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ABSTRACT

Digital Roots or Digital Routes? Broadband Expansion and the Rural-Urban Migration in China

This study investigates broadband internet's impact on rural-urban migration in China, using the Universal Broadband and Telecommunication Services pilot program as a quasi-experimental setting. Analyzing China Household Finance Survey data (2013-2021) through difference-in-differences estimation, we find that improved internet access significantly increased rural-urban migration. Effects were strongest in villages with initially low migrant populations, locations closer to county centers, and those with better road infrastructure. At the individual level, impacts were most pronounced among females, younger people, the more educated, and those from higher-income households. Increased attention to economic information, rather than enhanced e-commerce opportunities, appears to drive these migration decisions. Our findings suggest broadband creates "digital routes" facilitating outmigration rather than "digital roots" anchoring residents to rural areas.

JEL Classification: O15, R2, L86

Keywords: information and communications technology, migration, urbanization, China

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1. Introduction

Rural connectivity through infrastructure building represents one of the most significant policy levers for promoting growth in remote areas. Traditional physical infrastructure like roads primarily reduces transportation costs; digital infrastructure has the potential to reshape rural economies through distinct mechanisms: by providing instant access to information and facilitating knowledge transfer (Aviles, et al. 2016; Fennell et al. 2018).

Recent studies have documented wide-ranging positive effects of rural internet connectivity: boosting agricultural productivity (Kaila and Tarp 2019), spurring firm entry and rural industrial development (Kim and Orazem 2017; Whitacre, et al. 2014), and increasing household consumption and reducing extreme poverty (Leng 2022; Mora-Rivera and Garcia-Mora 2021). The growth of e-commerce and digital financial services, enabled by internet connectivity in rural areas, has created new economic opportunities and consumption patterns (Couture et al. 2021; Munyegera and Matsumoto 2018; Zhang, et al. 2022).

However, like how physical infrastructure can have unexpected effects on rural development, digital connectivity's impact is not straightforward. Just as better roads can either stimulate local economic growth by reducing transaction costs and improving market access (Adamopoulos 2025; Dappe and Lebrand 2024; Donaldson 2018; Fiorini and Sanfilippo 2022), or accelerate rural-to-urban migration (Asher and Novosad 2020; Morten and Oliveira 2024), potentially leading to village depopulation and generating negative externalities (Garg, et al. 2024), internet connectivity could either anchor population through new rural economic opportunities or facilitating their departure by reducing information barriers about urban prospects. Understanding this relationship is crucial for evaluating the full impact of rural digitalization policies.

The impact of internet connectivity on rural-urban migration likely depends on the interplay between existing village and individual characteristics. Villages with stronger initial connections to urban areas might leverage digital access differently than more isolated communities. At the individual level, factors such as age, education, and household resources could determine whether internet access primarily creates local opportunities or facilitates outmigration. Understanding these potential heterogeneous effects is important for thinking about whether digital infrastructure potentially reduces or amplifies existing spatial and social disparities.

China's experience with rural broadband expansion offers an important case study of these dynamics. In 2015, the government launched the Universal Broadband and Telecommunication Services Program (UBTS) for rural and remote areas with $22.3 billion in funding to achieve 98% broadband coverage in rural villages (The State Council 2015). This significant push for rural connectivity raises an important question about its potential impact on rural development: Does the expansion of UBTS in rural China create digital roots that anchor residents to their villages, or digital routes that facilitate their migration to urban areas? This study aims to answer this question.

To answer this question, we employ a quasi-experimental setting using UBTS pilot program to examine the causal relationship between internet connectivity and migration decisions. Our analysis uses panel data from the China Household Finance Survey (CHFS 2013-2021) in which we can identify UBTS pilot villages. Our analysis of pilot village selection reveals that the selection was primarily driven by city-level factors rather than individual village characteristics. In the following analysis we employ a difference-in-differences (DID) model with individual fixed effects to compare migration patterns between pilot and non-pilot villages before and after UBTS implementation.

Our results provide strong evidence that improved internet connectivity creates digital routes rather than digital roots. The UBTS program significantly increased total migration from pilot villages by 3.2-3.4 percentage points in 2017-2019, with effects particularly pronounced for cross-county migration. These effects are robust to using alternative control groups, including comparing pilot villages to non-pilot villages within the same pilot cities to account for the importance of city-level factors in pilot village selection, and to examining results based on all pilot villages, including the relatively few which implemented UBTS after 2017. Importantly, we verify that these migration effects cannot be attributed to other concurrent development initiatives, as we find no significant differences between pilot and non-pilot villages in the implementation of other public investments such as roads, transportation, water conservation, or social programs during this period.

Our heterogeneity analyses reveal that the program's impact was strongest in villages with initially low migrant populations and better infrastructure connectivity to urban areas, suggesting that internet access complements existing physical infrastructure in facilitating migration. At the individual level, the effects were more pronounced among females, younger individuals, those with higher education levels, and individuals from higher-income households. These results suggest that internet access may be particularly valuable for individuals with greater capacity to process information and act upon newfound urban opportunities, potentially exacerbating existing inequalities in migration possibilities.

We also find that UBTS implementation increased villagers' attention to economic and financial information but did not affect their online shopping behavior. The lack of impact on online shopping suggests that improved internet access isn't primarily operating through increased access to urban consumption goods or by making rural life more comfortable — factors that might create "digital roots." Instead, the increased attention to economic and financial information suggests that internet connectivity primarily serves as an information channel, potentially helping rural residents learn about and evaluate urban employment opportunities. This interpretation aligns with the "digital routes" hypothesis, where internet access primarily facilitates outward mobility by reducing information frictions rather than by improving the quality of rural life through enhanced access to urban amenities.

By examining internet connectivity and individual rural-to-urban migration decisions in China, we make several of key contributions to the literature. First, we advance the literature on the impacts of information communication technology (ICT) by revealing its demographic effects through rural-to-urban migration. While previous work has extensively documented ICT's economic outcomes and social-political effects, [1] and some studies have examined international migration or domestic migration in developed countries (Thomas J. Cooke and Shuttleworth 2018; Thomas John Cooke and Shuttleworth 2017; Grubanov-Boskovic et al. 2021; Pesando et al. 2021; Walk, Garimella, and Christia 2023; Winkler 2017), the impact of physical internet infrastructure expansion on domestic rural-urban migration decisions in the developing region remains understudied.

[1] One strand of the ICT impacts literature focuses on economic outcomes and has extensively documented how ICT adoption positively affects economic growth, employment, firm productivity, and technology adoption (Akerman, Gaarder, and Mogstad 2015; Atasoy 2013; Bahia et al. 2024; S. Chen, Liu, and Song 2020; Czernich et al. 2011; Dutz et al. 2017; Greenstein and McDevitt 2011; Hjort and Poulsen 2019; Martey and Armah 2021). Another strand of the literature examines political and social outcomes, showing how internet access or usage affects election outcomes (Miner 2015), changes political attitudes (Guriev, et al. 2021; Harmel and Yeh 2019), lowers subjective well-beings (Nie, Sousa-Poza, and Nimrod 2017; Zhu et al. 2020), impacts gender disparities (Galperin and Arcidiacono 2021; Viollaz and Winkler 2022), and influences individual health behaviors ((Amaral-Garcia et al. 2022; L. Chen and Liu 2022; Ding, et al. 2023).

