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ARTICLE

Assessing the Impact of Land Titling Policy on Population Urbanization in China: Empirical Analysis Based on a Time-varying DID Model

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ABSTRACT

This study aims to investigate how land titling influences population urbanization in China, with a particular focus on the mechanisms and regional heterogeneity of this effect. While previous research on population urbanization has primarily examined factors attracting people to cities, fewer studies have explored institutional barriers that limit rural-to-urban migration. The land titling policy implemented by the Chinese government represents a major institutional reform that can ease such constraints by enhancing rural residents' land tenure security. Using panel data from 31 provinces in China from 2006 to 2020, this study employs a time-varying difference-in-differences (DID) model to estimate the impact of land titling on population urbanization. The empirical results show that: (1) Land titling can promote population urbanization. (2) Land titling contributes to population urbanization by strengthening livelihood security and increasing income. (3) The more economically developed an area is, the more the population urbanization can be promoted by land titling. (4) the impact is greater in non-major grain-producing areas than in major grain-producing areas. Policy implications including setting up land rights adjustment committees in developed eastern regions; providing legal aid in less developed areas; establish-

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ing standardized land transfer platforms; forming land trusteeship cooperatives in major grain areas; linking land titling with employment support.

Keywords: Property Rights; Urbanization Rate of Registered Population; Livelihood Security; Income; Regional Heterogeneity

1. Introduction

Population urbanization is widely recognized as a key driver of economic growth, facilitating the reallocation of labor from low-productivity agricultural sectors to higher-productivity industrial and service sectors [1–3]. Between 1978 and 2022, China's GDP increased from 0.37 trillion yuan to 121.02 trillion yuan, with an average annual growth rate (in constant 1978 prices) of 4.6% In the meanwhile, around 140 million rural populations settle in urban areas from 2012 to 2022.

Traditionally, China's urbanization strategy has centered on land urbanization, involving the conversion of collectively-owned land into state-owned land and the reallocation of agricultural land for urban development. This process, intensified by fiscal decentralization and land-based finance, leveraged land expansion and transfer to attract investment, thus boosting GDP and expanding the tax base. It also capitalized on cheap rural labor while restricting migration to minimize costs. However, this has exacerbated the urban-rural income gap (with the urban-to-rural income ratio rising from 1.82 in 1978 to 2.45 in 2022), and created a paradox where migrant workers fuel urban development yet lack corresponding social benefits. In response, China's National New Urbanization Plan (2014–2020) advocated a people-centric urbanization mode, prioritizing rural-to-urban resident transition as a key strategy for dismantling the urban-rural dual system and foster social equity.

In this new policy context, land titling emerged as a critical reform to address institutional barriers to migration. According to property rights theory [4], well-defined and secure property rights improve resource allocation efficiency, enhance asset transferability, and reduce transaction costs. In rural China, the "Three Rights Separation Measures" (TRSM) divided farmland rights into land ownership rights (LOR), land contract rights (LCR), and land management rights (LMR), strengthening legal protection for farmers' contractual and operational rights [5]. The Opinions of the State Council on Further Promoting the Reform of the Household Registration System explicitly stated that "the withdrawal of the rights to contract and manage farmland shall not be a precondition for farmers to move into urban areas and settle down." This legal assurance means that farmers can retain their farmland rights even after settling in urban areas, reducing migration risks and unlocking the potential for farmland market activation. Clearer property rights thus lower disputes, improve farmland allocation efficiency, and ease the institutional constraints on rural-to-urban migration [6].

The rural-urban migration literature has predominantly emphasized urban pull factors as key drivers of migration flows. A major strand of research focuses on industrial upgrading, whereby expansion in the secondary and tertiary sectors increases labor demand and offers rural migrants access to higher wages and more stable employment opportunities [7,8]. While these studies highlight the economic incentives drawing migrants to cities, many rely on aggregate regional data or cross-sectional surveys, which limit their ability to capture the nuanced heterogeneity of migrant experiences and regional policy contexts. Residential security, particularly through hukou reforms and housing policies, is also recognized as a crucial pull factor by reducing settlement costs and facilitating migrants' urban integration [9–14]. However, much of these literatures tend to assume that easing hukou restrictions or expanding housing access automatically translates into increased migration, often overlooking the complex institutional and social barriers migrants face. Similarly, improved public service provision, including healthcare, education, and elderly care, in urban areas is shown to enhance living standards and attract migrants [15–18], but the literature often lacks rigorous evaluation designs to isolate the causal effects of these services on migration decisions. This body of work,

while rich in identifying various pull factors, rarely engages critically with the methodological challenges or the potential endogeneity inherent in migration studies, such as reverse causality or omitted variable bias.

