From Bytes to Business: Broadband Networks and Rural Entrepreneurship in China *

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Abstract

Can enhanced broadband access create rural entrepreneurs and how? Analyzing a major subsidized telecommunications network rollout in China (2016 – 2018), our staggered difference-in-differences estimates show a significant increase in rural self-employment, especially among women who transitioned from salaried work. These effects are persistent and grow over time. Interestingly, the intervention also decreased out-migration and encouraged skilled individuals to return. This entrepreneurial shift, concentrated in non-service sectors, boosted total family income despite a decline in wage earnings. Our results suggest that enhanced broadband access can be a powerful tool for retaining talent and fostering female entrepreneurship in rural economies.

Keywords: Broadband Access, Rural Entrepreneurship, Telecommunication Service
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1 Introduction

A thriving economy relies on entrepreneurship and the establishment of new businesses. In many developing countries, formal sector jobs are insufficient, especially for young people, making self-employment a profitable alternative (de Mel et al., 2008) and, in some contexts, a healthier one (Blattman and Dercon, 2018). However, starting and growing a business is challenging, particularly in rural areas, due to credit constraints, savings constraints, and a lack of managerial skills (Banerjee and Duflo, 2014). Additionally, women entrepreneurs face more obstacles than men and tend to earn less (Hardy and Kagy, 2018, 2020).

To assist entrepreneurs in developing countries in establishing or expanding their small businesses, numerous intervention programs have been implemented, focusing on aspects such as labor subsidies (Mel et al., 2019), cash grants (Blattman et al., 2016), business training (McKenzie and Puerto, 2021), technology adoption (Atkin et al., 2017), and business plan competitions (McKenzie, 2017). Evaluations of these interventions have yielded mixed results: while some find significant and sustained impacts, others discover that the effects, especially on female entrepreneurs—are not persistent (Blattman et al., 2016).

The rapid development of telecommunication technology and the widespread penetration of broadband services have significantly transformed people's daily lives and business operations, with substantial impacts on firms' productivity, local employment, and consumer demand (Hjort and Tian, 2024; Bertschek et al., 2015; Akerman et al., 2015). Although some research suggests that the deployment of high-speed Internet could exacerbate inequality (Akerman et al., 2015), other studies demonstrate that Internet access can benefit disadvantaged groups (Niu et al., 2022; Leng, 2022; Viollaz and Winkler, 2022). Despite this growing literature, there is limited evidence on the causal impacts of broadband access on individual-level self-employment and entrepreneurial activity, partly due to the lack of exogenous variation in network access.

This paper addresses this gap by exploiting a plausibly exogenous shock to broadband access, the rollout of the China Universal Telecommunication Service (UTS) Projects starting in 2016. The UTS is a national initiative aimed at promoting the construction of broadband network infrastructure in rural areas, particularly in nationally designated poverty-stricken counties and border regions. It represents a specific implementation of the Broadband China strategy launched in 2013. The UTS project features a staggered deployment, with four waves of pilot city lists selected between 2016 and 2018 by the Ministry of Industry and Information Technology (MIIT) and the Ministry of Finance (MOF). It provides subsidies for the construction of broadband internet facilities for both fixed networks and mobile networks, with the goal of providing mobile service and broadband internet to every county and village.

This policy intervention provides a particularly interesting test ground because of the concurrent explosion of digital entrepreneurship in China. Propelled by platforms like *Rednote* (Xiaohongshu) and *Douyin* (the Chinese version of TikTok), live-stream e-commerce has become a multi-trillion yuan market (Zhang, 2024). This transformation is especially potent in rural areas where the UTS was targeted. Farmers, once isolated by geography, now leverage live-streaming to sell agricultural goods directly to a national consumer base. For instance, a vlogger in Shaanxi province helped local farmers achieve over $1 million in sales by incorporating their products into his videos depicting tranquil rural life (Xinhua, 2025).

We begin by developing a local labor market model with heterogeneous workers endowed with sector-specific efficiency units of labor. The model describes how workers with different skill levels allocate themselves across sectors, including agriculture, self-employment, and formal employment, and how technological change, specifically enhanced access to broadband networks, affects wage rates and occupational choices. We focus on how disadvantaged workers, such as younger individuals with less experience, medium-educated workers, and women, may particularly benefit from this technological change. The model generates several testable predictions: (1) enhanced broadband access can attract marginal workers from agriculture or salaried employment into self-employment; (2) the impacts are more pronounced among younger, medium-educated, and female workers; and (3) this technological change could attract internal migrants back to their hometowns to become self-employed. We then test these predictions using our empirical findings and use them to rationalize our regression results.

The staggered rollout of the UTS projects provides a quasi-natural experiment that we exploit using a staggered difference-in-differences (DID) strategy and representative household panel survey data to examine the causal impacts of enhanced broadband access on rural entrepreneurship and business development. Our empirical results show that rural residents are more likely to use mobile internet and have higher monthly cellphone expenditures after the UTS projects cover their prefectures. Moreover, rural residents are slightly more likely to choose self-employment as their primary occupation, with this effect concentrated among women, younger individuals (aged 16 to 45), and those with medium education levels (elementary or junior high school graduates). Dynamic analysis indicates that these positive impacts persist and grow over time. Additionally, regression results on household data reveal that families in UTS-covered prefectures are slightly more likely to own businesses and have higher average total income. However, we find no significant impacts on business income or business assets.

To further explore the mechanisms behind the positive impacts of broadband internet on rural self-employment, we find that the increase in self-employment comes from a decline in formal salaried employment, particularly among lower-paid workers. The majority of the increased self-employment occurs in non-service sectors, including agriculture, manufacturing, mining, and construction. Interestingly, our results show that families with enhanced broadband access are more likely to borrow from friends and relatives. At the same time, there is no significant change in loans from banks or non-financial institutions. Additionally, our mechanism analysis indicates that more returning migrants move back to their hometowns when these areas are equipped with broadband internet. These findings suggest that enhanced access to broadband networks increases self-employment in rural China by strengthening social networks, easing credit constraints through acquaintances, providing market information, and attracting returning migrants.

Our results are validated through multiple robustness checks, including different specifications with various fixed effects, alternative control groups, different age limits, and different time intervals. We also replicate our analysis using data from an alternative, albeit less representative, household survey. To address concerns that our staggered two-way fixed effects (TWFE) estimates may be biased due to treatment effect heterogeneity across time or groups, we conduct dynamic analysis using two alternative estimation methods robust to such heterogeneity, and both methods yield consistent results.

The key contribution of this paper is that we are among the few to demonstrate that enhanced broadband access triggers significant socioeconomic transformations extending beyond the support of individual entrepreneurial ventures. We establish this by analyzing a unique context where traditional economic infrastructures are limited. Our findings show that improved internet access fosters entrepreneurship by reducing barriers to market access, strengthening social capital, and alleviating credit constraints. Furthermore, our analysis of mechanisms provides a more comprehensive understanding of these effects by linking them to key issues in developing economies, such as the role of informal social networks in securing financial support, the persistence of credit constraints in rural settings, and challenges related to market access. Additionally, we examine how internet-driven changes in local labor markets influence internal migration patterns, contributing to a reduction in out-migration from rural areas and encouraging return migration. This research thus adds crucial nuance to the understanding of how technological advances can drive inclusive economic growth in traditionally marginalized regions.

Specifically, we contribute to the literature on the obstacles to entrepreneurship and interventions designed to foster and support entrepreneurs, particularly in developing countries. Starting and growing a business is challenging, particularly in rural areas, due to credit constraints, savings constraints, and a lack of managerial skills (Banerjee and Duflo, 2014). Additionally, women entrepreneurs face more obstacles than men and tend to earn less (de Mel et al., 2008, 2009; Hardy and Kagy, 2018, 2020). To assist entrepreneurs in developing countries in establishing or expanding their small businesses, numerous intervention programs have been implemented, focusing on aspects such as labor subsidies (Mel et al., 2019), cash grants (Blattman et al., 2016), business training (McKenzie and Puerto, 2021), technology adoption (Atkin et al., 2017), and business plan competitions (McKenzie, 2017). Evaluations of these interventions have yielded mixed results: while some find significant and sustained impacts, others discover that the effects, especially on female entrepreneurs, are not persistent (Blattman et al., 2016). The impacts of telecommunication technology development, and specifically broadband internet penetration, on entrepreneurship represent an emerging area of study. For instance, Beem (2021), Barnett et al. (2019), and Tan and Li (2022) discuss the impacts of technological development on entrepreneurship, particularly in rural areas. Our paper contributes to this literature by providing causal evidence of the impact of broadband internet access on rural entrepreneurship, particularly among disadvantaged groups, including female, younger, and medium-educated individuals. Our work is distinct from related papers in its utilization of plausibly exogenous variation in the adoption timing of a universal technological service project that targets only rural areas. Furthermore, our study provides more detailed evidence on the underlying mechanisms using individual-level information.

Second, our study contributes to the literature on telecommunications technology, its development, and its broader impacts in the developing world. As surveyed in Bertschek et al. (2015) and Hjort and Tian (2024), the literature has extensively explored the impacts of telecommunications technology, such as broadband internet, on both the supply side—through labor productivity (e.g., Akerman et al., 2015; Caldarola et al., 2023; Bahia et al., 2024), human capital development (e.g., Hjort and Poulsen, 2019; Bianchi et al., 2022; Lakdawala et al., 2023; Oster and Steinberg, 2013), innovation (Xu et al., 2019; Yang et al., 2022), and firm-worker matching (e.g., Houngbonon et al., 2022; Porcher et al., 2024; Zuo, 2021; Bhuller et al., 2023)—and the demand side, including market access (e.g., Couture et al., 2021; Hjort et al., 2020), international trade (Sun, 2021; Fernandes et al., 2019; Malgouyres et al., 2021), and information frictions (e.g., Jensen, 2007; Fernandes et al., 2019). More generally, previous research shows that technological development, particularly broadband internet, decreases inequality (Liu et al., 2024a; Leng, 2022; Niu et al., 2022), and particularly gender gaps (Viollaz and Winkler, 2022). Our study complements this strand of literature by specifically examining how telecommunications technology, particularly broadband internet, influences self-employment and entrepreneurship. Our finding that internet development fosters entrepreneurship aligns with the results of Bahia et al. (2023).

Outline The remainder of the paper is structured as follows. Section 2 provides institutional background on telecommunication technology development, E-commerce, and entrepreneurship in China. Section 3 represents a local labor market model to describe sectoral choices and the impacts of telecommunication technological change, providing several testable predictions. Section 4 describes the data sources and presents descriptive evidence. Section 5 states the empirical strategy, identification assumptions, and potential threats. Section 6 presents the main regression results, robustness checks, and the mechanisms behind the impacts. Section 7 concludes.

2 Institutional Background

2.1 Development of Broadband Internet in China

China has rapidly advanced in internet development and broadband penetration. Internet access began in earnest on April 20, 1994, with the establishment of the first international connection. Broadband adoption accelerated significantly after 2000, driven primarily by commercial promotion of Asymmetric Digital Subscriber Line (ADSL) technology[1]. By June 2005, according to the sixteenth Statistical Report on Internet Development by the China Internet Network Information Center (CNNIC), China's internet users surpassed 100 million, with over half utilizing broadband connections[2]. However, access remained uneven, and quality varied significantly. By the end of 2011, rural internet users comprised only 26.5% of total internet users[3], despite rural residents accounting for 48.17% of China's population[4].

