0.1416
	(0.0901)	(0.1154)	(0.1375)
ATT (Ever treated)	0.2334***	0.2107**	0.2648*
	(0.0843)	(0.1070)	(0.1402)
Individual Controls	No	No	No
Community Controls	No	No	No
N	2,000	1,182	818

Note: Estimated using the Callaway and Sant'Anna (2021) difference-in-differences estimator with regression adjustment (RA) method. ATT (Treated by 2012) and ATT (Treated by 2014) report the average treatment effect on the treated for cohorts treated by 2012 and 2014, respectively. ATT (Ever treated) reports the overall average treatment effect on the treated across all cohorts. Column 1 shows results for the full sample. Column 2 shows results restricted to observations with information on gender role preferences of both wives and husbands. Column 3 shows results restricted to observations that do not have information about gender role preferences for at least one spouse. No individual or community controls included. Robust standard errors in parentheses. * indicates $p < 0.10$, ** indicates $p < 0.05$, *** indicates $p < 0.01$.
Source: China Family Panel Survey (CFPS).

	(1) Preferences match	(2) Progressive wife	(3) Conservative wife
ATT (Treated by 2012)	-0.1144	0.0905	0.6005*
	(0.2591)	(0.2485)	(0.3189)
ATT (Treated by 2014)	0.5367***	0.3621*	0.3105
	(0.1724)	(0.2115)	(0.2131)
ATT (Ever treated)	0.1283	0.2037	0.4339**
	(0.1890)	(0.1775)	(0.1958)
Individual Controls	No	No	No
Community Controls	No	No	No
N	465	349	316

Note: Estimated using the Callaway and Sant'Anna (2021) difference-in-differences estimator with regression adjustment method. The dependent variable is log remittances. ATT (Treated by 2012) and ATT (Treated by 2014) report the average treatment effect on the treated for cohorts treated by 2012 and 2014, respectively. ATT (Ever treated) reports the overall average treatment effect on the treated across all cohorts. Column 1 shows results for preference matching couples. Column 2 shows results restricted to sample with progressive wife. Column 3 shows results restricted to sample with conservative wife. No individual or community controls included. * indicates $p < 0.10$, ** indicates $p < 0.05$, *** indicates $p < 0.01$.
Source: China Family Panel Survey (CFPS).

ate as negotiation tool combined with migrant husband's monitoring. However, past literature does not show any empirical evidence that remittance operating as negotiating tool. Table 17 presents the results of a CSDID model without any covariates using standardized log remittances as the dependent variable and cell tower establishment as the independent variable with multiple treatment periods. If remittance can operate as negotiate tool between separated couples, then remittance is endogenous and intertwined with migrant husband's monitoring and wife's employment. Therefore, Table 17 will only provide information on how cell tower installation and remittance is associated. If we assume that cell tower establishment increases the communication between men and women in separated couples, the cell ownership and/or expenditure of left-behind wives, which are proxies for communication, should consistently increase the amount of remittances across groups. Conservative wives and progressive husbands show the largest overall ATT, while progressive wives and conservative husbands show the smallest ATT for the group treated by 2014. As a result, left-behind wives' increase in cell ownership and/or expenditure tends to increase the remittances sent by their migrant husbands, however, show no evidence that it is used as negotiation tool. Figure 7 provides the estimation results from the logit model, showing marginal effects of 0, 2,000, 10,000, 21,000, and 100,000 yuan in remittances on left-behind women's employment. Each segment is a 25th percentile of the remittance variable. Remittances have a significant and positive direct effect on left-behind women's LMP when I include year and community fixed effects. This result supports studies which found positive association between remittance and women's employment rather than operating as a negotiation methods Yang (2008); Khanna et al. (2022). Further analysis is needed to clearly understand if left behind wife whose labor market behavior shift in the direction of their migrant husband's preference is associated with remittance size. I may able to reveal the relationship via share of remittance of total earning of migrant husband and hometown visit frequency and timing of migrant husband.

IX. ROBUSTNESS CHECKS

I conduct robustness checks to address two concerns. The first is for pretreatment plots showing above the zero line consistently regardless of model specification. The second is to address the fact that the majority of couples with misaligned gender role preference show only a 1 point scale difference. According to Figure 5, Figure 6 and Figure A4, the pretreatment period is consistently above the zero line. This finding may due to how the treated period is defined. The treated by 2014 cohort includes communities in which a cell tower was installed as early as 2012. Consequently, when evaluating the changes in outcomes between 2010 and 2012, which is the pretreatment period for the cohort treated by 2014, the pretreatment trend may capture an increase in employment among left-behind women that is attributable to recent cell tower construction. To check

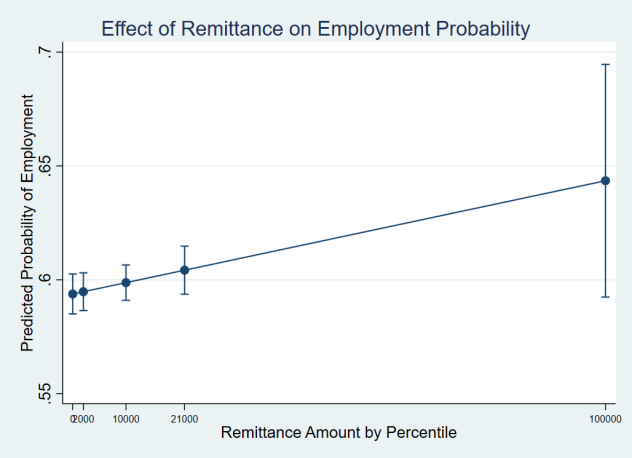


Figure 7. : Remittances and Left-behind Wives' Employment

Note: The sample for this model includes women with migrant husbands, regardless of treatment status. Figure 7 presents the marginal effect of remittance size at each percentile. The model is estimated using a logit specification in which women's employment status, defined independently of remittance receipt, serves as the dependent variable, with year and community fixed effects included. Marginal effects are calculated at the first through fourth quartiles of the remittance distribution. Results indicate a positive relationship between remittance amount and the probability of employment.

for robustness, I dropped the cohort treated by 2012 and ran the main model with the same specifications. According to Table 18, the size and significance of the estimation results are similar to those of the main model including the cohort treated by 2012. Therefore, the main estimation results are mostly driven by the cohort treated by 2014.