Second, our study contributes to understanding the determining factors of Chinese farmers' rural-urban migration decisions by highlighting the role of digital infrastructure. Previous research has established that village characteristics play a fundamental role in migration decisions, interacting with individual and household factors to jointly shape migration outcomes (Chen et al. 2022; Giles and Mu 2024). For example, institutional variations across villages — such as differences in national ID card issuance policies (Brauw and Giles 2017) and land tenure security (Giles and Mu 2018; Ma and Mu 2020) — significantly affect migration patterns. Other research highlights how physical infrastructure, particularly access to high-speed railways, drives rural-to-urban mobility (Kong et al. 2021). We advance this literature on how village institutions and infrastructure shape migration by demonstrating that village access to digital infrastructure acts as another key determinant of rural-urban migration. This focus on digital infrastructure is particularly important as China's focus on rural digital inclusion reflects a broader trend among developing countries — Brazil, India, and Indonesia are among other nations implementing ambitious broadband expansion programs (BBC 2019; Medina 2020; Mike 2011). Our study thus speaks to the broader question of how the digital transformation of rural areas may reshape patterns of internal migration, urbanization, and labor market integration in developing regions.

We also provide insights for policy discussions regarding China's rural vitalization strategy launched in 2018 (Xinhua News 2017). This initiative aims to reduce rural-urban migration through industrial investment, agricultural technology advancement, and improved rural living conditions. Our results suggest the complexity of such efforts. The digital infrastructure — a key component of rural development — can actually accelerate outmigration from the rural areas, highlighting potential tensions between different rural development objectives and the importance of considering migration incentives for rural retention policies.

The rest of the paper is structured as follows. Section 2 reviews the literature linking internet connectivity to migration decisions, examining both theoretical channels and empirical evidence on how digital access affects information frictions and mobility choices. Section 3 introduces China's broadband strategy and details the implementation of UBTS, providing institutional context for our empirical analysis. Section 4 describes our data from CHFS and explains our identification strategy using the UBTS pilot program as a quasi-experimental setting. Section 5 presents our empirical results on how internet connectivity affects rural-urban migration, including heterogeneity analyses across village and individual characteristics. Section 6 concludes with policy implications and directions for future research.

2. Internet Connectivity and Migration Decisions

Internet connectivity has the potential to significantly influence migration decisions through a variety of mechanisms, both enabling and hindering human movement. On the enabling side, broadband access can facilitate migration by providing enhanced information access, allowing individuals to conduct more effective job searches and discover increased employment opportunities (Hjort and Poulsen 2019; Kuhn and Mansour 2014). This improved access to job market information can lower the barriers to finding non-local jobs, making migration a more attractive option. Additionally, internet connectivity strengthens and expands social networks, enabling potential migrants to maintain closer ties with friends and family who have already moved to urban areas as well as those who have stayed behind, thus providing valuable support systems and information channels.

The internet also plays a crucial role in shaping aspirations and practical considerations related to migration. Exposure to information about life in other places can influence individuals' aspirations and increase their desire to migrate, as they become more aware of potential opportunities and lifestyles available elsewhere (Dekker, Engbersen, and Faber 2016; Pesando et al. 2021). Furthermore, internet access eases the logistical challenges of migration, such as finding housing in the destination place and maintaining communication with those left behind.

However, improved connectivity can also have hindering effects on migration. By enabling better economic opportunities at home, such as improving agricultural-related business revenues through better market information and supply chain management (Jensen 2007), internet access may reduce the economic incentive to migrate. Additionally, improved amenities at home, including better entertainment, communication, and shopping options made possible by internet connectivity, can increase the attractiveness of remaining home. Lastly, by lowering the costs of engaging in economic activity in remote locations, internet access may make it more feasible for individuals to pursue economic opportunities without the need to relocate (Forman et al. 2012).

Existing empirical evidence on the relationship between internet access and migration decisions presents a complex and sometimes contradictory picture, varying across specific migration contexts. In international migration, several studies have found a positive association between internet use and migration tendencies. For instance, Dekker et al. (2016), Pesando et al. (2021), and Thulin and Vilhelmson (2014) all demonstrate that internet use is positively correlated with both migration aspirations and concrete preparations to migrate. These studies emphasize that increased access to information and communication technologies facilitates international relocation by providing potential migrants with valuable resources and connections. However some studies, such as those by Kotyrlo (2020) and Winkler (2017), indicate a negative association, where increased internet penetration in either origin or destination countries is linked to decreased international migration. The improved connectivity seems to have anchored individuals to their home countries by enhancing local opportunities or satisfaction.

Regarding internal migration patterns, the studies on inter-state migration within the United States and Ireland found a strong negative effect of ICT use, arguing that better connectivity might reduce the need or desire to relocate within a country (Cooke and Shuttleworth 2018; Cooke and Shuttleworth 2017).

3. The Broadband China Strategy and the UBTS

The Broadband China Strategy, launched in 2013, represents a significant national initiative to develop broadband infrastructure as a strategic public utility for China's economic and social development (The State Council 2013). The implementation strategy of the Broadband China initiative adopted a differentiated approach for urban and rural areas, recognizing their distinct development needs and challenges. While urban areas focused on technological advancement and service quality improvements through demonstration cities, rural areas required more fundamental infrastructure development and financial support mechanisms.

The urban implementation strategy centered on creating "Broadband China Demonstration Cities". Starting in 2014, the Ministry of Industry and Information Technology (MIIT) and National Development and Reform Commission (NDRC) jointly selected groups of demonstration cities annually. These cities served as models for broadband development, implementing advanced technologies and innovative applications (General Office of MIIT and General Office of NDRC 2014).

For rural areas, the strategy took the form of the UBTS program. This initiative, formalized in 2015, specifically targets rural and remote areas to bridge the digital divide between urban and rural regions. The UBTS program set ambitious goals for rural broadband development. By 2020, it aimed to provide broadband access to approximately 50,000 previously unconnected administrative villages and upgrade broadband services for over 30 million rural households. The target was to achieve broadband coverage in 98% of administrative villages, gradually implementing wireless broadband coverage, with a total planned investment exceeding 140 billion yuan (The State Council 2015).

UBTS targeted two categories of villages: administrative villages without broadband access and those with access speeds below 12Mbps (MF and MIIT 2015). The process began with pilot applications from city-level governments, followed by provincial-level review and recommendation to central authorities. After pilot regions were selected and central fiscal support was allocated, implementing enterprises were chosen through open bidding. Building upon the initial UBTS framework, in 2018, MF and MIIT issued a new policy document that significantly expanded the program's implementation (MF and MITT 2018).[2] To support broader rural development, the UBTS program was integrated with other rural initiatives such as e-commerce development and poverty alleviation efforts, being explicitly aligned with national strategic objectives, particularly the Rural Revitalization Strategy.

The "Broadband China" strategy has since served as a quasi-natural experiment for researchers examining the socioeconomic impacts of digital infrastructure. Employing DID designs to exploit the temporal and spatial variations in broadband implementation across China, multiple studies have analyzed city-level or provincial panel data from the mid-2000s to late 2010s, with some incorporating micro-level data from firms or households.

[2] The 2018 policy particularly reached to remote villages, border regions, and island areas and provided varying levels of support for construction and operating costs in those places.

These studies reveal multifaceted socioeconomic effects of broadband development in China, spanning urban labor markets, international trade, firm innovation and productivity, capital investment, energy usage, and regional inequality. The evidence consistently shows that broadband infrastructure creates significant positive spillovers across the Chinese economy, though with varying distributional impacts. In labor markets, broadband access doesn't seem to increase overall employment rates, but it substantially improves job quality for low-skilled workers and also creates new opportunities in skilled service sectors (Wang et al. 2022; Yu et al. 2023). At the firm level, broadband infrastructure generates substantial economic benefits through various complementary channels. Broadband dramatically enhances firm export performance by reducing information frictions and logistics costs, creating a more efficient trade ecosystem that benefits firms regardless of regional location (Zhou et al. 2022). This digital transformation catalyzes innovation across urban China, which translates into measurable productivity increases (Chen et al. 2020; Yang et al. 2022). The improved information environment also attracts venture capital, creating a more dynamic entrepreneurial ecosystem (Li et al. 2022). Beyond direct economic outcomes, broadband infrastructure also delivers environmental benefits by reducing electricity consumption and improving energy efficiency (Wang et al. 2022; Wu et al. 2021).