In contrast, migration theory, including the foundational Todaro model, emphasizes that migration decisions are shaped by both pull forces in destination areas and push constraints in origin areas [19,20]. Institutional barriers in rural home regions, such as ambiguous or insecure farmland rights prior to land titling reforms, represent significant push-side constraints that increase migration risks and deter relocation [21]. Despite their theoretical importance, these push factors remain underexplored in both Chinese and broader international migration research. Few empirical studies systematically analyze how land tenure insecurity or other rural institutional deficiencies constrain migration choices or interact with urban pull factors. This gap results in an incomplete understanding of migration dynamics, particularly in developing economies where rural land institutions play a critical role in shaping livelihoods and mobility [22].

Given these gaps, this study addresses the following questions: (1) Does land titling significantly promote population urbanization in China? (2) Are there regional differences in its impact? (3) Through what mechanisms does land titling influence rural-to-urban migration? To answer these questions, this study makes two main contributions. First, while most research on population urbanization concentrates on pull factors, this study shifts the focus to push-side constraints, particularly institutional barriers arising from unclear farmland rights. It thus reframes rural-urban migration as the joint outcome of push and pull forces, offering insights applicable to other developing economies with similar land tenure systems. Second, methodologically, unlike standard DID models, this research employs a time-varying DID design that accounts for the staggered rollout of land titling reforms across regions, producing more credible causal estimates and providing a replicable strategy for evaluating staggered policy interventions globally.

2. Conceptual Framework and Hypothesis

2.1. Farmland System and Land Titling in China

The Household Responsibility System has been implemented since 1978 in China [23]. In response to the population change caused by birth, death, or marriage among villages, land reallocations were inevitable [24,25]. However, land reallocations periodically resulted in tenure insecurity [26]. To better guarantee farmers' farmland use rights, three rights separations and land titling were implemented. Land titling policy is not implemented in all provinces at the same time, but is accomplished stepwise throughout the country. Specifically, it can be divided into two phases: village-wide implementation (2009–2013) and province-wide implementation (2014–2017). Before 2014, land titling was piloted in some villages. Since 2014, land titling in China has been implemented at the province level, and all provinces promoted the program in four batches between 2014 and 2017. **Table 1** presents the information about land reforms in China.

Table 1. Related land reforms in China.

Land Reforms	Time	Main Content
Household responsibility system	1978	Different from farmers in the private ownership system, farmers in China have only the land-use rights of contracted farmland, but not land-owned rights. Collective land ownership ensures villagers' rights to share farmland equally.
Land titling pilot in selected counties	2009–2013	The program requires each community to identify the contracted land boundaries by conducting a topographic land survey, and then issue a land certificate to each household. Because of the collective ownership of farmland, land titling only guarantees the security of farmers' use rights of the contracted farmland by legislation. Before 2014, land titling was only piloted in some selected counties.
Three rights separations	2014	Farmland property rights were separated into the ownership rights, the contract rights, and the management rights.
Land titling implementation at the province level	2014–2017	Since 2014, land titling in China has been implemented at the province level, and all provinces promoted the program in four batches between 2014 and 2017.

2.2. Population Urbanization

Population urbanization is the process of rural population migrating to urban areas and becoming urban residents [27]. Typically, two indicators are applied to represent the urbanization level. The first is urbanization rate of permanent population, which refers to the proportion of urban permanent residents in the total permanent residents of a region. And the second is urbanization rate of registered population, which refers to the proportion of urban registered population in the total registered population of a region. We use the urbanization rate of registered population to represent the population urbanization. The reasons are as follows:

According to the *National New Type of Urbanization Plan (2014~2020)* issued by the Chinese government, China prepared a plan to migrant 100 million rural residence to urban areas with the transferring of household registration. This plan emphasizes the consistency of the location of the population and the place of household registration because nowadays in China, many migration people register as rural residents but work and live in urban area for most of their time. This kind of population with residence-registration mismatch cannot enjoy the same social welfare as urban residents. When measuring the urbanization level by applying the urbanization rate of permanent population, population with residence-registration mismatch are not excluded. Therefore, it may overestimate the actually level of urbanization. Then, this study uses the urbanization rate of registered population as representor of population urbanization.