According to Table 4, approximately 71% of separated couples show no difference or a 1-point scale difference. One may be concerned that those with a 1-point scale difference are not much different from those with no difference. Table 19 includes only those with a more than 2-point scale difference. However, due to the small sample size, I was not able to verify whether the main estimation result is driven by those with a more than 2-point scale difference.

X. CONCLUSION

China's industrialization has created an incentive for married men to migrate to industrialized areas for higher incomes and leave their wives behind. The literature shows mixed results on the impact of husbands' migration on left-behind women's LMP. To reconcile the results in the literature, this paper focuses on communication and monitoring between men and women in separated couples and its impact on the LMP of left-behind wives. It contributes by investigating

Table 18—: Robustness: CSDID without the Cohort Treated by 2012

Panel A: By Gender Role Information Availability

	(1) All obs.	(2) Has gen. pref. info	(3) No gen. role pref. info	(4) Prefer. match
ATT (Treated by 2014)	−0.0984	−0.0807	−0.1365	0.2053
	(0.0912)	(0.0982)	(0.1139)	(0.1713)
ATT (Ever treated)	−0.0984	−0.0807	−0.1365	0.2053
	(0.0912)	(0.0982)	(0.1139)	(0.1713)
Individual Controls	Yes	Yes	Yes	Yes
Community Controls	Yes	Yes	Yes	Yes
N	1,543	908	635	352

Panel B: By Gender Role Preference Combination

	(5) Prog. wife	(6) Prog. wife, nuclear HH	(7) Conser. wife	(8) Conser. wife, nuclear HH
ATT (Treated by 2014)	−0.2897*	−0.4028	0.0685	0.3601*
	(0.1523)	(0.2488)	(0.1371)	(0.2070)
ATT (Ever treated)	−0.2897*	−0.4028	0.0685	0.3601*
	(0.1523)	(0.2488)	(0.1371)	(0.2070)
Individual Controls	Yes	Yes	Yes	Yes
Community Controls	Yes	Yes	Yes	Yes
N	270	62	247	90

Note: Estimated using the Callaway and Sant'Anna (2021) difference-in-differences estimator with regression adjustment (RA) method. The dependent variable is a binary employment variable. Sample consists of married, left-behind women (women whose husbands are migrants living away from the household) in communities that got a cell tower during the study period or never got a cell tower. Only one treatment cohort (G2014) exists in this specification; ATT (Treated by 2012) is therefore omitted and ATT (Ever treated) equals ATT (Treated by 2014). Columns (6) and (8) further restrict to nuclear households. Same standardized controls as Table 25 and Table 29 included. Robust standard errors in parentheses. * indicates $p < 0.10$, ** indicates $p < 0.05$, *** indicates $p < 0.01$.
Source: China Family Panel Survey (CFPS).

Table 19—: Robustness: CSDID with an Absolute Difference Larger than 2

	(1) Progressive wife, conservative husband	(2) Conservative wife, progressive husband
ATT (Treated by 2012)	0.2060	−0.2473
	(0.1796)	(0.6284)
ATT (Treated by 2014)	−0.1939	0.2407
	(0.1588)	(0.2073)
ATT (Ever treated)	0.0606	0.1020
	(0.1182)	(0.2315)
Individual Controls	Yes	Yes
Community Controls	Yes	Yes
N	195	136

Note: Estimated using the Callaway and Sant'Anna (2021) difference-in-differences estimator with regression adjustment (RA) method. The dependent variable is a binary employment variable. Sample consists of married, left-behind women (women whose husbands are migrants living away from the household) in communities that got a cell tower during the study period or never got a cell tower. Both samples are further restricted to couples with a gender role preference gap of at least 2. ATT (Treated by 2012) and ATT (Treated by 2014) report the average treatment effect on the treated for cohorts treated by 2012 and 2014, respectively. ATT (Ever treated) reports the overall average treatment effect on the treated across all cohorts. Column 1 restricts the sample to couples with a progressive wife and conservative husband. Column 2 restricts the sample to couples with a conservative wife and progressive husband and includes individual and community controls. Robust standard errors in parentheses. * indicates $p < 0.10$, ** indicates $p < 0.05$, *** indicates $p < 0.01$.
Source: China Family Panel Survey (CFPS).

partially migrated households' communication and the decision-making power of left-behind women. The analysis uses cell tower installation as a shock to communication between men and women in separated couples and the CSDID approach to account for the staggered timing of cell tower installation. Using CFPS data and gender role preference variables that capture attitudes toward women's labor market participation, the main results present a mixed pattern overall. A subset of findings, however, indicates that cell tower installation, used here as a proxy for communication between geographically separated spouses with divergent gender role preferences, decreases labor market participation among progressive left behind wives, while increasing labor market participation among conservative left behind wives residing in nuclear households. For preference matched couples, left behind wives' labor market participation shows no significant change following cell tower installation. This result implies that the if installation of cell tower, increased monitoring environment for migrant husbands, it may shift their left-behind wives' employment to more closely align with their husbands' priorities. Therefore, policymakers should consider family structure and partners' preferences for LMP in development policies for women, especially women's LMP. Otherwise, development policies that are intended to bring left-behind women into the labor market will prove ineffective.