These studies predominantly focus on urban implementation of the Broadband China strategy. The urban emphasis reflects an earlier urban timeline, with demonstration cities selected annually beginning in 2014, while the rural implementation through UBTS program only formalized in 2015 and gained momentum in 2016. Deng et al. (2023) importantly highlights that while digital development improves absolute income levels in both urban and rural areas, it has a greater positive impact on urban residents, thus widening the urban-rural income gap —

suggesting that without complementary policies, digital infrastructure alone may exacerbate existing spatial inequalities.

4. Data and the Identification Strategy

The data used in this paper are mostly based on the China Household Finance Survey (CHFS) (2013-2021), which was carried out by Southwestern University of Finance and Economics biannually from 2013 to 2021, covering 29 provinces, and 1,046 communities. The sample was drawn as a three-state stratified sample with probability proportional to population size. All data were collected by interviewers using a computer-assisted interviewing system. The household survey covers detailed household information including the whereabouts of every household member; hence we can identify migrants working outside the village. To investigate individual labor allocation decisions, in the main analysis sample we include individuals from households with rural *hukou* who have members living in rural areas. All their household members (aged 16-60) are included in the analysis, counting those living in urban areas (migrants) and those in the rural areas (non-migrants).[3] Additionally, we utilize the community survey data for detailed village characteristics including distance to the county center, implemented development projects, and existing infrastructure.

From 2016 to 2023, the country implemented nine rounds of the UBTS pilot programs. In each round, the Ministry of Industry and Information Technology would announce the list of selected cities. A total of 267 cities participated in the program across all nine rounds. Each selected city would publish the list of specific pilot administrative villages implementing UBTS.

[3] In our regression analyses, we can't include individuals who moved away with their entire family because we have no information about their village of origin. We therefore don't include them in calculating these migration rates, which leads to an underestimation of the actual migration rates. The share of whole family migration is 7.0% in 2015.

Based on our searches of all the selected cities' official webpages, we compiled program information for 147,733 pilot administrative villages nationwide. Based on the list of pilot administrative villages, we matched them with the administrative villages in the CHFS data. Eventually, 121 administrative villages were successfully matched, accounting for 14.8% of the 818 surveyed administrative villages.

Table 1 presents the distribution of villages participating in the UBTS pilot program from 2016 to 2023, comparing national data with the CHFS sample. This table shows the number and percentage of pilot villages implemented each year, allowing us to analyze the temporal pattern of program rollout both nationwide and within our study sample. The UBTS pilot program saw its most significant implementation in the initial two years in 2016 and 2017, which together accounted for 62.2% of all pilot programs (with 45.1% in 2016 and 17.1% in 2017) (Column 3 of Table 1). This front-loaded implementation pattern is also pronounced in the CHFS sample, where 74.8% of the pilot villages participated in the first two years (57.7% in 2016 and 17.1% in 2017) (Column 5 of Table 1), suggesting that early adoption was a key feature of this rural telecommunication building initiative.[4]

In our main analysis, we first focus on the 92 villages that implemented UBTS during 2016-2017, excluding the 29 pilot villages that didn't initiate broadband construction until after 2018. This decision is based on the concern that, given our data timeline, we lack a sufficiently long post-treatment period to effectively study the impacts of these late starters. By focusing on

[4] It is important to note that in the CHFS data, among the 697 non-pilot administrative villages, 415 (59.5%) were from pilot cities. In our regression analyses, these non-pilot villages in pilot cities form an alternative control group to all the non-pilot villages.

early adopters, we ensure a more robust and consistent analytical framework with a longer observation period after treatment.

When analyzing the early implementers, a limitation of the CHFS data is its biennial collection schedule (2013, 2015, 2017, 2019, 2021), which prevents us from separately estimating effects for villages that implemented UBTS in 2016 versus 2017. However, this limitation does not significantly affect our analysis for several reasons. First, as shown in Table 1, the program implementation was heavily front-loaded, with 2016 implementers (57.7% of CHFS pilot villages) substantially outnumbering 2017 implementers (17.1%). Second, both cohorts represent the early adoption phase of the program and likely share similar characteristics. In our analysis, we therefore treat 2015 as the pre-treatment period and 2017 as the first post-treatment observation, capturing the combined effects of both 2016 and 2017 implementations. We later conduct robustness checks by including all 121 pilot villages, including the 29 later implementers.

Our sample reveals diverse initial village and individual characteristics in 2015 (Table 2). At the village level, broadband access is relatively widespread, with 77.5% of villages having broadband infrastructure, though the actual household connection rate averages only 19.4%.[5] Pilot villages comprising 13.6% of our total sample.[6] At the individual level, the sample is balanced in gender composition (52.5% male) with an average age of approximately 40 years. Educational attainment averages 8.1 years of schooling. Migration patterns show that 18.6% of individuals have out-migrated to cities. Annual per capita household income averages 11,309

[5] The share of villages with broadband access was 88.03% in 2017 to 93.3% in 2021. The percentage of households with broadband connections was 30.77% and 56.22% for these years.
[6] Among villages located in UBTS pilot cities, 21% were selected as pilot villages.

yuan [7], with considerable standard deviations indicating significant economic disparities within the sample.

Before we turn to identification strategies for analyzing individual migration decisions, we first summarize the differences in observable characteristics between the pilot villages which are covered by UBTS and those are not. We estimate the selection equations of the following form:

$$Pilot_{vcp} = V_{vcp,2015}\phi + D_c + \varepsilon_{vcp} \tag{1}$$

where $Pilot_{vcp}$ represents if village v in city c of province p was selected as a pilot village for the UBTS program. $V_{vcp,2015}$ is a vector of control variables of village characteristics, all of which are dated in 2015, prior to UBTS program implementations.

Table 3 examines the determinants of UBTS pilot village selection using pre-program village characteristics from 2015. The control variables are selected to account for factors that might influence both the likelihood of village selection for the UBTS program and migration outcomes. These variables include village demographics (the number of registered residents, ethnic minority share), economic conditions (cultivated land areas, income per capita), geography (distance from county center, administrative area), existing connectivity (broadband access and household adoption rates), and social structure (the number of natural villages, presence of lineage clans).

The results, first based on the province fixed effects model, show villages that were already connected to broadband were less likely to be selected as pilot villages, while smaller villages by population had a higher likelihood of selection. No other village characteristics are

[7] This is equivalent to $1800.40 based on average exchange rate in 2015.

significant determinants of the selection. When city fixed effects are introduced in the second model, most coefficients lose statistical significance, suggesting that much of the variation in selection was driven by city-level factors rather than individual village characteristics.

While these regressions are primarily descriptive, they helps identify whether program selection was based on factors that might independently influence migration decisions. The results in Table 3 suggest that the selection process wasn't strongly determined by observable village-level characteristics.

Understanding the determinants of village selection into UBTS helps us to strategize the potential identification of the causal links between internet connection and individual migration decisions. Even though this selection is not based on village initial observable characteristics, broadband construction under UBTS may be related to village unobservables. In addition, we cannot rule out the possibility that individual migration rates might change at different rates in the absence of UBTS. To partly address these concerns, we use the panel version of the difference-in-differences (DD) estimator in the following equation:

$$M_{ijv,t} = \beta_0 + \beta_1 Post2016 \times \ Pilot_{vp} + \ \boldsymbol{H_{jvt}}\, \boldsymbol{\beta_2} + Y_{p\times t} + \mu_i + \epsilon_{ijvt} \qquad (2)$$

in which $M_{ijv,t}$ denotes the out-migration of individual i in household j of village v in year t. $M_{ijv,t}$ is a function of their village's UBTS pilot status $Pilot_{vp}$. The interaction term $Post2016 \times \ Pilot_{vp}$identifies the change in migration probability before and after 2016 when the UBTS started between the individuals in pilot villages and those in non-pilot villages, conditional on all the control variables including a vector of household characteristics H_{jvt} , province-specific year fixed effects $Y_{p\times t}$, and individual fixed effects μ_i. Household characteristics control for time-varying household factors that could affect migration decisions independently of the UBTS program, particularly household demographic composition as measured by the number of household members in the following age groups: 0-5, 6-15, 16-30, 50 and older. The province-specific year fixed effects, allowing different time trends across provinces, capture province-specific shocks or trends caused by local economic conditions or policy changes that could affect migration. Including individual fixed effects, such as personality traits, risk preferences, and unchanging demographic factors, ensure we only use within-person variation in migration decisions before and after the UBTS program. These set of controls help isolate the causal effect of UBTS and leaves the interaction term to capture the causal effect of UBTS.