2.3. Population Urbanization before and after Land Titling

Figure 1 shows that before the provincial-level promotion of land titling (2000 to 2014), the number of urban-rural migrant population differs from the number of populations with residence-registration mismatch, which means the place that people regular residence is not the place they registered, and it shows a yearly increasing trend of number from 122 million and 144 million in 2000 to 253 million and 298 million in 2014, accordingly. Then from the province-wide promotion of land titling to the outbreak of Covid-19 epidemic (i.e., 2014–2019), the number of urban-rural migrant population and the number of populations with residence-registration mismatch in China showed a downward trend year by year, from 253 million and 298 million in 2014 to 236 million and 280 million in 2019 (see **Figure 2**). Based on this inference, before 2019, when there was no disruption from the pandemic, land titling might have slowed down migrant population and population with residence-registration mismatch in China. More intuitively, as shown in **Figure 2**, after land titling, the slope of population urbanization rate curve is lower than before, which shows that the growth rate of population urbanization rate increases obviously with the implementation of land tilting from 2014. Specifically, the average annual growth rate of population urbanization rate from 2014 to 2020 is 2.4%, which is higher than the average annual growth rate (1.7%) before the implementation of land titling (2006–2013).

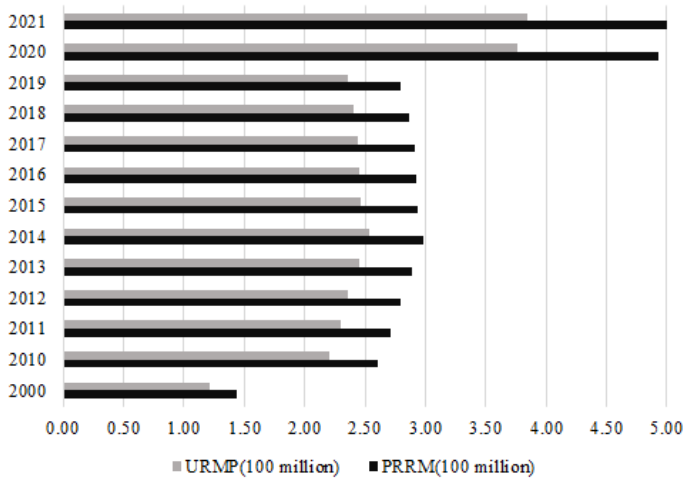

Figure 1. The number of urban-rural migrant population (URMP) and population with residence-registration mismatch (PRRM).

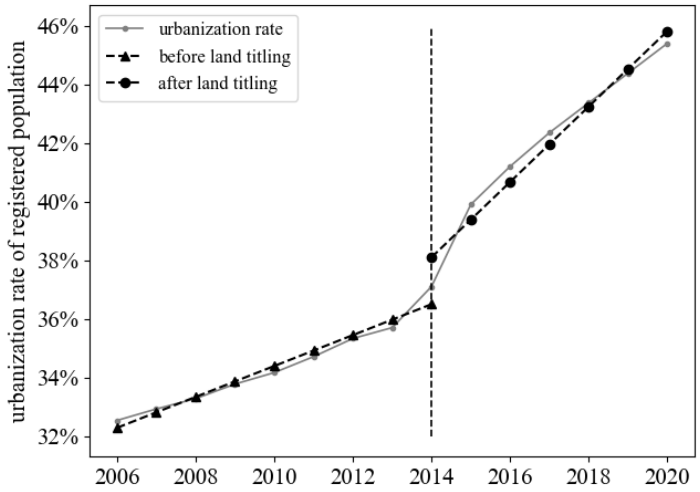

Figure 2. Urbanization rate of registered population.