Recognizing this disparity, the Chinese government launched the Broadband China strategy in 2013[5], aiming to substantially improve broadband infrastructure, particularly in rural areas. Targets included providing broadband access exceeding 12 Mbps to 98% of administrative villages by 2020. Between 2014 and 2016, the Ministry of Industry and Information Technology (MIIT) and the National Development and Reform Commission (NDRC) designated multiple Broadband China Demonstration Cities to accelerate broadband infrastructure development.

In 2016, MIIT, along with the Ministry of Finance (MOF), introduced the Universal Telecommunication Service (UTS) pilot project[6]. This initiative provided financial subsidies to local governments through a market-based procurement process, with central subsidies varying by regional economic status (15% for eastern provinces, 20% central, 30% western, and 35% autonomous regions), supplemented by local government budgets and private firm contributions. Infrastructure projects under UTS included fiber optic cable networks and 3G/4G base stations.

Four batches of pilot city lists were announced between 2016 and 2018. From 2019 onward, provincial governments assumed greater responsibility for project planning and execution. These efforts significantly enhanced broadband coverage in rural areas. By November 2021, all Chinese villages were connected to optical fiber networks. As illustrated in Figure 1, rural internet penetration has sharply increased since the inception of the UTS projects, substantially narrowing the urban-rural digital divide.

2.2 E-commerce and Entrepreneurship in China

Entrepreneurship in China has evolved significantly since economic reforms were initiated in 1978 (He et al., 2019), especially after private enterprises gained formal recognition in 1988 (Li, 2013). Transitioning from central planning to a market-oriented economy reduced institutional barri-

[1] A detailed timeline of early-stage internet development in China from 1986 to 2003 can be found at https://www.cnnic.com.cn/IDR/hlwfzdsj/201306/t20130628_40563.htm.

[2] The report is available at https://www.cnnic.cn/n4/2022/0401/c88-811.html (in Chinese).

[3] Data source: the twenty-ninth Statistical Report on Internet Development by CNNIC, available at https://www.cnnic.com.cn/IDR/ReportDownloads/201209/P020120904421720687608.pdf.

[4] Calculated using total population and rural residents statistics by the end of 2011 from the National Bureau of Statistics (NBS).

[5] The announcement and implementation details can be found: https://www.gov.cn/zwgk/2013-08/17/content_2468348.htm (in Chinese).

[6] The official announcement can be found: https://jjs.mof.gov.cn/tongzhigonggao/201512/t20151225_1632388.htm (in Chinese).

ers, facilitating rapid private sector growth, which became the primary driver of economic development by the early 1990s (He, 2009). Informal institutions such as *guanxi* (social networks) played essential roles initially (Yang and Li, 2008), later giving way to innovation-driven competitive advantages exemplified by global corporations like Alibaba and Tencent (Tse, 2016). The government's recent emphasis on "mass entrepreneurship and innovation" further bolsters the entrepreneurial environment, underscoring private enterprise as a crucial engine for sustainable economic growth (State Council of P.R. China, 2017).

Leveraging expanding broadband infrastructure, China's e-commerce market has grown dramatically, positioning the country as a global leader in online retail. By 2022, the online retail market consumer base reached approximately 845 million individuals, with overall e-commerce transactions totaling 43.83 trillion RMB (around 6.51 trillion USD)[7]. Retail e-commerce alone accounted for 13.79 trillion RMB (2.05 trillion USD), with rural e-commerce contributing 2.17 trillion RMB (0.32 trillion USD).

The rural e-commerce market has particularly benefited from broadband expansions, becoming a central policy priority for reducing urban-rural economic disparities. One notable initiative is the "Taobao Villages" program by China's largest e-commerce platform, Taobao. Empirical studies on these villages have yielded mixed outcomes, including increased rural household incomes, reduced living costs, and narrowed consumption inequality (Couture et al., 2021; Liu et al., 2024b; Luo and Niu, 2019). More recently, the landscape has been reshaped by the explosive growth of live-stream e-commerce, primarily on social media platforms like *Douyin* (the Chinese version of TikTok) and *Kuaishou*. This model merges entertainment with direct-to-consumer sales, allowing individual creators to build personal brands and market products in real-time. This marks a new paradigm for rural entrepreneurship. While the "Taobao Villages" model created geographic production hubs, live-streaming empowers individuals. "Farmfluencers" with a smartphone can now bypass traditional supply chains, selling directly to consumers nationwide and capturing more value.

Within this context, exploring the impacts of broadband internet policy on entrepreneurship and business formation offers timely and significant policy implications.

3 Model

We build upon the labor supply and occupational choice framework from Amodio et al. (2024) to model rural China's labor market, where firm production and labor demand are exogenous but responsive to broadband internet expansion.[8] Our model characterizes how broadband penetration

[7]Report available at `http://dzsws.mofcom.gov.cn/article/ztxx/ndbg/202306/20230603415404.shtml` (in Chinese).

[8]Amodio et al. (2024) propose a general equilibrium model exploring how market concentration reshapes labor markets and encourages self-employment. Here, we adapt their labor supply and occupational choice components to derive testable predictions.

influences occupational sorting, specifically the shift toward self-employment.

3.1 Model Setup

Consider rural China, which consists of multiple segmented labor markets indexed by k, each with a measure of $L_k \in \mathbb{R}+$ of heterogeneous workers sharing identical homothetic preferences. Each market k includes firms with a finite measure M_k.

Workers select occupations from agriculture (A), formal employment (F), or self-employment (S). Worker abilities are sector-specific, represented by their endowment of efficiency units of labor $a = \{a_A, a_F, a_S\} \in \mathbb{R}^3_+$, and drawn i.i.d. from market-specific distribution $G_k(a_A, a_F, a_S)$.

For simplicity, we treat the production and provision of consumption goods—whether by firms, self-employed individuals, or farmers—as given. Consequently, the returns per efficiency unit of labor in each sector are fixed and denoted by $W_{A,k}$, $W_{F,k}$, and $W_{S,k}$, respectively.

3.2 Labor Supply and Occupational Choice

A worker i earns income $I^i_{j,k} = W_{j,k}a^i_j$ in sector $j \in A, F, S$ and chooses the sector maximizing this income.

Worker i selects agriculture if: $\hat{W}_{AS,k} \geq \left(\frac{a^i_A}{a^i_S}\right)^{-1}, and \quad \hat{W}_{AF,k} \geq \left(\frac{a^i_A}{a^i_F}\right)^{-1}$, where $\hat{W}_{AS,k} \equiv \frac{W_{A,k}}{W_{S,k}}$ and $\hat{W}_{AF,k} \equiv \frac{W_{A,k}}{W_{F,k}}$, which are relative wages per efficiency unit in local labor market k. Similar conditions apply when worker i chooses sectors S or F.

We categorize workers into three ability-based types, reflecting their occupational choices and comparative advantages:

- **Low-ability** (L)**:** Lower efficiency in sectors S and F, thus choosing sector A.
- **Medium-ability** (M)**:** Comparative advantage in sector S, thus choosing self-employment.
- **High-ability** (H)**:** Comparative advantage in formal employment, thus choosing sector F.

3.3 Technological Change

Technological change, such as broadband internet penetration, influences sector returns. Specifically, returns in self-employment $(W_{S,k})$ may rise due to increased revenue or decreased costs, while returns in formal employment $(W_{F,k})$ exhibit ambiguous effects due to skill complementarity (Akerman et al., 2015). We assume agricultural wages remain constant.

Under this technological change and updated returns in each sector, for marginal workers previously in sector A, the increased returns in sector S could reverse their comparative advantage, leading them to switch from sector A to sector S. Similarly, some marginal workers in sector F may alter their occupational choice if their comparative advantage shifts in favor of sector S.

Suppose broadband reduces wages for low-skilled formal employees but raises returns for higher-skilled formal employees ($W'_{F,k} \leq W_{F,k}$). In that case, occupational shifts toward self-employment become more pronounced. This aligns with Bu and Tang (2023), who find that high-speed internet slightly decreases average formal-sector wages, prompting occupational shifts.

Extending this model to include gender wage gaps, we assume women have lower formal-sector wages ($W^f_{F,k} \leq W_{F,k}$, in which $W_{F,k}$ represents men's wage rate), while agricultural and self-employment wages remain gender-neutral.[9] Enhanced broadband access may incentivize more women to shift from formal employment to self-employment.

Another extension involves multiple local labor markets, including rural, urban, and regional divisions. Suppose there are two separate local labor markets, indexed by u (urban) and r (rural), with different distributions of workers' abilities G_u and G_r, and different sector wage rates. We assume sector A does not exist in the urban market and that urban wages are higher in both sectors S and F, i.e., $W_{S,u} \geq W_{S,r}$ and $W_{F,u} \geq W_{F,r}$. Rural workers may migrate to urban areas for higher returns, factoring in migration costs.

If enhanced broadband access occurs only in rural markets, increasing returns in self-employment ($W'_{S,r} \geq W_{S,r}$) may influence the migration decisions of marginal workers. Higher returns in sector S in rural areas could incentivize some workers to remain or return to the rural labor market, opting for self-employment. Consequently, technological advancements in broadband access could attract internal migrants back to their hometowns.

This model yields the following testable predictions:

- Technological advancements increase self-employment, drawing from agriculture and formal employment.
- Medium-ability workers are most responsive to shifting toward self-employment.
- Women are more likely than men to transition from formal employment to self-employment.
- Enhanced rural broadband encourages internal return migration toward rural self-employment.

4 Data Source

Our empirical analysis primarily relies on the China Family Panel Survey (CFPS), conducted by Peking University's Institute of Social Science Survey (ISSS). The CFPS is a nationally representative longitudinal dataset covering 25 provincial regions in China since 2010, capturing detailed

[9]For example, Ben Yahmed (2018) finds significant gender wage gaps in formal employment but no bias in informal sectors after selection adjustments using urban Brazil data.

demographic and socioeconomic information for both rural and urban households. Our analysis incorporates all available survey waves from 2010 to 2020.[10]

To complement this dataset, we utilize data from the China Health and Retirement Longitudinal Studies (CHARLS), conducted jointly by Peking University and Wuhan University. CHARLS specifically targets individuals aged 45 and above, providing comprehensive data on older adults and their households. We examine the 2011, 2013, 2015, 2018, and 2020 waves, focusing primarily on household-level information related to family business ownership and operational status. While CHARLS offers detailed insights into older populations, it does not necessarily represent all rural households nationwide.[11]

National and City-level Data Additionally, we leverage national statistics on internet usage to calculate rural and urban internet penetration rates using data from the Statistical Reports on Internet Development in China, published by the China Internet Network Information Center (CNNIC). [12] City-level data on internet user households and related variables are sourced from the China City Statistical Yearbook, compiled by the National Bureau of Statistics (NBS).

5 Empirical Strategy

To test our model's predictions regarding the impact of improved access to broadband internet on the local rural labor market, we use a staggered difference-in-differences (DID) approach. Specifically, we capitalize on the staggered implementation of the UTS programs in different cities in different years and compare the changes in key outcomes for individuals or households that received the treatment (enhanced access to broadband internet) versus those that did not.