This study needs further work in exploring alternative mechanisms beyond monitoring via communication, as well as address the conflicting evidence between cell tower and cell phone ownership measures. Further investigation is also needed into how remittances may be leveraged to influence left behind wives' labor market behavior, particularly with respect to how remittances may relate to migrant husbands' monitoring activities. A limitation of this study is the small sample size due to missing gender role preference information and subsampling on the basis of couples' gender role preference match. The small sample weakens the external validity of the estimation results. In further analyses, household finance and savings management among partially migrated households would be worth investigating and would contribute to researchers' understanding of partially migrated households' financial behavior.

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Appendix

A1. Near Separation Diagnosis and Solution

This section of Appendix B presents how I diagnose the near separation in the CSDID approach and present the solution. According to Cunningham (2026), the CSDID approach with covariates that perfectly or near perfectly predict the treatment assignment leads to large propensity scores, which result in unstable coefficients. First, I investigate the CSDID results without any covariates. In Table B2, Model (2) with gender role preference information and Model (3) without gender role preference information show exactly the opposite relationship, which is less distinctive in the final model in Table 10. According to Table B3, I also observe a positive treatment effect for the group with matching preferences, which is similar to the result under canonical DID estimation in Table 13. I also check the group-time average treatment effect across the treated group and subgroups. Table B4, provides disaggregated $ATT(g,t)$ values, where g represents the treated cohort (2012 or 2014) and t represents each time period. For example, $ATT(2014, 2016)$ represents a "group treated with cell towers by 2014" and compares the "never-treated group" with the 2016 employment outcomes of each group. For the subgroup consisting of progressive wives and conservative husbands (Column (5)), the 2014 treated group is 26.9% less likely to be employed with a cell tower connection. None of the ATT values seem to be high or show large standard error values without covariates. Figure A4 presents an event study-style graph that shows that the pretreatment trend is not parallel except for the group without gender role preference information and the group consisting of progressive wives and conservative husbands.

Second, I include covariates that satisfy the pretreatment parallel trends test. Table B5 and Table B6 present the results. I observe that pairs consisting of a conservative wife and a progressive husband show a treatment effect that exceeds a probability of 1 when considering the pretreatment mean. It is very likely that the estimation results for Table B5 and Table B6 show "near separation". When I check the $ATT(g,t)$ of the CSDID model with covariates, Table B7 shows a distinctively high disaggregated treatment effect, especially for $ATT(2012, 2012)$, $ATT(2012, 2014)$, $ATT(2012, 2018)$, and also $ATT(2014, 2018)$. To further diagnose the near-separation problem, I examine the propensity score

distributions for the two most volatile groups. Inverse probability tilting (IPT) is used to balance covariates; however, near-separation can induce extreme weights concentrated at 0 or 1, which propagate into both the inverse probability weighting (IPW) and doubly robust (DR) estimands. Figure B5 plots the propensity score distributions for the treated and comparison groups consisting of conservative wives and progressive husbands and preference-matched couples. The blue bars are the comparison group's propensity score distributionm while the red bar is treated group's propensity score distribution. Darker red shaded bars show the overlap between the two groups. For the group consisting of conservative wives and progressive husbands, the left tail of the distribution is notably asymmetric. The treated group has substantially less coverage than the comparison group in this region. In contrast, the preference-matched group exhibits stronger common support. Lastly, I identify the 'small cell' problem, and I examine whether certain cohorts have treated or comparison unit counts that are small enough to destabilize the estimation results. According to Table B8, the group treated by 2012 shows a significantly small size, smaller than 20. This cohort could lead to unstable estimations.

The solution and troubleshooting suggested by Cunningham (2026) are winsorizing and standardizing the covariates to prevent extreme values and adopting an estimation approach different from "drimp". First, extreme covariate values may further contribute to estimation instability. Winsorization preserves the full sample while capping extreme values, specifically by replacing observations above the 99th percentile and below the 1st percentile with their respective threshold values. As I suspect that the extreme value of some covariates might be causing a perfect or near-perfect estimation of the treatment status, replacing the tail end of the distribution with the 99th and 1st percentiles reduces the skewness of the distribution. Covariates were selected for winsorization based on their coefficient of variation (SD/mean). The following variables were winsorized: remittances, monthly food expenditure, the community area size, community population, the number of residents without community registration, and the highest and lowest community-level egg prices. Next, I apply log transformation and standardization to continuous variables exhibiting extreme distributional properties. Specifically, for variables with a high coefficient of variation, skewness, or kurtosis, I first winsorize, then log transform, and finally standardize the values. Lastly, among the available estimation options for CSDID models, I adopt the "reg" option, which first uses comparison group to fit unweighted OLS and then predicts the fitted value of the regression for every cohort g. The average of the gap between the actual outcome differences and the predicted comparison group outcome differences is weighted. The major difference is the use of propensity scores during the calculation stage. Considering that the dataset has a small treated group, the "reg" method inherits less of the problem. With these approaches, the final main results in Table 10 and Table 14 show a stable output with satisfying parallel pretreatment periods. According to Table B9, none of the $ATT(g,t)$ results show

extreme values.