The key identifying assumption of the above framework is the parallel trends assumption — in the absence of UBTS, migration patterns in pilot and non-pilot villages would have followed parallel trajectories over time. While this counterfactual cannot be directly observed after treatment begins, we can examine whether the trends were indeed parallel before the treatment by using the event-study version of this DD estimation which includes interaction terms between each specific year dummy and the pilot village status:

$$M_{ijv,t} = \gamma_0 + \gamma_1 Year2013 \times Pilot_{vp} + \gamma_2 Year2017 \times Pilot_{vp} + \gamma_3 Year2019 \times Pilot_{vp} + \gamma_4 Year2021 \times Pilot_{vp} + \boldsymbol{H_{jvt}}\,\boldsymbol{\gamma_5} + Y_{p\times t} + \mu_i + \epsilon_{ijvt} \quad (3)$$

The coefficients $\gamma_1$through γ_4 capture the differences in migration patterns between pilot and non-pilot villages for different years, all measured relative to 2015, the year before the UBTS started. The coefficient on year 2013 (γ_1) measrues pre-trend. The subsequent coefficients γ_2, γ_3, and γ_4 measure the year-specific impacts of UBTS. As the specification outlined in (3) allows us to test the parallel trends and captures potential dynamic effects of UBTS that may evolve over time, it is the main estimation methods we adopt in our regress analyses.

5. Results

Before examining the UBTS impact on individual migration decisions, we first seek empirical evidence confirming increased internet access in pilot villages. Similar to our approach for migration outcomes, we employ an event study methodology to analyze broadband access. This event study analysis of UBTS and broadband access is reported in Figure 1, which shows the estimated coefficients for the effect of being a UBTS pilot village across different years (2013, 2017, 2019, and 2021), relative to the baseline year 2015.

Figure 1 presents results for two key connectivity measures: village-level broadband access (Panel A) and the share of households with broadband connections (Panel B). For broadband access, we observe insignificant coefficients in 2013, supporting the parallel trends assumption prior to UBTS implementation. Following program introduction, pilot villages, compared to non-pilot villages, experience approximately 10 percentage and 20 percentage points higher broadband access in 2017 and 2021 respectively. For the household broadband share measure, data is only available during 2015-2019, making pre-trend assessment impossible. Nevertheless, this measure provides important complementary evidence on the intensive margin of broadband adoption. The results show that the share of households with broadband connections in pilot villages increased by approximately 10 percentage points by 2019 relative to non-pilot villages. Together, these findings confirm that the UBTS program significantly expanded both village-level internet infrastructure and household-level connectivity, establishing the technological foundation through which broadband access might influence migration decisions.

5.1 Impacts of UBTS on Migration Decisions

Now we turn to the program's impact on migration outcomes. Table 4 presents our baseline event study analysis results examining three separate migration outcomes: total migration, cross-county migration, and cross-province migration. These results support the parallel trends assumption, as indicated by the small and statistically insignificant coefficients for 2013 across all migration measures. This suggests that pilot and non-pilot villages had similar migration trajectories before UBTS implementation.

The program's effects begin to emerge in 2017, with UBTS implementation increasing total migration by 3.2 percentage points in pilot villages (significant at the 5% level). While the coefficients for both cross-county and cross-province migration are positive during this period, they are not statistically significant. The impact persists and strengthens slightly in 2019, with total migration showing a 3.4 percentage point increase (significant at the 10% level). Notably, the 2019 effect appears to be driven primarily by cross-county migration, which shows a significant 3.1 percentage point increase. This pattern suggests that improved internet access particularly facilitates intermediate-distance migration.

By 2021, the coefficients across all migration measures become statistically insignificant, though they remain positive. This pattern needs to be interpreted within the context of China's COVID pandemic response. From early 2020 through late 2022, China enforced zero-COVID policy, implementing extensive control measures that fundamentally altered normal patterns of population movement and economic activity across the country (Burki 2023; Liu et al. 2024; Yuan 2022). This pandemic experience makes it challenging to disentangle any long-term UBTS effects from the impact of COVID-19 and the related pandemic control measures.

Table 5 presents robustness checks for the above main findings, using two different control groups. Panel A compares pilot villages to non-pilot villages within the same pilot cities, which effectively controls for city-level characteristics and policies that might influence migration patterns. Given the hierarchical implementation structure of the UBTS program—where city governments first applied to become pilot cities before selecting specific villages—this within-city comparison provides our most credible counterfactual. Cities that applied for UBTS likely shared unobserved characteristics related to administrative capacity, development priorities, or economic conditions that could independently affect migration trends. By comparing villages under the same city-level governance but differing only in UBTS implementation status, we minimize potential selection bias.

The results from this preferred specification strongly support the main findings. The 2013 pre-treatment effects remain insignificant across all migration measures, confirming the parallel trends assumption. In 2017, the program shows a significant 3.1 percentage point increase in total migration. The effects become stronger and more significant in 2019, with a 3.7 percentage point increase in total migration, driven by increases in both cross-county migration and cross-province migration (2.6 percentage points). Again, in 2021, while the effects remain positive, they become statistically insignificant.

Panel B presents an alternative specification comparing pilot villages to those in non-pilot cities. While this specification also shows insignificant pre-treatment effects and significant migration increases post-implementation, the magnitudes are notably larger. Total migration increases by 4.9 percentage points in 2017, primarily driven by cross-county migration (4.7 percentage points). However, these larger effects likely reflect not only the UBTS impact but also unobserved city-level differences that influenced program participation decisions. Since our analysis of selection factors (Table 3) revealed the importance of city-level application in the implementation process, the within-pilot-city comparison in Panel A produces more conservative and reliable estimates that better isolate the causal effect of the UBTS program.

To further verify the robustness of our findings, we extend our analysis to include all UBTS pilot villages implemented between 2016 and 2021. This expanded sample adds 29 villages that implemented the program after 2017, creating variation in treatment timing across villages. Given this staggered implementation design, we apply the dynamic semi-parametric DID estimator proposed by Callaway and Sant'Anna (2021), which is designed to handle multiple time periods and heterogenous treatment timing.

Figure 2 reports these results. The estimates continue to show no significant pre-trends before UBTS implementation across all three migration measures. Total migration (top panel) shows the largest and most significant impact, increasing by approximately 3-4 percentage points after UBTS implementation. Cross-county migration (middle panel) also shows a statistically significant positive effect, though with a smaller magnitude of around 2 percentage points. For cross-province migration (bottom panel), the point estimates suggest a positive effect of similar magnitude to cross-county migration, but these effects are not statistically significant at conventional levels.

In sum, our core analyses using the early-implementing villages (Tables 4 and 5) and our extended analysis including all pilot villages (Figure 2) show a consistent finding: the UBTS program has significant positive effects on migration, increasing migration rates by approximately 3-4 percentage points. This robust pattern persists across different control group specifications and estimation approaches.

A key concern in identifying the causal effect of the UBTS program on migration is that pilot villages might have simultaneously received other development programs or infrastructure improvements. If this were the case, the increased migration we observe could be attributed to these other interventions rather than the UBTS program itself. To address this concern, we examine six different types of development projects recorded in our data: road infrastructure, other transportation projects, water conservation construction, cultural and entertainment facilities, social security programs, and social organization development. Figure 3 presents the corresponding results.