5.1 Staggered DID Method

The staggered design of the UTS program allows us to test its impacts using the staggered DID model as follows:

$$Y_{ict} = \beta UTS_{ct} + \Gamma X_{ict} + \delta_c + \sigma_t + \epsilon_{ict}, \tag{1}$$

where Y_{ict} is the outcome variables of individual or family i in city c at year t. UTS_{ct} is an absorbing indicator of whether city c had already been included by the UTS projects at year t. β is the main coefficient of interest, which stands for the average treatment effects of the UTS project on outcomes Y_{ict}. X_{ict} are individual or household controls. δ_c is city fixed effect. σ_t is year fixed effect, and ϵ_{ict} are error terms, clustered at city level.

[10]More information about CFPS is available at http://www.isss.pku.edu.cn/cfps/en/index.htm.
[11]Further details on CHARLS can be found at https://charls.pku.edu.cn/en/.
[12]CNNIC data are accessible via https://www.cnnic.com.cn/index.htm.

The absorbing treatment status UTS_{ct} is determined at the city level, meaning that once a city is included in the UTS project during a specific year, it is considered treated from that point on. There are two important issues to consider with this empirical design. Firstly, while the MIIT and MOF announced the pilot city list at the city level between 2016 and 2018, each city submitted applications and program proposals specifically for villages where new 3G/4G stations or broadband internet facilities will be constructed. Although we have access to county information of interviewed households, we lack more detailed village information, making it impossible to identify whether an individual or household lives in a village targeted by the UTS project. As a result, we simplify the design of the treatment status at the city level, and the estimates of treatment effects can be considered as a conservative lower bound of the true average treatment effects of such a project. Second, in the first four rounds of pilot cities between 2016 and 2018, some cities were chosen more than once. This occurred when multiple eligible villages were without adequate broadband internet access, and the UTS project could not support all of them in a single year. The UTS project enabled rural individuals and households to access broadband internet by constructing new village facilities. The project's ongoing support could extend to more villages or additional residents within the same village, but it did not focus on improving existing internet connections. We consider a city as "treated" when initially included in the UTS project.

To causally identify the average treatment effects of the UTS project on rural entrepreneurship using the DID specification, two assumptions are necessary: the non-anticipatory effects assumption and the parallel trend assumption (Sun and Abraham, 2021; Borusyak et al., 2024; Roth et al., 2023). The assumption of non-anticipation requires that rural individuals or households do not know when the UTS project will be introduced in their city for the first time. Therefore, they would not start new businesses anticipating the UTS project. As explained in Section 2, the central government determined the UTS pilot city list, and the provincial government summarized and submitted the application. As a result, it was unlikely that an individual or household could foresee the exact inclusion time of a city. We believe the anticipatory effects in the context of this paper were limited.

Unsurprisingly, MIIT and MOF did not determine the list of pilot cities of UTS randomly, nor did the application decisions of the prefectural and provincial governments. If the criteria for selecting cities for the UTS projects were in non-parallel trends between treated and control cities, in the absence of treatment, and these selected cities also have different trends in the main outcomes of individuals or households, it could raise concerns about identification. In Figure 2, we show the time trends of several main economic indicators among different groups of cities with different UTS coverage years. Figure 2 indicates that cities that were included in the UTS projects earlier in 2016 and 2017 were less developed in terms of GDP per capita, government revenue, and government expenditure, and there were also fewer entrepreneurs and fewer mobile phone and internet users before the UTS project's commencement. However, the graphs also show that the main city-level indicators are on a similar time trend before 2016, including GDP per capita, total population, population natural growth rates, self-employment number, government revenue, government expenditure, mobile phone users, and broadband internet users.

5.2 Event Study Method

We use an event study design to demonstrate the dynamic effects of the UTS projects on rural entrepreneurship and to test for parallel trend assumption. The dynamic DID model is expressed as follows:

$$Y_{ict} = \sum_{r \neq -1} \mathbb{1}[R_{ct} = r]\beta_r + \Gamma X_{ict} + \delta_c + \sigma_t + \epsilon_{ict}, \tag{2}$$

where R_{it} represents the relative years since the city where individual or household i resides was first selected for the UTS project at year t, while β_r is the corresponding dynamic impact over treated individuals or households at the relative year of r. It's important to note that in this study, the construction of broadband internet facilities takes an average of one year, as reported by the local government [13]. Therefore, we can expect to observe the effects of improved access to broadband internet in affected rural areas after a certain period, if any, with potentially stronger impacts compared to the immediate effects during the year when the UTS project was first announced. As a result, the event study method is well-suited to assess whether the UTS project has lagged and persistent impacts on rural entrepreneurship activities and to serve as a test for parallel pre-trend of treated and control groups before the UTS projects.

5.3 Issues on Treatment Effects Heterogeneity

As shown in several recent econometric papers, the staggered DID estimation method, either static or dynamic, will be biased by treatment heterogeneity among groups and periods (Callaway and Sant'Anna, 2021); Goodman-Bacon (2021); de Chaisemartin and D'Haultfœuille (2020); Sun and Abraham (2021); Borusyak et al. (2024); also see reviews by Roth et al. (2023), and de Chaisemartin and D'Haultfœuille (2023). This contamination happens because, in a staggered adoption design model, in both static and dynamic settings, the TWFE estimator is a weighted average of all 2X2 comparisons between any pair of groups and periods. However, these weights can be negative without any economic interpretation because of "Forbidden Comparisons" (Goodman-Bacon, 2021). Some comparisons are considered as forbidden because the control groups within such comparisons are early-treated groups.

We respond to this concern of biased estimates due to treatment effects heterogeneity using

[13] Two examples of local official reports on the first patch UTS project completion review in Gansu and Xinjiang can be found in the following webpage: `http://www.caict.ac.cn/xwdt/hyxw/201804/t20180426_157241.htm` and `https://www.xjtc.gov.cn/zzb/tzgg6__ywdt/tzgg/zhgg/content_29880` (both in Chinese). The first batch of the UTS pilot city list was announced in January 2016. Gansu province claimed to be the first province to complete the first batch of the UTS project in May 2017, and Tacheng prefecture of Xinjiang announced completing the project in January 2018.

the following practices: first, we use the alternative estimation method proposed by Callaway and Sant'Anna (2021) as a robustness test, which only uses never-treated and not-yet-treated groups as controls; second, we also use the new event study method proposed by Sun and Abraham (2021) as a robustness check, which uses only never-treated or last-treated groups as controls and uses better-defined weights.

6 Results

6.1 Impact of UTS Projects on Rural Internet Usage

City-Level Internet Usage We first examine whether the implementation of the UTS projects affects city-level broadband internet usage and mobile phone usage. Panel A of Table 2 presents the regression results of the UTS project's impact on the number of mobile phone users and the number of fixed broadband internet-using households at the city level. The results show that being covered by the UTS project increases the total number of mobile phone users by 10.4% city-wide on average. Moreover, the total number of fixed broadband internet users also increase by 27.1% (or 21.3% with city controls). This regression results at the city level imply that the UTS projects effectively increase the penetration rates of mobile phone usage and broadband internet usage.

Individual Internet and Cellphone Usage The second panel of Table 2 reports the regression results of the UTS projects on individual-level internet and cellphone usage. The findings suggest no significant impacts on general internet or cellphone usage. However, rural individuals in UTS-covered cities are slightly more likely to use cellphone internet and pay significantly higher monthly cellphone fees, with an increase of 3.268 RMB per month, representing an 8.77 percent increase.

6.2 Impact of UTS Projects on Rural Self-Employment

Next, we present the regression results of the UTS project's impact on rural self-employment, which is the primary focus of this paper. Table 3 indicates that, on average, rural individuals living in UTS-covered prefectures are more likely to choose self-employment as their primary occupation. However, the coefficient is not statistically significant.

As the overall impact may mask important heterogeneous patterns, we proceed to evaluate whether the UTS project incurs differential impacts on different groups of individuals. A heterogeneous analysis by gender reveals that women with improved access to broadband internet are significantly more likely to be self-employed, exhibiting a 17.85 percent increase compared to the control group. No noticeable impact is observed for men. These heterogeneous effects by gender support the prediction from our model that female workers are more likely to switch to sector S

compared with men of the same ability and educational attainment.

Additionally, younger individuals aged 16 to 30 and 31 to 45 are more likely to be self-employed, with increases of 2.2 and 2.9 percentage points, respectively. No significant differences are found in the impact on ethnic minorities.

Moreover, the UTS project significantly affects rural individuals' self-employment choices with elementary or junior high school education. At the same time, no noticeable difference is observed among college graduates or those without a college degree. This result aligns with our model's prediction that medium-ability workers are more likely to switch to sector S than very low-ability (below elementary or junior high school) or very high-ability (college graduate) workers.

Dynamic Impacts Our dynamic analysis, illustrated in Figure 3, demonstrates that the effects of enhanced broadband access on rural entrepreneurship persist and grow over time following the implementation of the UTS project. These effects amplify due to the time required to construct internet infrastructure (approximately one year on average) and for new businesses to commence operations or individuals to transition careers. The results indicate that after four years, there are significant and largest increases in the probability of choosing self-employment as the primary occupation.

We further explore the varying effects of the UTS projects based on gender, age, and education levels of rural individuals in Figure B.1 and Figure B.2. From Appendix B, we observe that women in rural areas tend to experience earlier and slightly larger benefits from the UTS projects than men. Moreover, Figure B.2 suggests that individuals with at least a junior high school education increasingly opt for self-employment over time. However, as indicated in Appendix B, there is no significant difference in the dynamic impacts of the UTS project on self-employment between younger and older rural individuals.

Business Profits and Assets Beyond the extensive margin of occupational choice and job switching, we investigate whether access to broadband internet leads to intensive margin benefits for the income and assets of existing or new businesses and whether it increases average family income in rural areas. Table 4 shows that rural families in UTS-covered prefectures are more likely to own a business, although the effect is statistically insignificant. No significant impacts are detected on the family's income or assets. This finding is consistent with Couture et al. (2021), which finds that expanding e-commerce initiatives to internet-connected villages in China has no significant impact on production or income. However, the UTS project has positive impacts on rural families' average income, suggesting that enhanced access to broadband internet leads to an increase in family income from sources other than business operations. These increases in family income could facilitate rural families' ability to start a business.

6.3 Robustness Checks

To ensure the validity of our findings on the lasting and increasing effects of the UTS projects on rural entrepreneurship—and the more pronounced impacts on women, younger individuals, and those with medium education—we conduct several robustness checks. These checks involve alternative model specifications, controls, estimation methods, and data sources. Detailed analyses are provided in the Appendix, and we summarize the key findings here.

Different Set of Fixed Effects Our main results remain robust under different model specifications. In Table A.1, we present regression results incorporating city and province-year fixed effects instead of city and year fixed effects. This specification better captures common temporal factors at the provincial level that might influence the outcomes. The results continue to demonstrate a positive impact of the UTS projects on rural self-employment, with more pronounced effects on younger individuals, those with medium levels of education, and women.