Figure A1. : Employment Trend by Treatment Cohort

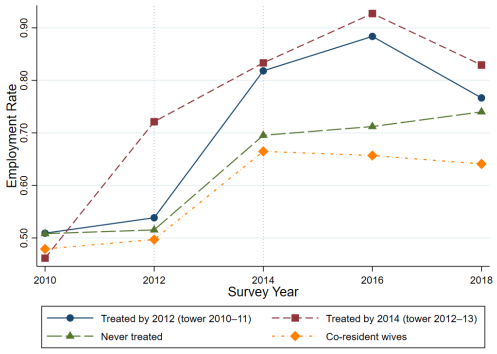


Figure A2. : Employment Trend by Treatment Cohort and Subgroup

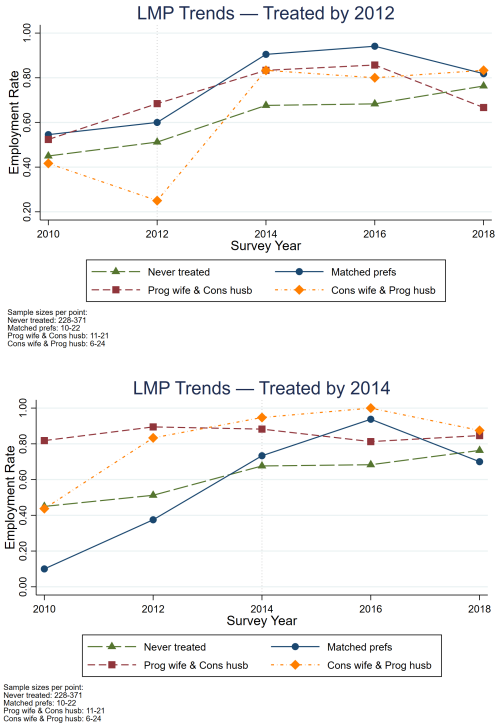


Figure A3. : Cell Ownership Trend by Treatment Cohort

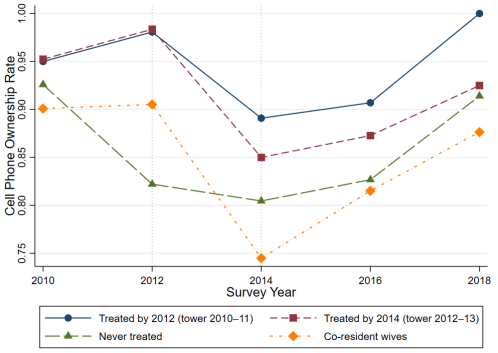


Figure A4. : Pre- and Posttreatment Trends: CSDID without Covariates

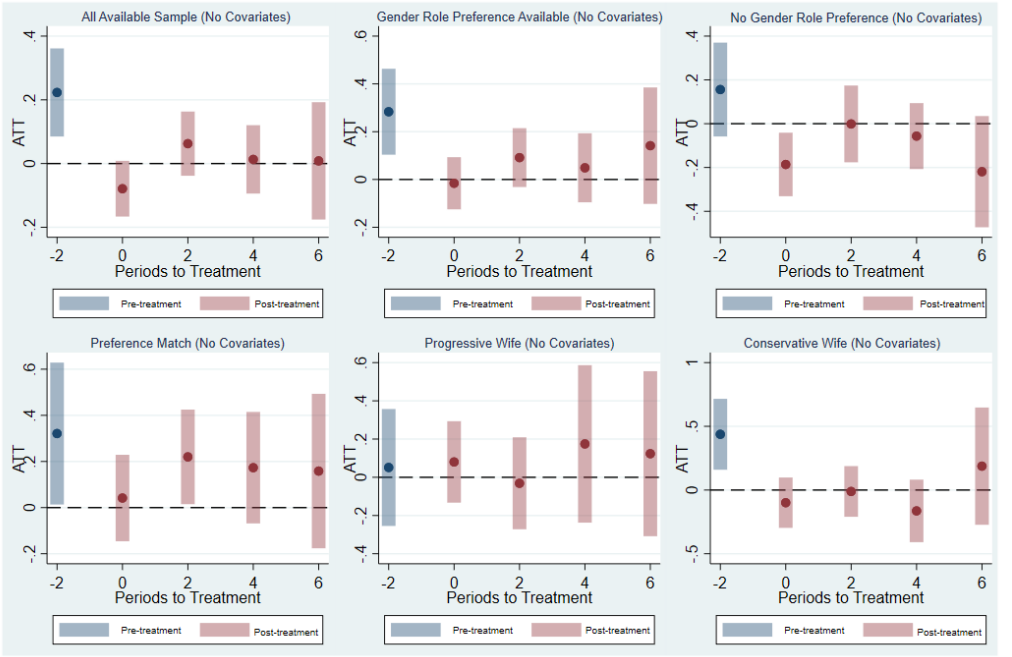


Figure A5. : Common Support

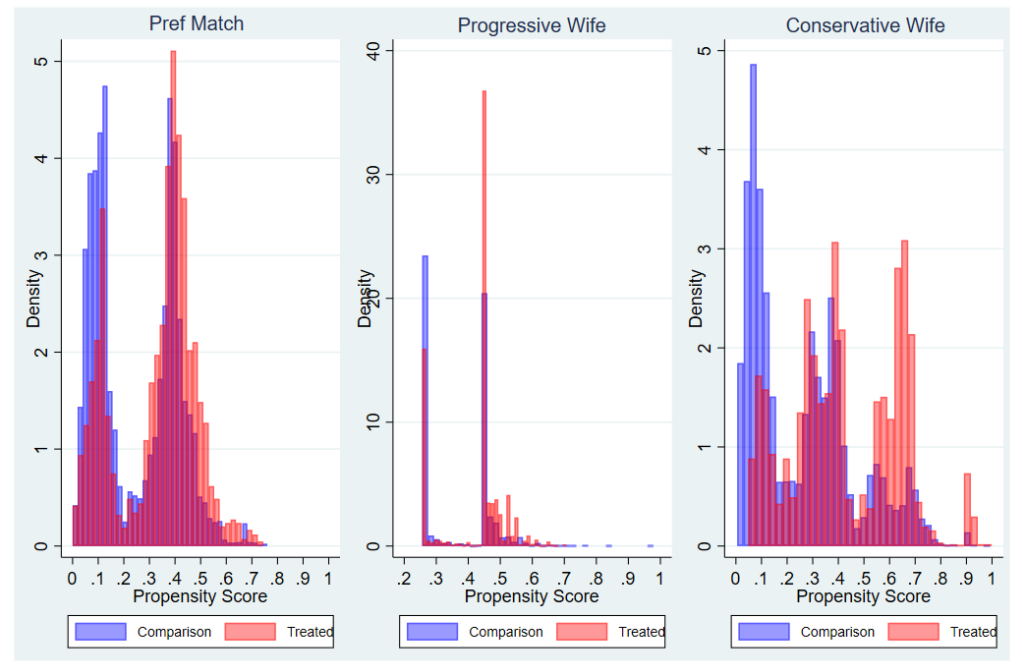


Table A1—: Gender Role Preference Pair Matrix

Panel A: Matched Couples

	Husband Gender Role Score					
Wife	**1**	**2**	**3**	**4**	**5**	**Total**
1	2	0	0	0	0	2
2	0	5	0	0	0	5
3	0	0	45	0	0	45
4	0	0	0	86	0	86
5	0	0	0	0	354	354
Total	2	5	45	86	354	492

Panel B: Progressive Wife / Conservative Husband

	Husband Gender Role Score			
Wife	**3**	**4**	**5**	**Total**
1	12	18	31	61
2	12	6	32	50
3	0	61	97	158
4	0	0	90	90
Total	24	85	250	359

Panel C: Conservative Wife / Progressive Husband

	Husband Gender Role Score				
Wife	**1**	**2**	**3**	**4**	**Total**
2	4	0	0	0	4
3	13	17	0	0	30
4	1	3	47	0	51
5	18	12	97	119	246
Total	36	32	144	119	331

Notes: Rows represent wife's gender role attitude score; columns represent husband's gender role attitude score. Scale ranges from 1 (most progressive) to 5 (most conservative). Panel A includes couples where wife and husband scores are equal. Panel B includes couples where wife's score exceeds husband's score. Panel C includes couples where husband's score exceeds wife's score.

Table A2—: CSDID: Full Sample, No Covariates

	(1) All observations	(2) Has gen. pref. info	(3) No gen. pref. info
ATT (Treated by 2012)	0.0285	0.1354*	-0.1444*
	(0.0592)	(0.0815)	(0.0782)
ATT (Treated by 2014)	-0.0447	-0.0498	-0.0370
	(0.0507)	(0.0631)	(0.0876)