2.4. Hypothesis

Before the implementation of land titling, rural populations were generally hesitant about urbanization due to two main concerns. First, unclear farmland rights during household registration conversion created the risk of losing land without securing alternative livelihood options. This uncertainty meant that unsuccessful urban integration could leave migrants without a basic means of living [28]. Tenure insecurity discourages migration because households fear losing farmland while away, particularly in settings where land reallocation or disputes are common. Second, the lack of stable income sources made it difficult to meet the higher living costs in urban areas, further discouraging migration [29]. **Figure 3** presents the theoretical framework of land titling effects on urbanization population.

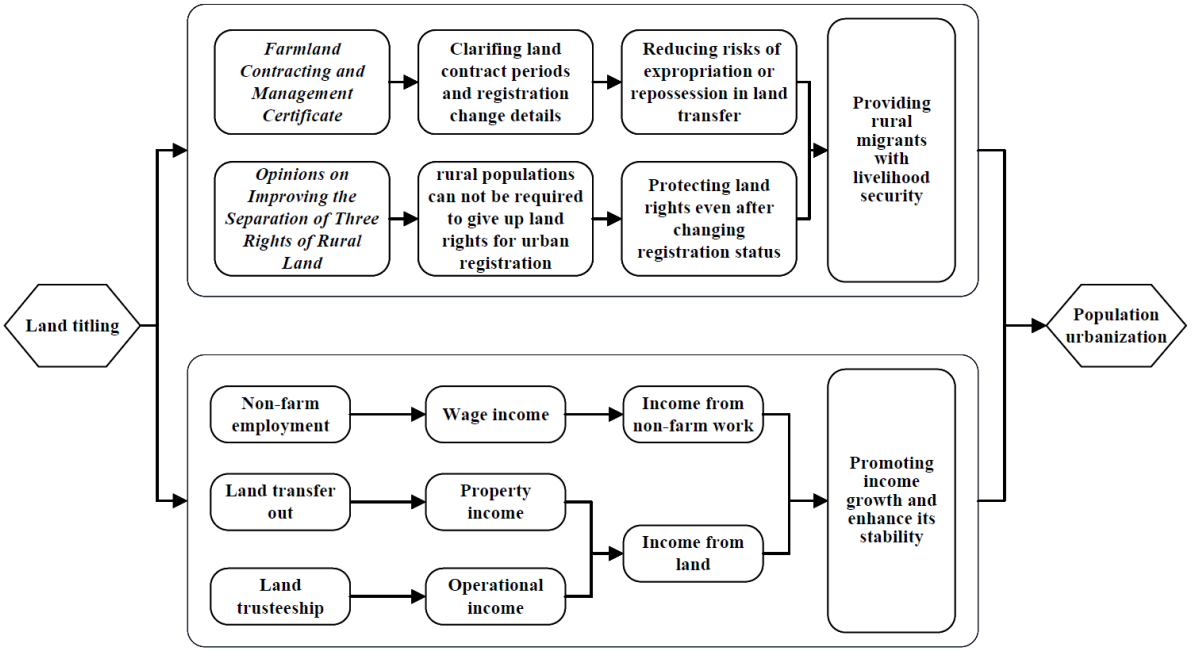

Figure 3. The framework of land titling effects on urbanization population.

Land titling has fundamentally altered this situation, though not without potential unintended consequences. On the positive side, land titling protects the farmland rights of rural migrants, ensuring they retain

a livelihood safety net even if they return to rural areas. Policy documents, such as the *Opinions on Improving the Separation of Ownership, Contracting Rights, and Management Rights of Rural Land*, explicitly state that rural populations should not be required to give up their contracting and management rights as a condition for obtaining urban household registration. This protection is reinforced by the Farmland Contracting and Management Certificate, which clarifies contract terms and facilitates farmland transfers, trusteeship, and mortgages while reducing risks of expropriation [30]. With this security, migrants can pursue urban opportunities without fear of irreversible loss of rural livelihood assets [26,31].

In addition, land titling promotes income growth and enhances its stability. By establishing a clear property rights protection mechanism, it enables rural populations to engage in farmland transfer and trusteeship, generating property income and improving operational efficiency [32]. Furthermore, secure land tenure allows rural laborers to take up long-term non-farm employment without concerns about farmland rights loss, contributing to stable wage income growth [31]. These diversified and sustainable income sources improve households' financial capacity to cover urban housing, education, and healthcare, thereby strengthening their willingness to change household registration from rural to urban.