It's important to note that data for road types is missing in the 2015 survey, and for other infrastructure variables, data collection only began in 2015. This means we cannot test pre-trends for any of these infrastructure variables, as we lack either 2013 data or 2015 data. Despite this limitation, the analysis remains valid for our purposes. The key question is not whether these infrastructures were developing in parallel before UBTS implementation, but whether their post-implementation trajectories correlate with UBTS rollout in ways that could explain our migration findings.

As Figure 3 clearly shows, none of these alternative infrastructure measures exhibit significant increases in pilot villages after UBTS implementation. The absence of post-treatment effects for these other infrastructure developments strongly supports our conclusion that the migration effects we observe are specifically attributable to broadband access rather than concurrent infrastructure improvements. Even without pre-trend validation, the lack of differential post-UBTS infrastructure development between pilot and non-pilot villages effectively rules out these alternative explanations for our main findings.

5.2 Heterogeneities in Migration Effects

Having established the overall impact of UBTS on migration decisions, we now examine whether these effects vary across different village and individual pre-program characteristics. This heterogeneity analysis may illuminate potential mechanisms through which broadband access affects migration decisions by showing which contextual factors amplify or attenuate the effects. Additionally, heterogeneity analysis can reveal whether broadband expansion reduces or exacerbates existing inequalities in migration opportunities. Tables 6 and 7 present these heterogeneity analyses for village-level and individual-level characteristics, respectively.

For our village-level heterogeneity analysis in Table 6, we use village characteristics primarily measured from 2015 data to form subgroups, except for road condition variables which come from 2013 (as this information was not collected in 2015). At the village level, several clear patterns emerge. First, villages with initially low migrant population shares (below the sample median in 2015) saw larger increases in migration following UBTS implementation — 4.3 percentage points in 2017 compared to insignificant effects in villages with higher initial migration. Second, the program's effects were stronger in villages closer to county centers (less than 25km), with significant increases of 6.5 percentage points in 2017 and 9.0 percentage points in 2019, whereas more remote villages showed no significant changes. Third, villages with better initial road conditions (asphalt/cement roads rather than sand/gravel/dirt roads) experienced larger migration responses, with a significant 5.9 percentage point increase in 2017. Finally, villages at lower altitudes (below the sample median) showed significant migration increases of 6.2 percentage points in 2017 and 5.4 percentage points in 2019, while higher-altitude villages saw no significant effects.

These heterogeneity results reveal important insights about how internet connectivity interacts with pre-existing village conditions to influence migration outcomes. The stronger effects in villages with lower initial migration rates suggest that internet access may serve as a substitute for migration networks, providing information and connections that were previously only available through social ties. By democratizing access to information about distant opportunities, broadband helps equalize migration possibilities for communities that lacked established migration patterns. Meanwhile, the concentration of effects in villages closer to county centers, with better road infrastructure, and at lower altitudes demonstrates that digital connectivity complements geographic advantages and physical infrastructure rather than compensating for their absence. This complementarity indicates that broadband access magnifies pre-existing locational advantages rather than leveling the playing field for more remote or isolated communities. The digital infrastructure appears most effective when layered upon adequate physical infrastructure, suggesting that internet connectivity alone may be insufficient to overcome fundamental geographic disadvantages.

For our individual-level heterogeneity analysis in Table 7, we examine how UBTS impacts vary across demographic and socioeconomic characteristics measured in 2015. The results show UBTS significantly increased migration primarily among females, younger individuals (age ≤ 40), more educated individuals (>6 years of schooling), and those from higher-income households ≥median income), while their counterparts experienced positive but statistically insignificant effects.

The stronger effects for females are particularly noteworthy, suggesting that internet connectivity may help overcome gender-specific barriers to mobility by providing alternative information channels beyond traditional, often male-dominated social networks. This finding hints at the potential for digital connectivity to promote greater gender equality in migration opportunities. Whereas the overall pattern also raises concerns about digital infrastructure potentially exacerbating existing inequalities. Education appears crucial for effectively utilizing online information about distant labor markets, while higher household income likely provides the financial resources necessary to act upon newfound opportunities. Similarly, younger individuals may possess greater digital literacy and face fewer family constraints when responding to opportunities discovered online. By disproportionately benefiting those who already possess advantageous individual characteristics (education, income, youth), internet connectivity may widen the gap between those who can and cannot migrate for better opportunities.

5.3 Mechanisms: Information-Seeking Behavior and Consumption Patterns

To understand the mechanisms driving the migration effects, we examine how UBTS influenced information-seeking and consumption behavior (Figure 4). Event study analyses show that UBTS implementation significantly increased villagers' attention to economic and financial information in pilot villages. By 2019, residents in UBTS villages were approximately 8 percentage points more likely to report paying close attention to economic and financial news compared to their counterparts in non-pilot villages.

In contrast, the program had no discernible impact on online shopping behavior: neither the probability of engaging in online shopping nor the value of online expenditures showed any significant changes in response to UBTS implementation across all post-treatment years. The coefficients for both shopping-related outcomes remain statistically insignificant and close to zero throughout the study period.

These findings suggest that improved internet access primarily operates through an information channel—helping rural residents learn about and evaluate urban opportunities—rather than by enhancing rural life through expanded access to goods and services via e-commerce. The increased attention to economic information likely facilitates better awareness of employment opportunities, wage differentials, and living conditions in potential migration destinations. This information-focused mechanism is consistent with our heterogeneity findings, particularly the stronger effects among more educated individuals who may be better positioned to process and act upon economic information obtained online.

6. Conclusion

This study examines how rural broadband expansion affects internal migration in China by analyzing the implementation of the UBTS program. Using panel data and a difference-in-differences approach, we find that improved internet access significantly increases rural-urban migration, particularly cross-county movement. The program increased total migration by 3.2-3.4 percentage points in pilot villages during 2017-2019, with effects strongest in villages close to county centers and those with good road infrastructure. At the individual level, the impacts were larger for females, younger individuals, those with higher education, and individuals from high-income households. Our analysis of mechanisms suggests that increased access to economic information, rather than enhanced e-commerce opportunities, drives these migration decisions.

These findings have important implications for rural development policies. While digital infrastructure is often promoted as a tool for rural revitalization, our results suggest it may actually accelerate rural-urban migration by reducing information barriers about urban opportunities. This highlights potential tensions between different rural development objectives:

efforts to enhance rural connectivity may conflict with goals of maintaining rural population stability.

Related to this issue, our findings raise a couple of important questions for future research. First, understanding how digital infrastructure interacts with other development initiatives, such as agricultural technology extension and village enterprise initiatives, in shaping migration decisions warrants further investigation. The interplay between digital connectivity and these programs could either amplify or dampen migration incentives. For example, if internet access enhances the effectiveness of agricultural extension services or facilitates rural entrepreneurship, it might help retain rural population. Conversely, if digital connectivity primarily helps rural residents better leverage urban opportunities, it could accelerate migration despite other rural development efforts.

Second, our finding that broadband access particularly affects migration through information channels suggests the need to examine how digital technology reduces specific information barriers in migration decisions. Future research could disentangle whether internet access primarily helps rural residents overcome information constraints about labor market opportunities—such as job availability, skill requirements, and wage distributions—or whether it mainly provides information about urban living conditions, including housing costs, public services, and amenities. Understanding the relative importance of labor market information versus information about urban living costs and amenities would illuminate the nature of information frictions in migration decisions and help design more targeted policies to support rural-urban labor market integration.