Different Control Sample Sized Table A.2 further shows that our findings are robust when using different control groups. Specifically, we exclude wealthier cities not covered by the UTS projects until 2018 to create a more comparable control group. The results remain consistent, reinforcing the validity of our conclusions. Similarly, as displayed in Table A.3, our results are robust when excluding older individuals aged 60 and above. Moreover, the primary results are not driven by data from the year 2020—when the survey was conducted during the COVID-19 pandemic—suggesting that the pandemic did not confound our findings, as shown in Table A.4.

Impacts on Urban Individuals In addition, we examine the impacts of the UTS projects on urban residents' internet usage and self-employment choices. Since the UTS projects provided subsidies exclusively for internet infrastructure in rural communities within covered prefectures, we would expect no direct impacts of this policy on urban residents' internet usage unless other parallel policies also improved internet penetration. Table A.5 confirms that urban residents in UTS-covered prefectures did not experience significant changes in cellphone and internet usage attributable to this policy. These results reinforce our initial findings that the UTS project had direct impacts on rural internet and cellphone usage.

Furthermore, Table A.6 presents the impacts of the UTS projects on urban residents' self-employment choices and the heterogeneity of these effects. Interestingly, the results indicate that urban individuals living in UTS-covered prefectures are also more likely to be self-employed, with more pronounced impacts among women, prime-age individuals, and noncollege graduates. One possible explanation for these significant impacts on urban residents is spillover effects from rural to urban areas. However, the dynamic impacts illustrated in Figure B.3 show no evidence of persistent effects on urban self-employment. Therefore, we cannot rule out the possibility that urban residents in UTS-covered cities also benefit from the project due to spillovers from rural areas. Alternatively, the observed effects may result from non-comparability between the treated and control urban samples.

Alternative Data Sources We also validate our findings using alternative data sources. Regression results presented in Table A.7 utilize data from the China Health and Retirement Longitudinal Study (CHARLS) to examine the impact of UTS project coverage on family business ownership, profits, and assets. Although CHARLS may have limitations in representativeness, as discussed in Section 4, the results indicate that improved access to broadband internet in rural areas significantly increases the proportion of households owning businesses and the average number of businesses owned. While there is evidence of higher business income, the effect is not statistically significant.

Alternative Estimation Methods Our event-study results are robust to alternative estimation methods proposed by Sun and Abraham (2021) and Callaway and Sant'Anna (2021). These methods address potential biases arising from treatment effect heterogeneity across groups or periods. Figure B.6 presents the regression results using the method and code from Sun and Abraham (2021), employing never-treated groups as controls. The dynamic results confirm the growing and persistent impacts of the UTS projects on rural entrepreneurship. Additionally, Figure B.7 shows event-study results using the estimators proposed by Callaway and Sant'Anna (2021), which, while indicating less pronounced effects, still demonstrate positive impacts over time.

6.4 Mechanism Analyses

Our mechanism analyses follow the implications of the model framework laid out in Section 3.

Who Are Those New Entrepreneurs? Becoming an entrepreneur is a self-selection process. To understand why the UTS policy induces more self-employment, we first explore who those new entrepreneurs are. Panel A in Table 5 implies that although not statistically significant, the increase in self-employed rural individuals came from job switchers from waged employment but not from non-working individuals or the agricultural sector. In other words, we see more switches from formal sectors. This is consistent with the model implication that enhanced access to broadband networks leads to labor reallocation due to the increased return in sector S, i.e., self-employment.

Access to Market The other way that UTS could alter the return in sector S is through improved access to the market. Therefore, we further test whether that is the case. However, we do not have direct measures for market access from the data. Instead, we test which sector of the business experiences the most increase in self-employment rates. We categorize occupations into two sectors: the service and manufacturing sectors.[14] Results in Panel B of Table 5 show that UTS has no significant effect on self-employment in the service sector. However, there is a small positive and statistically significant effect on self-employment in the manufacturing sector. UTS increases the likelihood of self-employment in manufacturing by 0.4 percentage points. The increase is likely due to the expansion of market access for the manufacturing sector driven by internet advancements. One possibility is that broadband internet fosters enterprise innovation (Yang et al., 2022; Feng et al., 2019), promoting the development of new products and thereby increasing returns in the manufacturing sector. This finding also aligns with Liu et al. (2023), who show that the internet improves capital and labor allocative efficiency in the manufacturing sector, further contributing to increased returns.

Social Capital Third, it is also likely that enhanced access to the internet induced by the UTS policy can create more social capital, as individuals can now stay more connected relatively easily. The increased social capital can further reduce entry costs of the sector S, as discussed in Section 3. As shown in Panel C of Table 5, after the UTS project was deployed, more rural families owed money from friends or relatives, and the amount owed to friends or relatives was also higher. Specifically, we find that UTS increases the likelihood of owing money to friends by 1.9 percentage points, a relatively modest but statistically significant effect. There is no evidence showing there were more loans to the bank or through non-financial institutes(e.g., peer-to-peer (P2P) finance). It implies that better access to broadband networks could lead to better connections with friends and relatives and better access to informal credits if needed.

Internal Migration Fourth, we explore whether there are geographical reallocations of talents induced by the UTS policy, which were quantified using migration information from the panel structure of the CFPS data. The CFPS data is suitable for constructing migration information since it has detailed information on an individual's hukou status and the current place of household registration. We define migrant using information at the city level following An et al. (2024). We define "returning to hometown migration" as the case when the individual was a migrant in the previous period and a local resident in the current period. We also filtered out the case of converting hukou. We define "moving-in migration" as the case when the current residence place of the individual is different from the previous one. Panel D in Table 5 shows that the UTS policy significantly increased both types of migration—UTS increased the likelihood of individuals returning to their hometown by 0.1 percentage points and the probability of moving into a new area by 1 percentage point. This pattern indicates that the policy may also create heterogeneous effects on returns to self-employment for different regions, which induced not only labor reallocation within

[14]CFPS collected and categorized the occupation and sector information based on national standard classification of occupations, i.e., GB/T 6565-2009 (Xie et al., 2017). We combined the mining, manufacturing, utilities, and construction sectors into a single category referred to as the 'Manufacturing' sector.

the same market but also reallocation across different geographical regions. We further dig into the characteristics of those induced migrants. We find that those who are relatively younger and more educated are more likely to move across regions. This exploration again supports our main finding of the heterogeneous treatment effect on self-employment in Table 3—this group of individuals is indeed those who experienced a higher return of self-employment after the implementation of the UTS policy.

Overall, our mechanism exploration suggests that while UTS has a limited impact on overall labor market transitions, it does appear to affect self-employment in manufacturing and borrowing from social networks. Notably, UTS also fosters mobility among rural individuals, encouraging both the return to familiar environments and the exploration of new opportunities.

7 Conclusion

A prosperous economy relies on entrepreneurship, both in developed and developing countries. However, aspiring entrepreneurs, especially those in less-developed regions and from disadvantaged groups such as younger individuals lacking skills and experience, women, and those with lower education levels, face significant challenges. At the same time, substantial resources have been dedicated to developing telecommunication and information technology infrastructure. Yet, much of the research has focused on its effects on employment, firm productivity, wages, and consumption.

In this paper, we provide one of the first pieces of evidence on the impact of telecommunication service penetration on entrepreneurship in rural China. Specifically, we assess the causal relationship between access to telecommunication services, particularly broadband internet, and entrepreneurship in rural areas. To identify these effects, we exploit the staggered implementation of a highly subsidized broadband infrastructure project called the Universal Telecommunication Service (UTS) project alongside a nationally representative household survey. The first four waves of the project, initiated in early 2016, mid-2016, 2017, and 2018, provide an exogenous rollout that allows us to estimate the impacts credibly.

Our findings show that improved access to broadband internet, as facilitated by the UTS project, leads to increased mobile internet usage and a significant rise in monthly spending on mobile services. Enhanced broadband access also promotes a shift towards self-employment, particularly benefiting women, younger individuals (under 45), and those with medium levels of education. Our dynamic analysis indicates that this shift towards self-employment is not only persistent but also grows over time. Further analysis suggests that better broadband access helps mitigate credit constraints, as shown by increased borrowing from relatives and friends. We also find that the rise in self-employment partly results from individuals transitioning out of salaried jobs, especially low-wage positions. Additionally, improved broadband access appears to encourage more migrants to return to their hometowns, thereby contributing to increased entrepreneurial activity. To support our empirical findings, we also develop a simple local labor market model that demonstrates how broadband access can shift occupational choices for individuals with varying skill levels. The predictions from this model are consistent with our main empirical results.

In summary, our study provides strong and persistent evidence that better access to broadband internet can stimulate small business growth in rural China, particularly benefiting disadvantaged groups. Our results suggest that even without direct interventions such as business training, credit support, or skills development programs, access to broadband can help mitigate some of the barriers to entrepreneurship. While we did not find significant impacts on existing businesses' revenues or assets, and the effects on business survival remain to be explored, our findings contribute to ongoing policy debates on telecommunication and information service penetration in both developed and developing contexts, as well as to the broader literature on entrepreneurship in developing regions.

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Tables

Table 1: Summary Statistics

	Mean	SD	N
Panel A: Summary Statistics of Individual Information			
Gender(Male=1)	0.503	0.500	106,317
Age	45.832	17.347	106,307
Minority	0.118	0.323	90,547
Marriage Status	0.770	0.421	106,290
Elementary School or Higher	0.670	0.470	103,797
Junior High School or Higher	0.425	0.494	103,797
College Graduates or Higher	0.040	0.196	103,797
Use Cellphone	0.781	0.413	65,561
Use Fixed Internet	0.142	0.349	76,196
Use Cellphone Internet	0.313	0.464	59,954
Monthly Cellphone Fee	42.800	51.052	64,272
Working Status	0.761	0.427	92,866
Agricultural Job	0.460	0.498	90,698
Salaried Job	0.234	0.423	85,358
Self-Employed	0.060	0.237	85,354
(Log) Wage Rates	0.649	1.286	91,490
Self-Employed in Service Sectors	0.042	0.200	73,322
Self-Employed in Non-service Sectors	0.020	0.139	73,322
Panel B: Summary Statistics of Family Information			
Family Operating Business(es)	0.073	0.260	39,937
(Log) Family Business Income	4.075	4.617	39,022
(Log) Family Business Assets	0.139	0.657	39,693
(Log) Family Average Total Income	9.366	1.369	37,933
Family Owes to Bank	0.090	0.287	39,910
Family Owes to Bank Amounts	0.945	3.085	39,857
Family Owes to Acquaintances	0.195	0.396	39,643
Family Owes to Acquaintances Amounts	1.882	4.026	32,570
Family Owes to Non-bank Institutes	0.014	0.119	39,672
Family Owes to Non-bank Institutes Amounts	0.147	1.238	32,621
Panel C: Summary Statistics of Family Information Using CHARLS			
Family Operating Business(es)	0.067	0.251	33,176
Family Operating Business(es) Amount	0.076	0.287	33,176
(log) Family Business Income	0.609	2.496	33,176
(log) Family Business Assets	0.809	2.578	25,536
Family Operating Business(es) in Service Sector	0.041	0.197	26,381
Family Operating Business(es) in Non-service Sector	0.022	0.146	26,381

Notes: This table reports the summary statistics for individual (Panel A) and family-level (Panel B) measures from CFPS, as well as family-level measures from CHARLS (Panel C). The first column lists the variables, the second column lists the corresponding mean, the third column lists the corresponding standard deviation, and the last column lists the observations. These are results when restrcting to rural individuals and households.