However, land titling may also introduce potential negative effects. Strengthened land tenure security can increase the market value of rural land, potentially raising the cost of land acquisition for farming or housing. This may disadvantage poorer households who wish to expand landholdings or maintain affordable access to farmland. In addition, as land becomes a more marketable asset, there is a risk of land concentration in the hands of wealthier households or outside investors, which could exacerbate rural inequality and weaken livelihood security for vulnerable groups. In summary, while land titling has the potential to enhance livelihood security and income stability, thereby encouraging rural-to-urban migration, it may also produce adverse effects that offset some of these benefits for disadvantaged households. Based on this analysis, we propose the following hypothesis:

H1. *Land titling can promote population urbanization.*

H2. *Land titling contributes to population urbanization by strengthening livelihood security and increasing income and its stability.*

Economic development exerts a significant influence on the vitality of farmland markets. In economically advanced provinces, the farmland market tends to be more flourishing due to the active involvement of enterprises and cooperatives [33], as well as the widespread adoption of innovative land transfer mechanisms, such as farmland shareholding, trusteeship, and leaseback arrangements. This dynamic results in a more vibrant farmland transfer market in these regions [34]. According to official Chinese government statistics, in 2020, economically developed provinces such as Shanghai, Beijing, Jiangsu, and Zhejiang exhibited farmland transfer rates of 91.11%, 63.76%, 61.30%, and 60.17%, respectively. In contrast, economically less developed provinces like Gansu, Shanxi, and Yunnan recorded significantly lower rates of 17.49%, 15.28%, and 10.09%, respectively.

Moreover, non-farm employment opportunities are intricately linked to economic development. Developed regions typically exhibit a high demand for labor in secondary and tertiary industries, facilitating the migration of rural labor seeking non-farm employment [35]. Furthermore, enterprises in these regions offer higher wages and more comprehensive welfare packages, enhancing their appeal in the labor market [36]. Additionally, economically developed regions boast superior infrastructure and public services, including advanced education and medical facilities, which are particularly attractive to migrants. Consequently, the impact of land titling on population urbanization is more pronounced in developed regions compared to less developed ones. This analysis leads to Hypothesis 3.

H3. *The more the region economically developed, the stronger the impact of land titling on population urbanization.*

The impact of land titling on population urbanization varies significantly between major grain-producing areas and non-major grain-producing areas. In major grain-producing areas, favorable natural conditions and robust agricultural policy support mitigate the effects

of natural and market fluctuations on farming income. Rural populations often prioritize income stability over higher returns [37]. While non-agricultural activities like migrant labor or entrepreneurship may offer greater earnings, they are more vulnerable to market volatility, and rural individual have limited capacity to manage such risks [38]. The wage gap between non-agricultural and agricultural activities is partially offset by the advantages of grain-producing areas, leading rural populations there to prefer stable, lower-risk agricultural production. Consequently, they are less willing to transition to urban household registration.

Conversely, non-major grain-producing areas are more vulnerable due to unfavorable natural conditions and weaker policy support, rendering agricultural income less stable and reducing rural populations' reliance on agriculture [39,40]. The lower opportunity cost of non-farm employment in these areas incentivizes rural populations to pursue alternative livelihoods. When land titling clarifies ownership and enhances land transfer efficiency, rural populations in non-major grain-producing areas are more likely to abandon agriculture and migrate to cities in search of higher incomes and improved living conditions. Thus, the impact of land titling on population urbanization is more pronounced in non-major grain-producing areas. This analysis leads to Hypothesis 4.

H4. *Land titling has a stronger promotion on population urbanization in non-major grain-producing areas than in major grain-producing areas.*