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Table 1. The UBTS Pilot Village Distribution: National Data and CHFS Sample

Program Implementation Year	# of pilot villages nationwide	Ratio	# of pilot villages in CHFS	Ratio
2016	66,606	45.1%	71	58.7%
2017	25,241	17.1%	21	17.4%
2018	8,389	5.7%	4	3.3%
2019	13,980	9.5%	11	9.1%
2020	9,655	6.5%	5	4.1%
2021	14,869	10.1%	3	2.5%
2022	6,230	4.2%	4	3.3%
2023	2,763	1.9%	1	0.8%
Total	147,733	100.0%	121	100%

Table 2. Summary Statistics of Initial Village and Individual Characteristics (2015)

	Means	S.d.
Village characteristics		
Village broadband access	0.775	0.412
Share of households connected to broadband	0.194	0.258
Proportion of UBTS pilot villages in pilot cities	0.210	0.408
Proportion of UBTS pilot villages	0.136	0.343
Number of villages	404	
Individual characteristics		
Male	0.525	0.499
Age	39.857	12.266
Years of schooling	8.147	3.579
Migration rate	0.183	0.388
Household asset per capita (Yuan)	92394.31	216369.5
Household income per capita (Yuan)	11308.68	30576.28
Number of individuals	23,251	

Table 3. Determinants of UBTS Pilot Village Selection (2015)

	(1)	(2)
	Selected as a Pilot Village	Selected as a Pilot Village
Connected to broadband	-0.118*	-0.106
	(0.059)	(0.100)
Proportion of households with broadband	0.051	0.093
	(0.074)	(0.112)
Number of registered residents (log)	-0.061**	-0.017
	(0.029)	(0.045)
Cultivated land area (log)	0.037	0.030
	(0.034)	(0.060)
Annual income per capita (log)	-0.019	-0.040
	(0.031)	(0.050)
Number of natural villages	-0.003	0.000
	(0.002)	(0.003)
Presence of any large lineage clan	-0.080	-0.055
	(0.055)	(0.118)
Distance from the county center	-0.012	-0.030
	(0.020)	(0.031)
Administrative area (log)	-0.014	-0.021
	(0.012)	(0.015)
Ethnic minority population share	0.003	-0.003
	(0.030)	(0.065)
Province fixed effects	Yes	
City fixed effects		Yes
Observations	404	404

Note: OLS regressions. Coefficients are reported with robust standard errors clustered at the province level in parentheses. *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively.

Table 4. Event Study Regression Results: UBTS and Individual Migration Decisions

	(1) Total migration	(2) Cross-county migration	(3) Cross-province migration
Year 2013 × pilot village	0.007	-0.005	-0.005
	(0.016)	(0.016)	(0.015)
Year 2017 × pilot village	0.032**	0.021	0.011
	(0.016)	(0.014)	(0.012)
Year 2019 × pilot village	0.034*	0.031**	0.019
	(0.018)	(0.015)	(0.014)
Year 2021 × pilot village	0.026	0.002	-0.001
	(0.030)	(0.026)	(0.021)
Demographic characteristics	Yes	Yes	Yes
Individual fixed effects	Yes	Yes	Yes
Province × year fixed effects	Yes	Yes	Yes
Observations	91,205	92,401	92,401

Note: OLS regressions. Coefficients are reported with robust standard errors clustered at the village level in parentheses. *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively. Demographic characteristics include the number of household members in the following age groups: 0-5, 6-15, 16-30, 50 and older.

Table 5. Robustness Checks: UBTS and Individual Migration Decisions with Different Control Groups

	(1) Total migration	(2) Cross-county migration	(3) Cross-province migration
Panel A: Control Group: Non-Pilot Villages in Pilot Cities			
Year 2013 × pilot village	0.006	-0.006	-0.005
	(0.017)	(0.018)	(0.016)
Year 2017 × pilot village	0.031*	0.021	0.013
	(0.016)	(0.014)	(0.012)
Year 2019 × pilot village	0.037**	0.035**	0.026*
	(0.018)	(0.015)	(0.014)
Year 2021 × pilot village	0.031	0.011	0.008
	(0.033)	(0.029)	(0.023)
Observations	62,147	63,117	63,117
Panel B: Control Group: Villages in Non-Pilot cities			
Year 2013 × pilot village	0.009	0.001	-0.012
	(0.026)	(0.023)	(0.018)
Year 2017 × pilot village	0.049*	0.047**	0.012
	(0.026)	(0.019)	(0.012)
Year 2019 × pilot village	0.019	0.030	-0.021
	(0.032)	(0.027)	(0.020)
Year 2021 × pilot village	0.007	-0.010	-0.048**
	(0.035)	(0.034)	(0.024)
Observations	39,910	40,328	40,328
Demographic characteristics	Yes	Yes	Yes
Individual fixed effects	Yes	Yes	Yes
Province × year fixed effects	Yes	Yes	Yes

Note: OLS regressions. Coefficients are reported with robust standard errors clustered at the village level in parentheses. *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively. Demographic characteristics include the number of household members in the following age groups: 0-5, 6-15, 16-30, 50 and older.

Table 6: Heterogeneity Analyses of Individual Migration Decisions (Total Migration) by Initial Village Characteristics

	Initial Migrant Population Share		Distance to County Center		Village Road Condition		Altitude	
	low	high	< 25km	≥ 25km	sand/gravel /dirt	asphalt/ cement	< Q50	≥ Q50
Year 2013 × pilot village	-0.028	0.010	0.031	-0.011	0.013	-0.005	0.005	0.013
	(0.020)	(0.021)	(0.029)	(0.021)	(0.031)	(0.023)	(0.025)	(0.023)
Year 2017 × pilot village	0.043*	0.014	0.065**	0.019	0.024	0.059**	0.062**	0.027
	(0.025)	(0.020)	(0.031)	(0.018)	(0.035)	(0.024)	(0.025)	(0.022)
Year 2019 × pilot village	0.028	0.020	0.090***	0.009	0.031	0.045	0.054**	0.035
	(0.023)	(0.023)	(0.030)	(0.024)	(0.035)	(0.027)	(0.027)	(0.022)
Year 2021 × pilot village	-0.038	0.049	0.000	0.035	0.065	0.015	0.033	0.044
	(0.034)	(0.037)	(0.039)	(0.044)	(0.044)	(0.068)	(0.055)	(0.048)
Demographic characteristics	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Individual fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Province × year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	43,856	45,247	42,971	44,512	18,498	42,543	40,495	41,105

Note: OLS regressions. Information from 2013 or 2015 data was used for all grouping variables. Coefficients are reported with robust standard errors clustered at the county level in parentheses. *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively. Demographic characteristics include the number of household members in the following age groups: 0-5, 6-15, 16-30, 50 and older.

Table 7: Heterogeneity Analyses of Individual Migration Decisions (Total Migration) by Initial Individual Characteristics

	Gender		Age		Years of Education		Household Income	
	Male	Female	≤ 40	> 40	≤ 6	>6	< Q50	≥ Q50
Year 2013 × pilot village	-0.010	0.028	0.006	0.006	0.016	0.003	0.009	0.002
	(0.020)	(0.018)	(0.034)	(0.013)	(0.018)	(0.022)	(0.002)	(0.022)
Year 2017 × pilot village	0.028	0.034**	0.058*	0.018	0.025	0.049**	0.013	0.042**
	(0.021)	(0.016)	(0.034)	(0.011)	(0.016)	(0.023)	(0.021)	(0.021)
Year 2019 × pilot village	0.031	0.035**	0.052	0.026**	0.024	0.035	-0.003	0.061**
	(0.023)	(0.016)	(0.038)	(0.012)	(0.018)	(0.027)	(0.021)	(0.027)
Year 2021 × pilot village	0.027	0.026	0.033	0.025	-0.011	0.050	0.031	0.019
	(0.036)	(0.030)	(0.070)	(0.020)	(0.040)	(0.040)	(0.041)	(0.036)
Demographic characteristics	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Individual fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Province × year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	47,966	43,239	36,184	55,021	33,933	57,272	39,662	51,528

Note: OLS regressions. Coefficients are reported with robust standard errors clustered at the county level in parentheses. *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively. Demographic characteristics include the number of household members in the following age groups: 0-5, 6-15, 16-30, 50 and older.