Table 2: Impacts of UTS on Rural Internet Usage

Panel A: Mobile Phone and Fixed Broadband Internet Users

	Mobile Phone Users		Broadband Internet Users	
	(1)	(2)	(3)	(4)
UTS	0.104***	0.101***	0.271***	0.213***
	(0.025)	(0.024)	(0.043)	(0.041)
Year FE	Yes	Yes	Yes	Yes
City FE	Yes	Yes	Yes	Yes
City Controls		Yes		Yes
Observations	4,904	4,594	4,871	4,563
Control Means	5.239	5.239	3.282	3.282

Panel B: Rural Individual Internet and Cellphone Usage

	Use Cellphone	Using Internet	Using Cellphone Internet	Cellphone Fee
	(1)	(2)	(3)	(4)
UTS	-0.002	-0.003	0.008	3.268***
	(0.011)	(0.009)	(0.013)	(1.192)
Year FE	Yes	Yes	Yes	Yes
City FE	Yes	Yes	Yes	Yes
Observations	52,873	59,337	46,554	51,603
Control Means	0.738	0.152	0.204	37.256

Notes: This table reports the impact of UTS on Internet Usage following equation (1). In Panel A, we examine the effects on the logged number of mobile phone users (measured at the city level) and fixed broadband internet users (measured as households using broadband at the city level). The city-level controls include the logged values of total population and GDP per capita. Panel B shows the effects on the detailed individual-level internet and cellphone usage. These are results when restricting to rural individuals and households. Standard errors clustered at the city level are reported in parentheses (* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$).

Table 3: Impacts of UTS on Rural Self-employment

	Self Employment						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
UTS	0.004	0.010**	-0.010**	0.004	-0.004	-0.002	0.003
	(0.004)	(0.005)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
UTS × Gender(Male)		-0.012***					
		(0.005)					
UTS × Age 16-30			0.032***				
			(0.011)				
UTS × Age 31-45			0.039***				
			(0.007)				
UTS × Minority				-0.001			
				(0.007)			
UTS × Elementary School or Higher					0.012**		
					(0.005)		
UTS × Junior High School or Higher						0.014**	
						(0.006)	
UTS × College							0.028
							(0.019)
$Test : \beta_1 + \beta_2 = 0$		0.679	0.048	0.741	0.119	0.056	0.114
$Test : \beta_1 + \beta_3 = 0$			0.000				
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
City FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	70,722	70,722	70,722	70,722	70,722	70,722	70,722
Control Means	0.056	0.056	0.056	0.056	0.056	0.056	0.056

Notes: This table reports the impact of UTS on self-employment following equation (1). Column (1) shows the overall impact. Column (2) shows the heterogeneous effect by gender, with females as the reference group. Column (3) shows the heterogeneous effect by age group, with age 46-60 as the reference group. Column (4) shows the heterogeneous effect of minority status with the Han ethnicity as the reference group. Columns (5)-(7) show the heterogeneous effect of educational attainment. We also report the p-values of the significance tests on the reference group, where β_1 denotes the coefficient of the UTS indicator, and β_2 and β_3 denote the coefficients of the reported interaction terms. These are results when restricting to rural individuals and households. Standard errors clustered at the city level are reported in parentheses (* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$).

Table 4: Impacts of UTS on Rural Family Business and Income

	Family Owning Business	Family Business Income	Family Business Assets	Family Average Income
	(1)	(2)	(3)	(4)
UTS	0.006	-0.059	0.001	0.060
	(0.007)	(0.179)	(0.017)	(0.054)
Year FE	Yes	Yes	Yes	Yes
City FE	Yes	Yes	Yes	Yes
Observations	36,937	36,188	36,771	35,118
Control Means	0.072	3.938	0.126	9.217

Notes: This table reports the impact of UTS on family business and family income following equation (1). These are results when restricting to rural individuals and households. Standard errors clustered at the city level are reported in parentheses (* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$).

Table 5: Impacts of UTS on Rural Labor Market Outcomes: Mechanism Analysis

Panel A: Job Switch

	Working Status	Agricultural Work	Salaried Job	Wage Rates
UTS	-0.006	0.013	-0.009	0.018
	(0.019)	(0.019)	(0.010)	(0.034)
Year FE	Yes	Yes	Yes	Yes
City FE	Yes	Yes	Yes	Yes
Observations	76,260	75,838	70,726	73,488
Control Means	0.728	0.430	0.203	0.547

Panel B: Self-employment by Sector

	Self-employment in Service	Self-employment in Manufacturing
UTS	-0.002	0.004*
	(0.004)	(0.002)
Year FE	Yes	Yes
City FE	Yes	Yes
Observations	59,021	59,021
Control Means	0.039	0.014

Panel C: Family Loans

	Owing Bank Loans	Owing Bank Loans (Amount)	Owing to Friends	Owing to Friends (Amount)	Owing to Non-financial	Owing to Non-financial (Amount)
UTS	0.004	0.073	0.019*	0.157	0.002	0.048
	(0.010)	(0.100)	(0.011)	(0.116)	(0.003)	(0.030)
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
City FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	36,915	36,869	36,713	29,812	36,742	29,863
Control Means	0.084	0.857	0.216	2.039	0.014	0.144

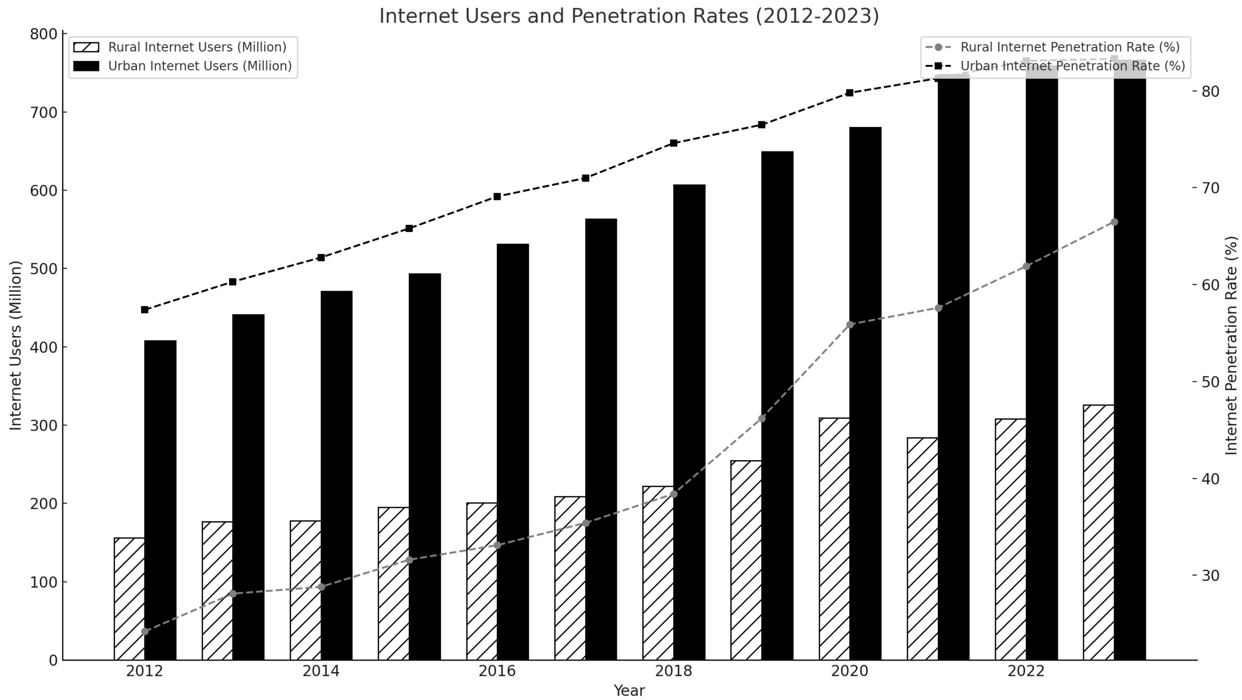
Panel D: Internal Migration

	Returning to hometown	Moving-in migration
UTS	0.001***	0.010**
	(0.000)	(0.004)
Year FE	Yes	Yes
City FE	Yes	Yes
Observations	61,168	63,010
Control Means	0.0004	0.0190

Notes: This table reports the impact of UTS on various rural labor market outcomes as the mechanism analyses. Panel A reports effects on job switching behaviors, including changes in working status, agricultural work, salaried job engagement, and wage rates. Panel B examines self-employment by sector, distinguishing between service and manufacturing. Panel C presents effects on family loan dynamics, including the likelihood and amount of bank and non-bank loans owed, as well as borrowing from friends. Panel D analyzes internal migration patterns, specifically the likelihood of returning to one's hometown and moving-in migration. Standard errors clustered at the city level are reported in parentheses (* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$).

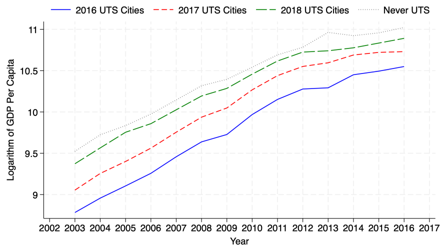
Figures

Figure 1: Internet Users and Penetration Rates (2012–2023)

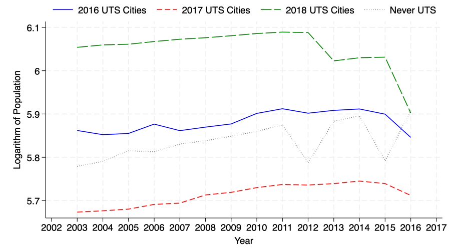


Notes: This graph shows broadband internet penetration in China, separated by urban and rural divide. Data source: Statistical Report on Internet Development in China by CNNIC, No. 31 to No. 53, via https://www.cnnic.com.cn/IDR/ReportDownloads/index.htm

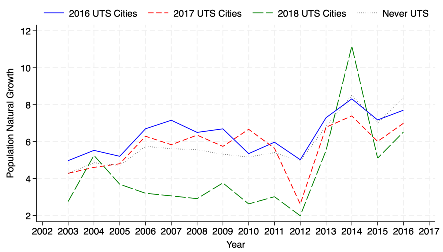
Figure 2: Pre-trends Checks in the City-level Characteristics, by UTS Year