ATT (Ever treated)	-0.0037	0.0493	-0.1022*
	(0.0405)	(0.0542)	(0.0578)
Individual Controls	No	No	No
Community Controls	No	No	No
Pre-treatment mean	0.584	0.628	0.526
N	2,089	1,231	858

Notes: Estimated using the Callaway and Sant'Anna (2021) difference-in-differences estimator with doubly robust improved (DRIMP) method. The dependent variable is a binary employment variable. Sample consists of married, left-behind women (women whose husbands are migrants living away from the household) in communities that got a cell tower during the study period or never got a cell tower. ATT(Treated by 2012) and ATT(Treated by 2014) report the average treatment effect on the treated for cohorts treated by 2012 and 2014, respectively. ATT (Ever treated) reports the overall average treatment effect on the treated across all cohorts. Column 1 shows results for the full sample. Column 2 shows results restricted to observations with information on gender role preferences of both wives and husbands. Column 3 shows results restricted to observations that do not have information about gender role preferences for at least one spouse. No individual or community controls included. Robust standard errors in parentheses. * indicates $p < 0.10$, ** indicates$p < 0.05$, *** indicates $p < 0.01$

Source: China Family Panel Survey (CFPS)

Table A3—: CSDID: Subsample, No Covariates

	(1) Preferences match	(2) Progressive wife	(3) Conservative wife
ATT (Treated by 2012)	0.1286	0.1927	0.0467
	(0.1127)	(0.1483)	(0.1676)
ATT (Treated by 2014)	0.1741	-0.1937	-0.1560*
	(0.1199)	(0.1235)	(0.0924)
ATT (Ever treated)	0.1456*	0.0599	-0.0697
	(0.0850)	(0.1096)	(0.0946)
Individual Controls	No	No	No
Community Controls	No	No	No
Pre-treatment mean	0.619	0.627	0.641
N	481	364	330