Figure 1. Event Study of UBTS and Broadband Access

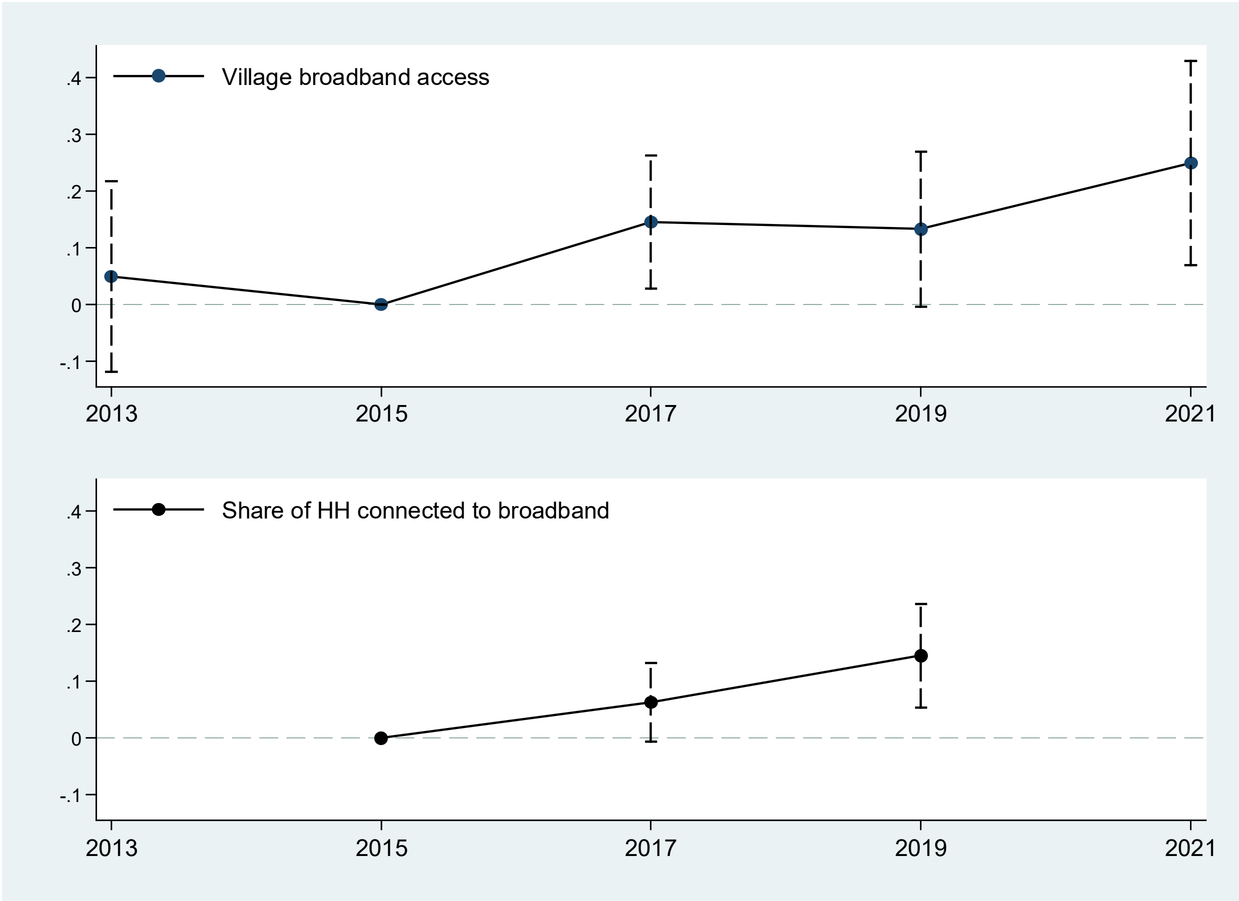


Figure 2: Robustness Checks: Migration Effects Including all UBTS pilot Villages (2016-2021 Implementation)