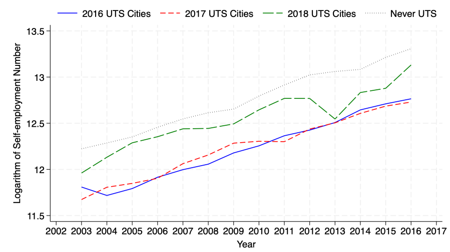
(a) GDP per capita



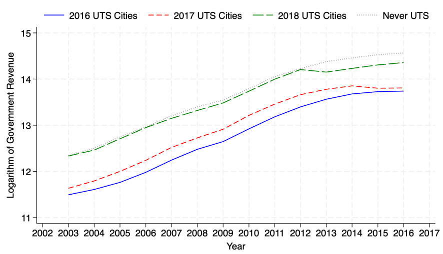
(b) Population



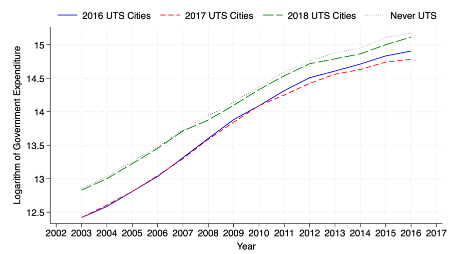
(c) Population Natural Growth



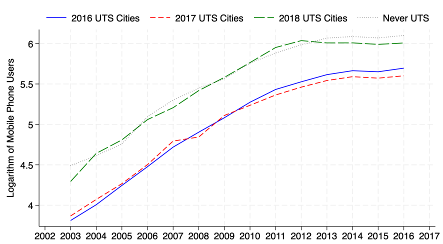
(d) Self-employment Numbers



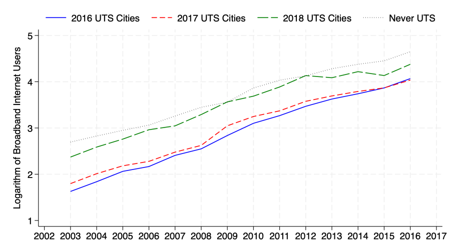
(e) Government Revenue



(f) Government Expenditure



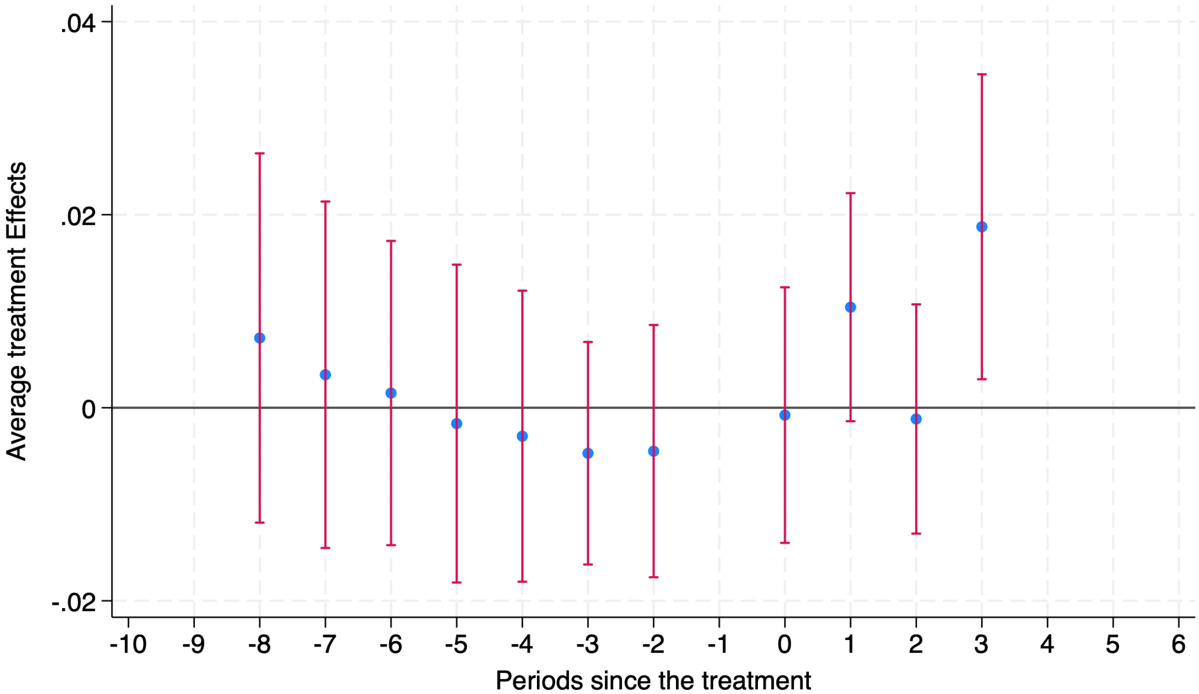
(g) Mobile Phone Users



(h) Broadband Internet Users

Notes: All city-level characteristics are from the China City Statistical Yearbooks, and cities are grouped by the first year covered by the UTS project. Each plot shows the time trend of logged values of the index or population growth rate from 2003 to 2016.

Figure 3: Dynamic Impacts of UTS on Rural Self-employment



Notes: This graph shows the dynamic impacts of UTS on rural self-employment. The point estimates are the estimated average treatment effects (ATE) over time, measured as periods since the treatment event. The x-axis represents the periods relative to the treatment, with negative values indicating periods before the treatment and positive values indicating periods after the treatment. The y-axis shows the magnitude of the ATE. Each point represents the ATE at a specific period, and the vertical bars denote the 95% confidence intervals around the estimates.

Appendices

A Tables

Table A.1: Robustness Checks: Using Different Specifications

	Self Employment						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
UTS	0.002	0.008	-0.011**	0.001	-0.006	-0.004	0.001
	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)
UTS × Gender(Male)		-0.012***					
		(0.005)					
UTS × Age 16-30			0.033***				
			(0.011)				
UTS × Age 31-45			0.040***				
			(0.007)				
UTS × Minority				0.009			
				(0.010)			
UTS × Elementary School or Higher					0.012**		
					(0.005)		
UTS × Junior High School or Higher						0.014**	
						(0.006)	
UTS × College							0.028
							(0.020)
$Test: \beta_1 + \beta_2 = 0$		0.485	0.047	0.298	0.293	0.127	0.150
$Test: \beta_1 + \beta_3 = 0$			0.000				
Province*Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
City FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	70,719	70,719	70,719	70,719	70,719	70,719	70,719
Control Means	0.056	0.056	0.056	0.056	0.056	0.056	0.056

Notes: This table reports the robustness check results of the impact of UTS on self-employment with alternative specifications of controlling for province × year and city fixed effects. Column (1) shows the overall impact. Column (2) shows the heterogeneous effect by gender, with females as the reference group. Column (3) shows the heterogeneous effect by age group, with age 46-60 as the reference group. Column (4) shows the heterogeneous effect of minority status with the Han ethnicity as the reference group. Columns (5)-(7) show the heterogeneous effect of educational attainment. We also report the p-values of the significance tests on the reference group, where β_1 denotes the coefficient of the UTS indicator, and β_2 and β_3 denote the coefficients of the reported interaction terms. These are results when restricting to rural individuals and households. Standard errors clustered at the city level are reported in parentheses (* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$).

Table A.2: Robustness Checks: Using Restricted Samples Without Never-treated Cities

	Self Employment						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
UTS	0.004	0.011**	-0.011**	0.004	-0.003	-0.001	0.004
	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)
UTS × Gender(Male)		-0.013***					
		(0.004)					
UTS × Age 16-30			0.031***				
			(0.010)				
UTS × Age 31-45			0.040***				
			(0.007)				
UTS × Minority				0.001			
				(0.007)			
UTS × Elementary School or Higher					0.011**		
					(0.004)		
UTS × Junior High School or Higher						0.015**	
						(0.006)	
UTS × College							0.005
							(0.020)
$Test: \beta_1 + \beta_2 = 0$		0.696	0.067	0.598	0.164	0.068	0.652
$Test: \beta_1 + \beta_3 = 0$			0.001				
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
City FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	51,630	51,630	51,630	51,630	51,630	51,630	51,630
Control Means	0.056	0.056	0.056	0.056	0.056	0.056	0.056

Notes: This table reports the robustness check results of the impact of UTS on self-employment with an alternative estimation sample—excluding wealthier cities not covered by the UTS projects until 2018 to create a more comparable control group. Column (1) shows the overall impact. Column (2) shows the heterogeneous effect by gender, with females as the reference group. Column (3) shows the heterogeneous effect by age group, with age 46-60 as the reference group. Column (4) shows the heterogeneous effect of minority status with the Han ethnicity as the reference group. Columns (5)-(7) show the heterogeneous effect of educational attainment. We also report the p-values of the significance tests on the reference group, where β_1 denotes the coefficient of the UTS indicator, and β_2 and β_3 denote the coefficients of the reported interaction terms. These are results when restricting to rural individuals and households. Standard errors clustered at the city level are reported in parentheses (* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$).

Table A.3: Robustness Check: Using Restricted Samples Containing Only Aged 16 to 60 Individuals

	Self Employment						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
UTS	0.003	0.008	-0.009	0.003	-0.007	-0.005	0.002
	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)
UTS × Gender(Male)		-0.011*					
		(0.006)					
UTS × Age 16-30			0.027**				
			(0.011)				
UTS × Age 31-45			0.022***				
			(0.007)				
UTS × Minority				-0.005			
				(0.009)			
UTS × Elementary School or Higher					0.013**		
					(0.006)		
UTS × Junior High School or Higher						0.016**	
						(0.006)	
UTS × College							0.023
							(0.019)
$Test : \beta_1 + \beta_2 = 0$		0.696	0.116	0.910	0.316	0.142	0.214
$Test : \beta_1 + \beta_3 = 0$			0.116				
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
City FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	54,021	54,021	54,021	54,021	54,021	54,021	54,021
Control Means	0.067	0.067	0.067	0.067	0.067	0.067	0.067

Notes: This table reports the robustness check results of the impact of UTS on self-employment with an alternative estimation sample—excluding older individuals aged 60 and above. Column (1) shows the overall impact. Column (2) shows the heterogeneous effect by gender, with females as the reference group. Column (3) shows the heterogeneous effect by age group, with age 46-60 as the reference group. Column (4) shows the heterogeneous effect of minority status with the Han ethnicity as the reference group. Columns (5)-(7) show the heterogeneous effect of educational attainment. We also report the p-values of the significance tests on the reference group, where β_1 denotes the coefficient of the UTS indicator, and β_2 and β_3 denote the coefficients of the reported interaction terms. These are results when restricting to rural individuals and households. Standard errors clustered at the city level are reported in parentheses (* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$).

Table A.4: Robustness Check: Using Restricted Samples Dropping Year 2020

	Self Employment						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
UTS	0.002	0.007	-0.011**	0.002	-0.006	-0.003	0.002
	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.004)	(0.005)
UTS × Gender(Male)		-0.009**					
		(0.005)					
UTS × Age 16-30			0.035***				
			(0.010)				
UTS × Age 31-45			0.036***				
			(0.008)				
UTS × Minority				0.000			
				(0.008)			
UTS × Elementary School or Higher					0.014***		
					(0.005)		
UTS × Junior High School or Higher						0.015**	
						(0.007)	
UTS × College							0.026
							(0.019)
$Test: \beta_1 + \beta_2 = 0$		0.686	0.028	0.744	0.173	0.097	0.150
$Test: \beta_1 + \beta_3 = 0$			0.004				
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
City FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	64,239	64,239	64,239	64,239	64,239	64,239	64,239
Control Means	0.056	0.056	0.056	0.056	0.056	0.056	0.056

Notes: This table reports the robustness check results of the impact of UTS on self-employment with an alternative estimation sample—excluding the year 2020 sample to avoid the confoundingness from the COVID-19 pandemic. Column (1) shows the overall impact. Column (2) shows the heterogeneous effect by gender, with females as the reference group. Column (3) shows the heterogeneous effect by age group, with age 46-60 as the reference group. Column (4) shows the heterogeneous effect of minority status with the Han ethnicity as the reference group. Columns (5)-(7) show the heterogeneous effect of educational attainment. We also report the p-values of the significance tests on the reference group, where β_1 denotes the coefficient of the UTS indicator, and β_2 and β_3 denote the coefficients of the reported interaction terms. These are results when restricting to rural individuals and households. Standard errors clustered at the city level are reported in parentheses (* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$).