Notes: Estimated using the Callaway and Sant'Anna (2021) difference-in-differences estimator with doubly robust improved (DRIMP) method. The dependent variable is a binary employment variable. Sample consists of married, left-behind women (women whose husbands are migrants living away from the household) in communities that got a cell tower during the study period or never got a cell tower. ATT (Treated by 2012) and ATT (Treated by 2014) report the average treatment effect on the treated for cohorts treated by 2012 and 2014, respectively. ATT (Ever treated) reports the overall average treatment effect on the treated across all cohorts. Column 1 restricts the sample to couples whose gender role preferences match, regardless of progressive or conservative gender role preferences. Column 2 restricts the sample to couples with a progressive wife and conservative husbands. Column 3 restricts the sample to couples with a conservative wife and progressive husbands. No individual or community controls included. Robust standard errors in parentheses. * indicates $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Source: China Family Panel Survey (CFPS)

Table A4—: ATT(g,t) Results for the 2012 and 2014 Cohorts, without Covariates

	(1) All obs.	(2) Role info avail.	(3) Role info unavail.	(4) Pref. match	(5) Progressive wife	(6) Conservative wife
Group 2012						
ATT(2012, 2012)	-0.1158*	0.0212	-0.2718***	-0.0426	0.2618	-0.1667
	(0.0688)	(0.0949)	(0.0969)	(0.1311)	(0.1663)	(0.2100)
ATT(2012, 2014)	0.0785	0.1437	-0.0675	0.1087	0.1802	0.1667
	(0.0776)	(0.0923)	(0.1374)	(0.1411)	(0.1777)	(0.1616)
ATT(2012, 2016)	0.1949**	0.2610**	0.0700	0.3465**	0.1746	0.0742
	(0.0823)	(0.1113)	(0.1107)	(0.1650)	(0.2101)	(0.2207)
ATT(2012, 2018)	0.0084	0.1415	-0.2190*	0.1585	0.1233	0.1875
	(0.0939)	(0.1243)	(0.1295)	(0.1708)	(0.2202)	(0.2347)
Group 2014						
ATT(2014, 2012)	0.2232***	0.2835***	0.1560	0.3211**	0.0513	0.4375***
	(0.0705)	(0.0917)	(0.1093)	(0.1569)	(0.1560)	(0.1419)
ATT(2014, 2014)	-0.0353	-0.0480	-0.0109	0.1594	-0.1224	-0.0569
	(0.0598)	(0.0703)	(0.1139)	(0.1393)	(0.1392)	(0.1075)
ATT(2014, 2016)	0.0469	0.0385	0.0564	0.3728**	-0.2694*	-0.1233
	(0.0665)	(0.0832)	(0.1138)	(0.1449)	(0.1479)	(0.1152)
ATT(2014, 2018)	-0.1836***	-0.1681**	-0.2099**	-0.0948	0.0000	-0.3125**
	(0.0592)	(0.0763)	(0.0955)	(0.1400)	(0.1538)	(0.1223)
$N_{\text{2012 treat}}$	396	238	158	94	84	52
$N_{\text{2014 treat}}$	404	259	145	69	76	94
N_{control}	1,289	734	555	318	204	184

Note: ATT(g,t) denotes the average treatment effect on the treated for the cohort first treated in year g, measured at time t, estimated using the Callaway and Sant'Anna (2021) difference-in-differences estimator with doubly robust improved (DRIMP) method. The dependent variable is a binary employment variable. N_{treat} and N_{control} report the number of treated and never treated observations used in each group comparison. Column 1 shows results for the full sample. Column 2 restricts to observations with gender role preference information available for both spouses. Column 3 restricts to observations without gender role preference information for at least one spouse. Column 4 restricts to couples whose gender role preferences match. Column 5 restricts to couples with a progressive wife and conservative husbands. Column 6 restricts to couples with a conservative wife and progressive husbands. Robust standard errors in parentheses. * indicates $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.
Source: China Family Panel Survey (CFPS).

Table A5—: CSDID: Full Sample, with Covariates

	(1) All observations	(2) Has gen. pref. info	(3) No gen. pref. info
ATT (Treated by 2012)	-0.0005	0.1285	-0.1324
	(0.0659)	(0.0861)	(0.0970)
ATT (Treated by 2014)	-0.0446	-0.1370	0.0135
	(0.0684)	(0.0912)	(0.1059)
ATT (Ever treated)	-0.0166	0.0159	-0.0856
	(0.0475)	(0.0630)	(0.0748)
Individual Controls	Yes	Yes	Yes
Community Controls	Yes	Yes	Yes
Pre-treatment mean	0.569	0.623	0.523
N	1,936	1,199	850

Notes: Estimated using the Callaway and Sant'Anna (2021) difference-in-differences estimator with doubly robust improved (DRIMP) method. The dependent variable is a binary employment variable. Sample consists of married, left-behind women (women whose husbands are migrants living away from the household) in communities that got a cell tower during the study period or never got a cell tower. ATT (Treated by 2012) and ATT (Treated by 2014) report the average treatment effect on the treated for cohorts treated by 2012 and 2014, respectively. ATT (Ever treated) reports the overall average treatment effect on the treated across all cohorts. Column 1 shows results for the full sample. Column 2 shows results restricted to observations with information on gender role preferences of both wives and husbands. Column 3 shows results restricted to observations that do not have information about gender role preferences for at least one spouse. Individual controls include urban residence, remittances, and age. Community controls include highest egg price, community area size, and prior ICT infrastructure availability. Robust standard errors in parentheses. * indicates $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Source: China Family Panel Survey (CFPS)