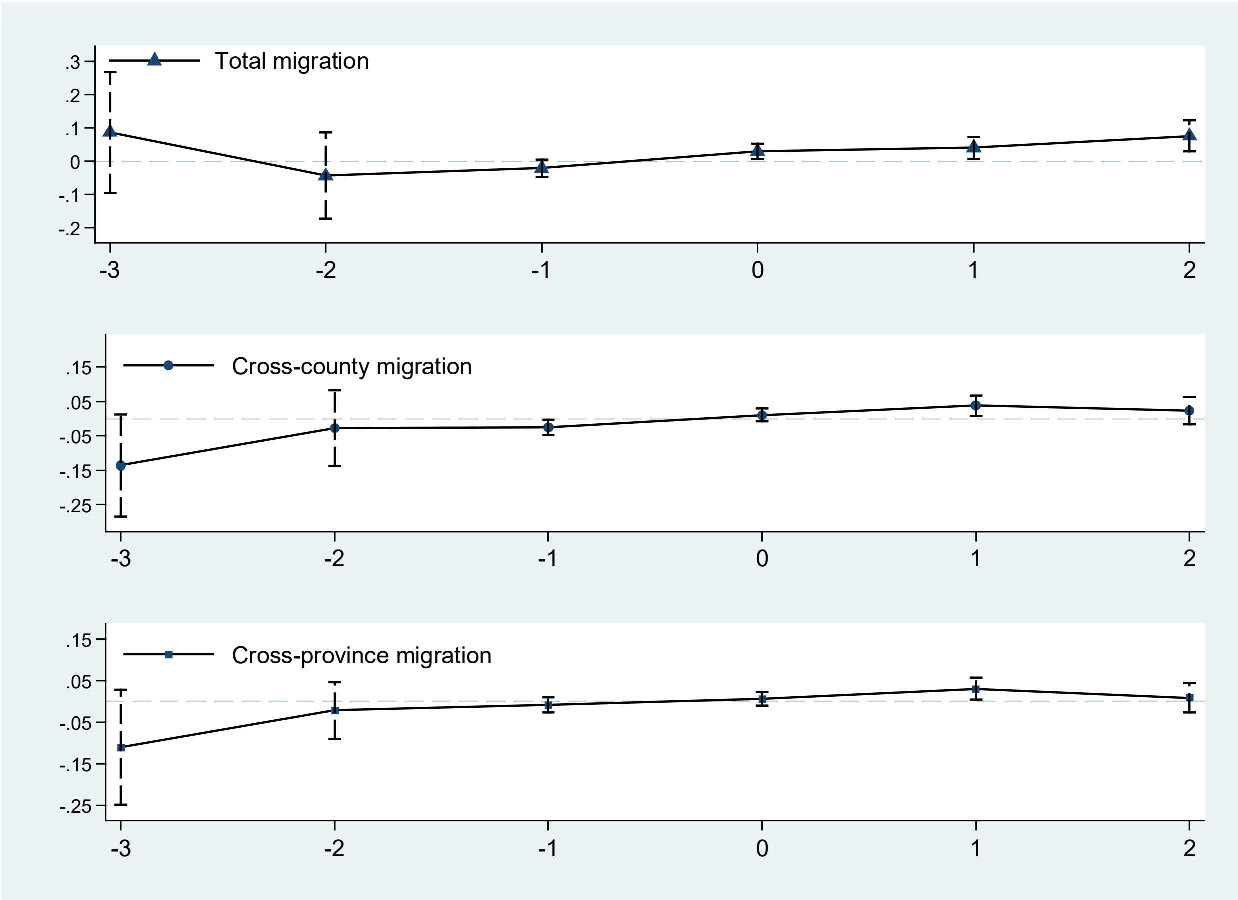
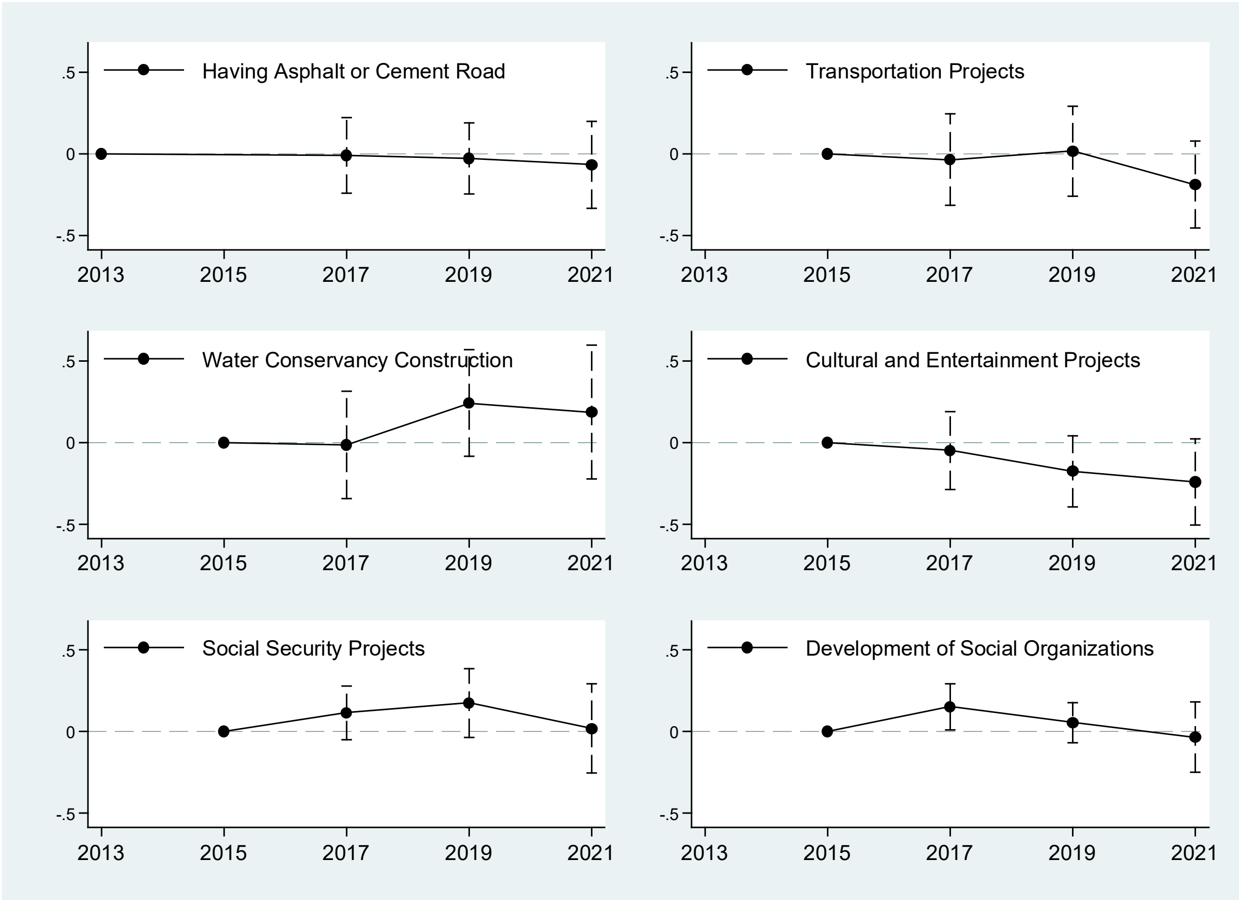
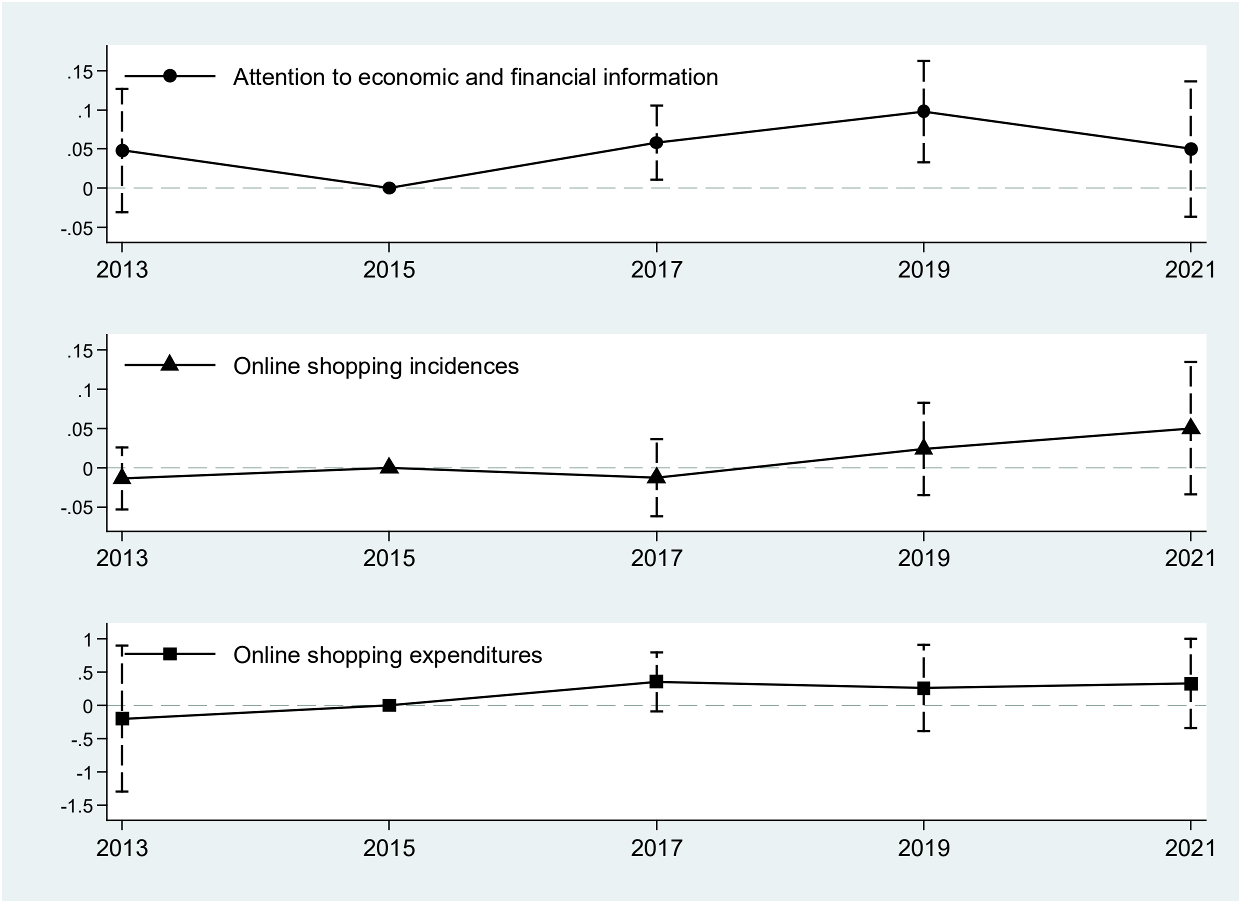


Figure 3. Robustness Checks: The Availability and Constructions of Other Infrastructures



Note: Data for road types is available for 2013, 2017, 2019, and 2021. The relevant questions were not asked in 2015. The remaining five development projects have data spanning from 2015 to 2021.

Figure 4. Event Study of UBTS and Changes in Information Seeking & Online Shopping



Note: (1). The outcome variable "attention to economic and financial information is based on survey question, "How much attention do you usually pay to economic and financial information?" with response options 1. Pay very close attention; 2. Pay close attention; 3. Average attention; 4. Pay little attention; 5. Never pay attention. In the event study analysis, we use a binary variable which equals 1 if respondents chose either option 1 (Pay very close attention) or option 2 (Pay close attention), 0 otherwise. (2) The two online shopping variables are based on these questions—"Have your household shopped online in the last 12 months?" and "How much money was spent on online shopping in total."