Table A.5: Robustness Check: Impacts of the UTS on Urban Internet Usage

	Use Cellphone	Using Internet	Using Cellphone Internet	Cellphone Fee	Weekly Internet Use Time
	(1)	(2)	(3)	(4)	(5)
UTS	0.007	-0.021**	-0.009	0.855	-0.021
	(0.008)	(0.009)	(0.014)	(1.185)	(0.272)
Year FE	Yes	Yes	Yes	Yes	Yes
City FE	Yes	Yes	Yes	Yes	Yes
Observations	46,880	52,760	41,057	45,984	47,284
Control Means	0.839	0.324	0.359	52.472	5.657

Notes: This table reports the impact of UTS on Internet Usage following equation (1) using urban population, serving as the robustness check. Standard errors clustered at the city level are reported in parentheses (* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$).

Table A.6: Robustness Check: Impacts of the UTS on Urban Self-employment

	Self Employment						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
UTS	0.015**	0.028***	0.006	0.015**	0.004	0.006	0.021***
	(0.006)	(0.006)	(0.006)	(0.006)	(0.008)	(0.008)	(0.007)
UTS × Gender(Male)		-0.028***					
		(0.008)					
UTS × Age 16-30			0.011				
			(0.013)				
UTS × Age 31-45			0.028***				
			(0.011)				
UTS × Minority				0.008			
				(0.021)			
UTS × Elementary School or Higher					0.014		
					(0.011)		
UTS × Junior High School or Higher						0.015	
						(0.011)	
UTS × College							-0.037***
							(0.013)
$Test : \beta_1 + \beta_2 = 0$		0.933	0.161	0.281	0.017	0.013	0.170
$Test : \beta_1 + \beta_3 = 0$			0.005				
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
City FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Urban	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	62,402	62,402	62,402	62,402	62,402	62,402	62,402
Control Means	0.097	0.097	0.097	0.097	0.097	0.097	0.097

Notes: This table reports the robustness check results of the impact of UTS on self-employment using the urban population. Column (1) shows the overall impact. Column (2) shows the heterogeneous effect by gender, with females as the reference group. Column (3) shows the heterogeneous effect by age group, with age 46-60 as the reference group. Column (4) shows the heterogeneous effect of minority status with the Han ethnicity as the reference group. Columns (5)-(7) show the heterogeneous effect of educational attainment. We also report the p-values of the significance tests on the reference group, where β_1 denotes the coefficient of the UTS indicator, and β_2 and β_3 denote the coefficients of the reported interaction terms. Standard errors clustered at the city level are reported in parentheses (* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$).

Table A.7: Robustness Check: Using Different Data Sources (CHARLS)

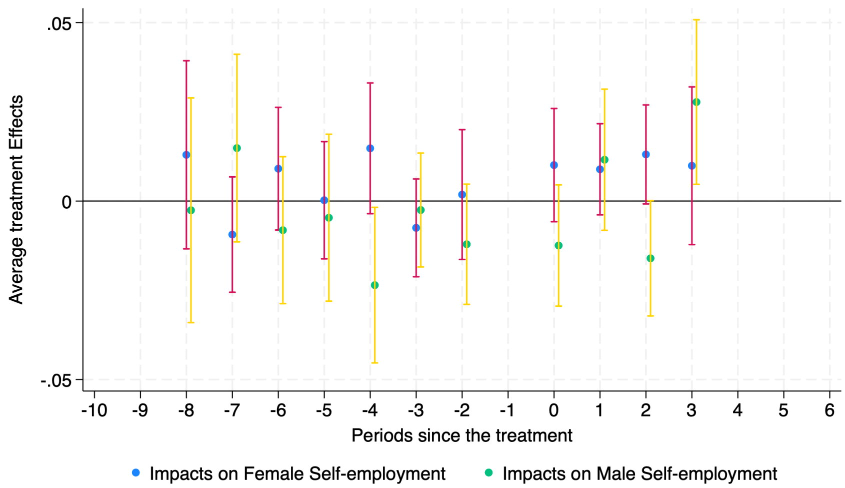
Panel A: Household Business Outcomes				
	Household Owing Business	Household Business Number	Household Business Income	Household Business Assets
	(1)	(2)	(3)	(4)
UTS	0.016**	0.019*	0.121	-0.047
	(0.008)	(0.010)	(0.074)	(0.098)
Year FE	Yes	Yes	Yes	Yes
City FE	Yes	Yes	Yes	Yes
Observations	33,176	33,176	33,176	25,536
Control Means	0.062	0.072	0.563	0.900

Panel B: Self-employment by Sector		
	Self-employment in Service	Self-employment in Manufacturing
	(1)	(2)
UTS	-0.008	0.018***
	(0.006)	(0.006)
Year FE	Yes	Yes
City FE	Yes	Yes
Observations	26,381	26,381
Control Means	0.039	0.022

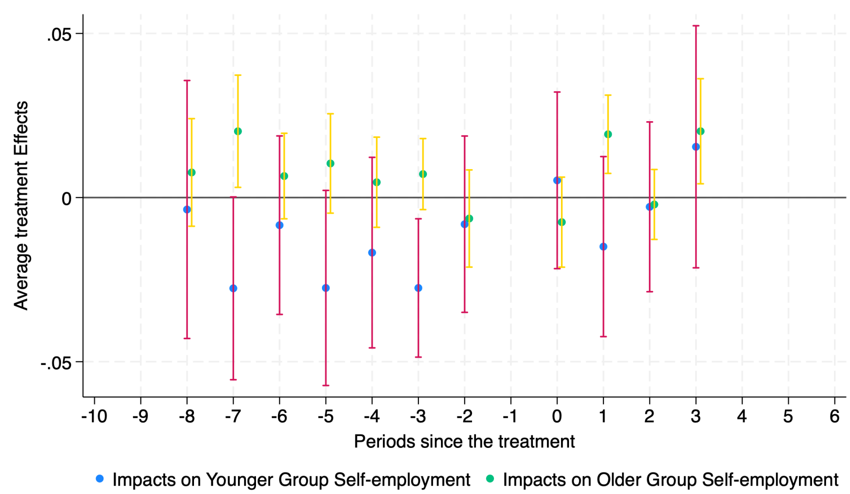
Notes: This table reports the robustness check results of the impact of UTS on family business ownership, profits, and assets (Panel A) and self-employment by sector (Panel B) using alternative data sources — the CHARLS data, following equation (1). Standard errors clustered at the city level are reported in parentheses (* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$).

B Figures

Figure B.1: Heterogeneous Dynamic Impacts of UTS on Rural Self-employment by Gender and Age



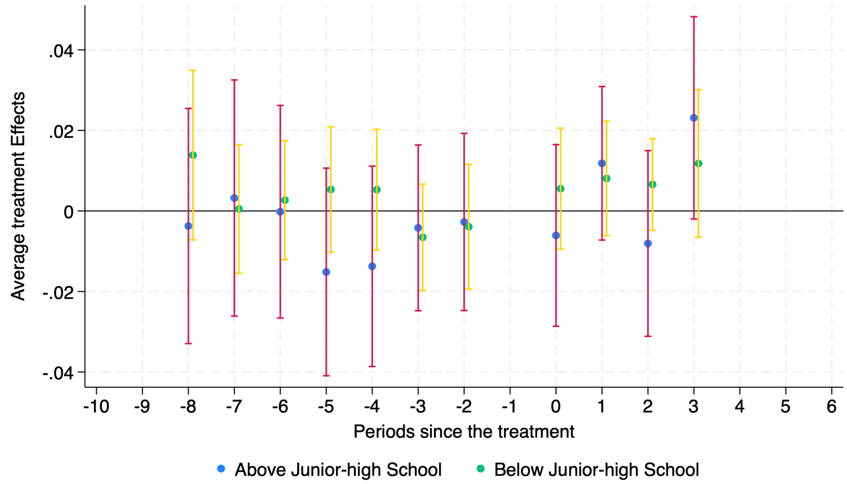
(a) By Gender



(b) By Age

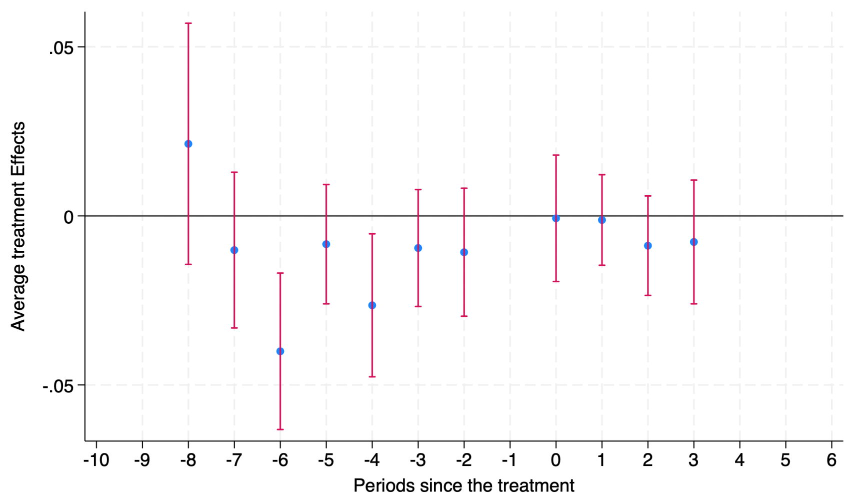
Notes: This figure presents the dynamic impacts of UTS on rural self-employment, separately for gender (Panel a) and age groups (Panel b). Panel (a) illustrates the estimated average treatment effects on male and female self-employment, while Panel (b) shows the impacts on younger and older age groups. We define those younger than or equal to 45 years old as the younger age group and vice versa. The x-axis represents the periods relative to the treatment, with negative values indicating periods before the intervention and positive values indicating periods after. The y-axis represents the average treatment effects, with zero denoting no effect. Each point corresponds to an estimate for a specific period, with 95% confidence intervals indicated by the vertical error bars. The color coding distinguishes between subgroups: blue for female/younger groups and green for male/older groups.