Table A6—: CSDID: Subsamples, with Covariates

	(1) Preferences match	(2) Progressive wife	(3) Conservative wife[a]
ATT (Treated by 2012)	0.0775	0.1670	1.2713**
	(0.1194)	(0.1374)	(0.6130)
ATT (Treated by 2014)	-0.8701	-0.2897*	0.1059***
	(0.7092)	(0.1523)	(0.0408)
ATT (Ever treated)	-0.2702	-0.0257	0.8746**
	(0.2847)	(0.1057)	(0.4213)
Individual Controls	Yes	Yes	Yes
Community Controls	Yes	Yes	Yes
Pre-treatment mean	0.625	0.627	0.624
N	465	364	316

Notes: Estimated using the Callaway and Sant'Anna (2021) difference-in-differences estimator with doubly robust improved (DRIMP) method. The dependent variable is a binary employment variable. Sample consists of married, left-behind women (women whose husbands are migrants living away from the household) in communities that got a cell tower during the study period or never got a cell tower. ATT (Treated by 2012) and ATT (Treated by 2014) report the average treatment effect on the treated for cohorts first treated in 2012 and 2014, respectively. ATT (Ever treated) reports the overall average treatment effect on the treated across all cohorts. Column 1 restricts the sample to couples whose gender role preferences match. Column 2 restricts the sample to couples with a progressive wife and a conservative husband. Column 3 restricts the sample to couples with a conservative wife and a progressive husband. Individual controls include urban residence and remittances. Community controls include highest egg price, community area size, and food expenditure. Robust standard errors in parentheses. [a] Estimates in Column 3 should be interpreted with caution due to small sample size ($N = 316$) and a larger covariate set, which may produce unstable estimates. * indicates $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Source: China Family Panel Survey (CFPS)

Table A7—: ATT(g,t) Results for the 2012 and 2014 Cohorts, with Covariates

	(1) All obs.	(2) Role info avail.	(3) Role info unavail.	(4) Pref. match	(5) Progressive wife	(6) Conservative wife[a]
Group 2012						
ATT(2012, 2012)	-0.1514**	0.0894	-0.2532**	-0.0563	0.2581	1.9470**
	(0.0766)	(0.1095)	(0.1057)	(0.1379)	(0.1689)	(0.8949)
ATT(2012, 2014)	0.1029	0.0858	-0.0443	-0.1636	0.1791	1.6977**
	(0.0753)	(0.1009)	(0.1839)	(0.1792)	(0.1753)	(0.6881)
ATT(2012, 2016)	0.0628	0.2365**	0.0248	0.3873**	0.1447	-0.2684
	(0.0984)	(0.1150)	(0.1444)	(0.1522)	(0.1852)	(0.6277)
ATT(2012, 2018)	-0.0863	0.1225	-0.1579	0.3023	0.0308	1.2105
	(0.1094)	(0.1314)	(0.1416)	(0.2358)	(0.2171)	(0.7492)
Group 2014						
ATT(2014, 2012)	0.1447	0.1552	0.1571	0.2840	0.1403	0.4837
	(0.0895)	(0.1123)	(0.1192)	(0.1926)	(0.1813)	(0.5766)
ATT(2014, 2014)	0.0138	-0.1819*	0.0813	0.0033	-0.2302	0.2197***
	(0.0543)	(0.1008)	(0.0891)	(0.1820)	(0.1690)	(0.0771)
ATT(2014, 2016)	-0.2387***	-0.1636	0.0676	0.2643	-0.4663**	0.0121
	(0.0707)	(0.1467)	(0.1241)	(0.2602)	(0.1929)	(0.0080)
ATT(2014, 2018)	-0.6427***	0.0964	-0.1970	-4.3425[b]	-0.1500	0.0759**
	(0.0695)	(0.1219)	(0.3138)	(3.1455)	(0.1975)	(0.0361)
Individual Controls	Yes	Yes	Yes	Yes	Yes	Yes
Community Controls	Yes	Yes	Yes	Yes	Yes	Yes
$N_{\text{2012 treat}}$	396	238	158	91	84	52
$N_{\text{2014 treat}}$	404	259	145	67	76	94
N_{control}	1,289	702	547	307	204	170

Note: ATT(g,t) denotes the average treatment effect on the treated for the cohort first treated in year g, measured at time t, estimated using the Callaway and Sant'Anna (2021) difference-in-differences estimator with doubly robust improved (DRIMP) method. The dependent variable is a binary employment variable. $N_{\text{2012 treat}}$, $N_{\text{2014 treat}}$, and N_{control} report the number of observations first treated in 2012, first treated in 2014, and never treated, respectively. Column 1 shows results for the full sample. Column 2 restricts to observations with gender role preference information available for both spouses. Column 3 restricts to observations without gender role preference information for at least one spouse. Column 4 restricts to couples whose gender role preferences match. Column 5 restricts to couples with a progressive wife. Column 6 restricts to couples with a conservative wife. Individual controls include urban residence, remittances, and age. Community controls include highest egg price, community area size, and prior ICT availability. [a] Estimates in Column 6 for Group 2012 should be interpreted with caution as they exceed the $[0, 1]$ support of the binary outcome, likely reflecting model instability due to small sample size ($N = 316$) and a relatively large covariate set. [b] ATT(2014, 2018) in Column 4 is extreme (-4.34, SE 3.15) and likely reflects near separation or thin cell counts in the 2018 wave for this subsample. Robust standard errors in parentheses. * indicates $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.
Source: China Family Panel Survey (CFPS).