Figure B.2: Heterogeneous Dynamic Impacts of UTS on Rural Self-employment by Education



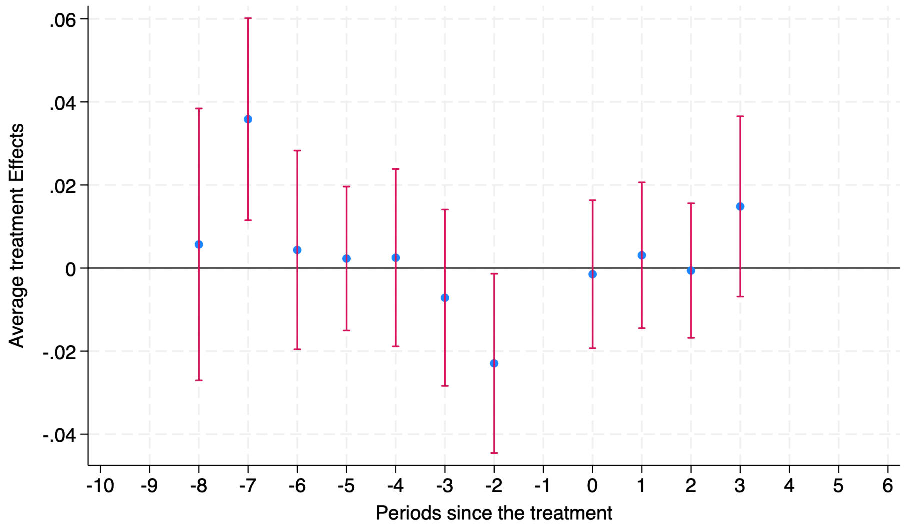
Notes: This figure illustrates the dynamic impacts of UTS on rural self-employment, segmented by educational attainment. The x-axis represents the periods relative to the treatment, with negative values indicating pre-treatment periods and positive values post-treatment. The y-axis shows the average treatment effects. The estimates are depicted for individuals with education levels above junior-high school (blue) and below junior-high school (green). Each point corresponds to the estimated treatment effect at a given period, with vertical error bars denoting the 95% confidence intervals. The heterogeneous effects show variations in treatment impact based on education level, with colors differentiating the subgroups.

Figure B.3: Dynamic Impacts of UTS on Urban Self-employment

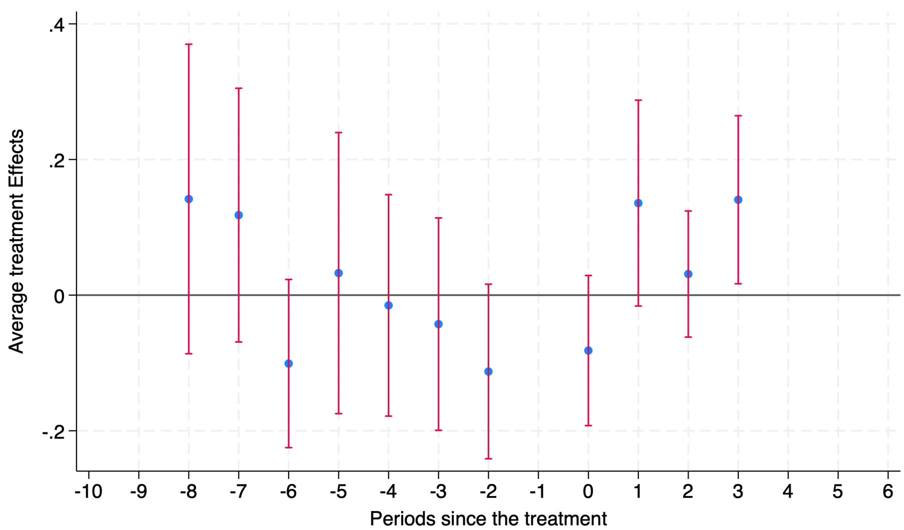


Notes: This graph shows the dynamic impacts of UTS on urban self-employment. The point estimates are the estimated average treatment effects (ATE) over time, measured as periods since the treatment event. The x-axis represents the periods relative to the treatment, with negative values indicating periods before the treatment and positive values indicating periods after the treatment. The y-axis shows the magnitude of the ATE. Each point represents the ATE at a specific period, and the vertical bars denote the 95% confidence intervals around the estimates.

Figure B.4: Dynamic Impacts of UTS on Rural Households' Business Owing and Average Income



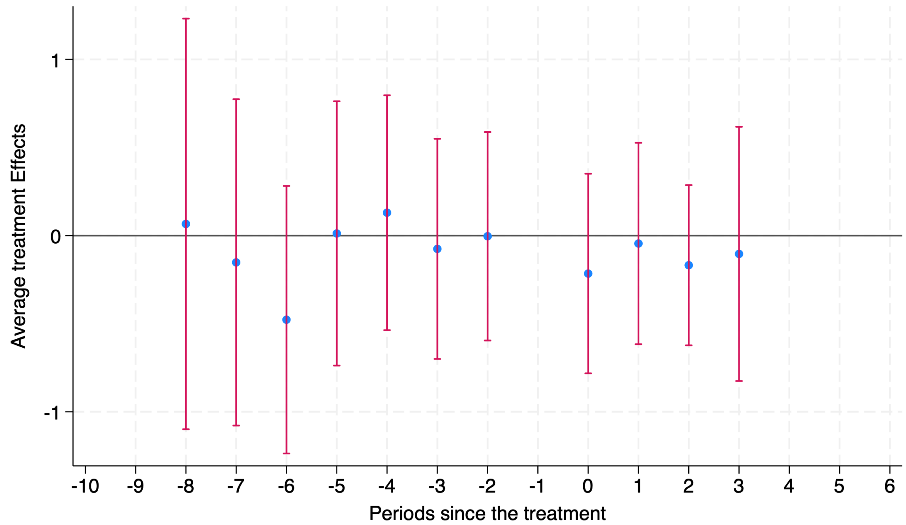
(a) Business Owing



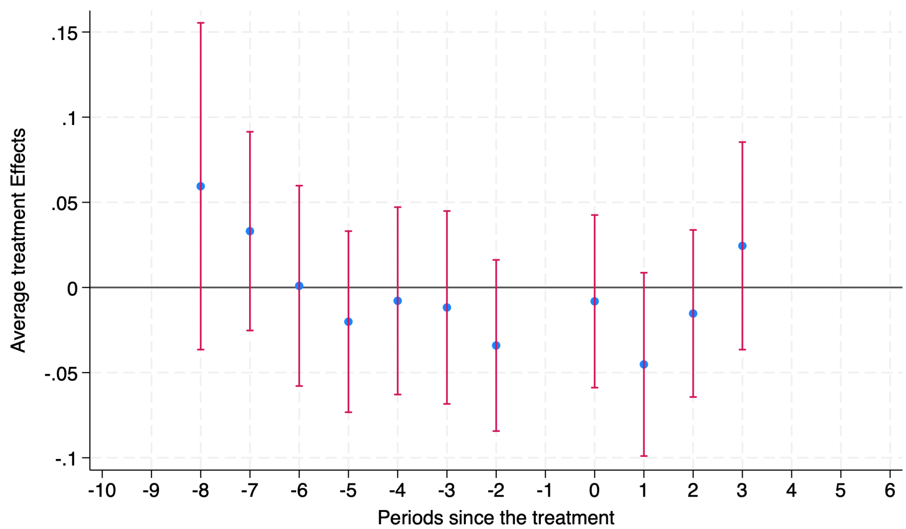
(b) Average Income

Notes: This figure presents the dynamic impacts of UTS on rural households' business owing (Panel a) and average income (Panel b). The x-axis represents the periods relative to the treatment, with negative values indicating periods before the intervention and positive values indicating periods after. The y-axis represents the average treatment effects, with zero denoting no effect. Each point corresponds to an estimate for a specific period, with 95% confidence intervals indicated by the vertical error bars.

Figure B.5: Dynamic Impacts of UTS on Rural Households' Business Income and Assets



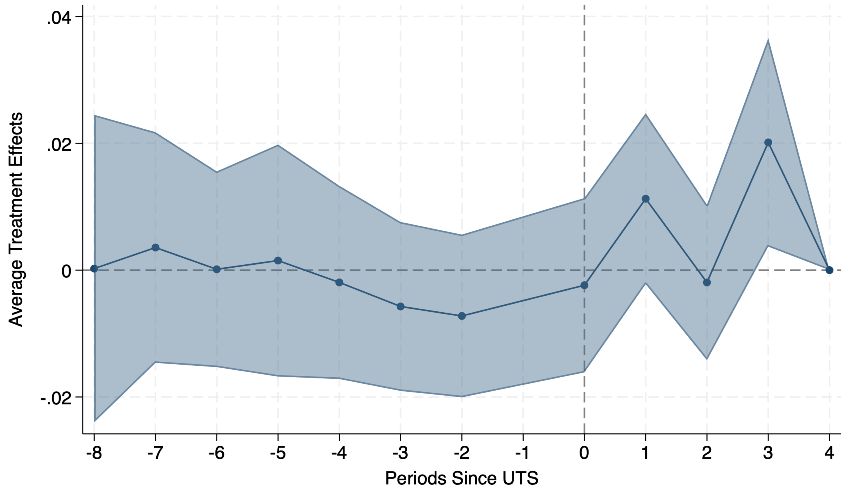
(a) Business Income



(b) Business Assets

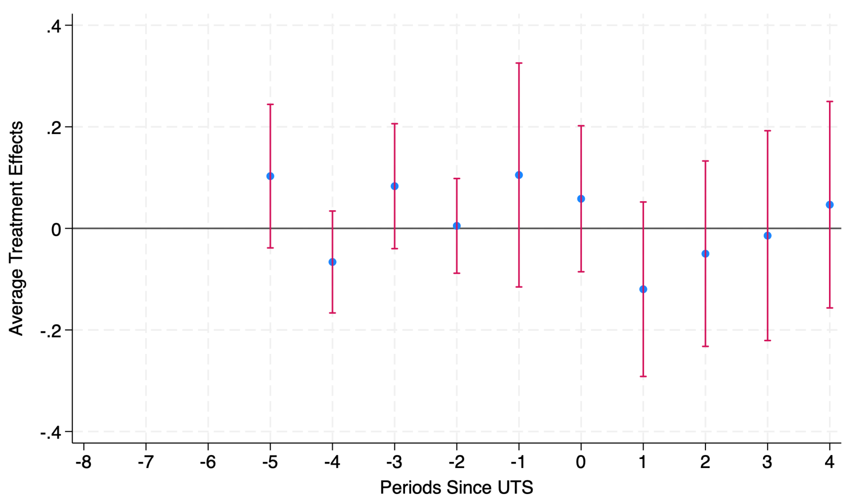
Notes: This figure presents the dynamic impacts of UTS on rural households' business income (Panel a) and business assets (Panel b). The x-axis represents the periods relative to the treatment, with negative values indicating periods before the intervention and positive values indicating periods after. The y-axis represents the average treatment effects, with zero denoting no effect. Each point corresponds to an estimate for a specific period, with 95% confidence intervals indicated by the vertical error bars.

Figure B.6: Dynamic Impacts of UTS on Rural Self-employment Using SA2021



Notes: This graph shows the dynamic impacts of UTS on rural self-employment using the alternative method from Sun and Abraham (2021) (SA2021). The point estimates are the estimated average treatment effects (ATE) over time, measured as periods since the treatment event. The x-axis represents the periods relative to the treatment, with negative values indicating periods before the treatment and positive values indicating periods after the treatment. The y-axis shows the magnitude of the ATE. Each point represents the ATE at a specific period, and the vertical blue areas denote the 95% confidence intervals around the estimates.

Figure B.7: Dynamic Impacts of UTS on Rural Self-employment Using CS2021



Notes: This graph shows the dynamic impacts of UTS on rural self-employment using the alternative method from Callaway and Sant'Anna (2021) (CS2021). The point estimates are the estimated average treatment effects (ATE) over time, measured as periods since the treatment event. The x-axis represents the periods relative to the treatment, with negative values indicating periods before the treatment and positive values indicating periods after the treatment. The y-axis shows the magnitude of the ATE. Each point represents the ATE at a specific period, and the vertical bars denote the 95% confidence intervals around the estimates.