Table A8—: Small Cell Problem

Panel A: Treated Timing — Preference Matching

Year Obs.	Comparison	2012 cohort	2014 cohort	Total
2010	51	22	10	83
2012	71	20	16	107
2014	73	21	15	109
2016	62	17	16	95
2018	50	11	10	71
Total	307	91	67	465

Panel B: Treated Timing — Con. Wife and Prog. Hus.

Year Obs.	Comparison	2012 cohort	2014 cohort	Total
2010	30	12	16	58
2012	39	12	24	75
2014	40	12	19	71
2016	38	10	19	67
2018	23	6	16	45
Total	170	52	94	316

Table A9—: ATT(g,t) Results for the 2012 and 2014 Cohorts, with Normalized Covariates

	(1) All obs.	(2) Role info avail.	(3) Role info unavail.	(4) Pref. match	(5) Progressive wife	(6) Conservative wife
Group 2012						
ATT(2012, 2012)	-0.1349	-0.0016	-0.2575**	-0.0572	0.2700	-0.1227
	(0.0841)	(0.1085)	(0.1138)	(0.1686)	(0.1689)	(0.2333)
ATT(2012, 2014)	0.0814	0.0683	-0.0410	-0.0140	0.1785	0.1912
	(0.1033)	(0.0999)	(0.1729)	(0.1743)	(0.1766)	(0.2074)
ATT(2012, 2016)	0.1457	0.2034*	0.0587	0.3046*	0.1498	0.0118
	(0.1026)	(0.1132)	(0.1314)	(0.1776)	(0.1844)	(0.2981)
ATT(2012, 2018)	-0.0211	0.1120	-0.2036	0.3594*	0.0833	0.4573
	(0.1048)	(0.1288)	(0.1690)	(0.1910)	(0.2026)	(0.3175)
Group 2014						
ATT(2014, 2012)	0.1335	0.1770	0.1289	0.2829	0.0791	0.2753
	(0.0984)	(0.1210)	(0.1306)	(0.1821)	(0.1743)	(0.1966)
ATT(2014, 2014)	-0.0929	-0.1074	-0.0659	0.1268	-0.2302	0.1004
	(0.1039)	(0.1145)	(0.1472)	(0.1549)	(0.1690)	(0.1640)
ATT(2014, 2016)	0.0578	-0.0002	0.0517	0.3395*	-0.4663**	0.1028
	(0.1298)	(0.1402)	(0.1343)	(0.1887)	(0.1929)	(0.1732)
ATT(2014, 2018)	-0.3246**	-0.1496	-0.5056***	0.1081	-0.1500	-0.0101
	(0.1262)	(0.1372)	(0.1744)	(0.2859)	(0.1975)	(0.1942)
Individual Controls	Yes	Yes	Yes	Yes	Yes	Yes
Community Controls	Yes	Yes	Yes	Yes	Yes	Yes
$N_{2012\ \text{treat}}$	380	235	145	91	84	52
$N_{2014\ \text{treat}}$	401	256	145	67	76	94
N_{control}	1,219	691	528	307	204	170

Note: ATT(g,t) denotes the average treatment effect on the treated for the cohort first treated in year g, measured at time t, estimated using the Callaway and Sant'Anna (2021) difference-in-differences estimator with regression adjustment (RA) method. The dependent variable is a binary employment variable. $N_{2012\ \text{treat}}$, $N_{2014\ \text{treat}}$, and N_{control} report the number of observations first treated in 2012, first treated in 2014, and never treated, respectively. Column 1 shows results for the full sample. Column 2 restricts to observations with gender role preference information available for both spouses. Column 3 restricts to observations without gender role preference information for at least one spouse. Column 4 restricts to couples whose gender role preferences match. Column 5 restricts to couples with a progressive wife. Column 6 restricts to couples with a conservative wife. Individual controls include normalized urban residence, log remittances, and age. Community controls include normalized highest egg price, log monthly food expenditure, log floating population (without household registration), polluting factory (within 5km), log community area size, and prior ICT availability. Robust standard errors in parentheses. * indicates $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.
Source: China Family Panel Survey (CFPS).

Table A10—: CSDID: Using Absolute Value Matching

	(1) Prog. wife	(2) Cons. wife
ATT (Treated by 2012)	-0.3147*	
	(0.1614)	
ATT (Treated by 2014)	0.2500	-0.0528
	(0.3062)	(0.4071)
ATT (Ever treated)	-0.0810	-0.0528
	(0.1196)	(0.4071)
Pre-treatment mean	0.579	0.765
N	85	25

Notes: Estimated using the Callaway and Sant'Anna (2021) difference-in-differences estimator with regression adjustment (RA) method. The dependent variable is a binary employment variable. Sample consists of married, left-behind women (women whose husbands are migrants living away from the household) in communities that got a cell tower during the study period or never got a cell tower. Progressive wife and conservative husband pairs are defined as women answering gender role attitude questionnaire as 1 or 2 scale while mat ATT (Treated by 2012) and ATT (Treated by 2014) report the average treatment effect on the treated for cohorts treated by 2012 and 2014, respectively. ATT (Ever treated) reports the overall average treatment effect on the treated across all cohorts. Column 1 includes urban residence as an individual control only. Column 2 includes urban residence and standardized age as individual controls, and standardized remittances, standardized food expenditure, standardized highest egg price, standardized number of persons, and polluting factory (within 5km) as community controls. Only one treatment cohort (G2014) exists in column 2 due to data limitation; ATT (Treated by 2012) is therefore omitted and ATT (Ever treated) equals ATT (Treated by 2014). Pre-treatment mean refers to the mean employment rate of the never-treated control group. Robust standard errors in parentheses. * indicates $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Source: CFPS