3. Data, Variables and Methods

3.1. Data Sources

This study uses the panel data of 31 provinces in mainland China from 2006 to 2020. Hong Kong, Macao and Taiwan regions of China are not included in the study areas due to lack of data. The data are obtained from *China Statistical Yearbook (2007–2021)*, *China Population and Employment Statistical Yearbook (2007–2021)*, *China Urban and Rural Construction Statistical Yearbook (2016–2021)*. Specifically, GDP, farmland area, average price of housing, average wage of employees in urban work units, per capita social security expenditures, industrial structure, number of students in colleges, urban green space area, urban population density is from *China Statistical Yearbook (2007 to 2021)*. The data for calculating population urbanization rate are from *China Population and Employment Statistical Yearbook (2007–2021)* and *China Urban and Rural Construction Statistical Yearbook (2016–2021).* The data for calculating incidence of land disputes are from *Annual Statistical Report on Rural Management and Operation in China (2007–2017)* and *Annual Statistical Report on Rural Policies and Reforms in China (2018–2021)*. The number of urban employee medical insurance participants (NUEMIP) is from National Bureau of Statistics website. Climate Physical Risk Index (CPRI) is from the literature [41]. This study uses the linear interpolation method to fill in missing values. **Table 2** demonstrates the descriptive statistics of the variables.

Table 2. Descriptive statistics of variables.

Variable	Unit	Average Value	Standard Deviation	Maximum Value	Minimum Value
Population urbanization rate	%	0.401	0.172	0.891	0.141
Farmland area	kha	5219.972	3845.952	6547.010	3053.112
Average price of housing	¥/m^2	6507.120	5011.680	22,500.500	885.000
Average wage of employees in urban work units	¥	53,311.420	27,127.490	133,252.70	5241.300
Per capita social security expenditures	10000¥	0.150	0.100	0.500	0.100
Industrial structure	%	0.890	0.060	1.000	0.800
Number of students in colleges	Ten thousand	112.850	75.490	238.100	14.600
Urban green space area	Hectares	7.850	8.310	22.000	1.600
Urban population density	Thousands of people/km^2	0.500	0.250	0.800	0.300
Per capita GDP	10000¥	4.344	2.714	16.493	0.614
twoChildyn	Dimensionless quantity	0.333	0.472	1.000	0.000
Climate Physical Risk Index (CPRI)	Dimensionless quantity	45.184	8.222	84.341	25.807

Table 2. *Cont.*

Variable	Unit	Average Value	Standard Deviation	Maximum Value	Minimum Value
Incidence of land disputes	Num/transfer areas (10K mu)	19.614	24.762	251.955	0.625
Disposable income of rural residents	¥	10,365.660	5971.249	34,911.000	2097.000
NUEMIP	10k people	875.653	742.707	4678.100	16.500

3.2. Variable Selection

3.2.1. Dependent Variable

The dependent variable is *Registered Population Urbanization Rate*, which measures the proportion of registered urban residents (hukou holders) in the total population of a given region[42]. This indicator differs from the *Resident Population Urbanization Rate*, which is based on residence regardless of hukou status. The rationale for using *Registered Population Urbanization Rate* is that the objective of "new-type urbanization" in China is not limited to physical relocation, but to enabling rural migrants to settle permanently in urban areas and gain access to the full package of urban welfare benefits, including healthcare, education, and housing security. Many rural migrants who live in cities without hukou cannot access these institutional benefits and may remain in precarious living conditions. In contrast, hukou-based urbanization better reflects the institutional integration and long-term stability of migration, which are directly relevant to the policy effects of land titling examined in this study.

3.2.2. Core Independent Variable

The core independent variable is the interaction term *treat * post*. Thereinto, *treat* is a dummy variable used to construct the experimental group and control group, treat is set to 1 to indicate the province where land titling was implemented, and treat is set to 0 to indicate the province where the policy is not implemented. And *post* indicates whether the year is before or after the policy was implemented, *post* is set to 1 to indicate the year after implementing land titling, and post is set to 0 to indicate the year before implementing land titling.

3.2.3. Control Variables

Based on prior studies, control variables include: *Farmland area*, representing the farming areas of each region[43]; *Average price of housing*, representing the cost of buying a house in urban areas[44]; *Average wage of employees in urban work units*, representing the income of employees in urban areas[45]; *Per capita social security expenditures*, representing social security level in each region[46]; *Industry structure*, representing the output of secondary and tertiary industries divided by gross production[47]; *Number of students in college*, representing the number of students in colleges[48]; *Urban green space area*, representing the environment conditions of urban areas[49]; *Urban population density*, representing the ratio of urban population divided by urban area[50]. *Per capita GDP*, representing the average economic output per individual in a given region[44]; *Two-Child Policy*, a dummy variable measuring whether a region or household was subject to China's relaxed fertility restrictions (1 if applicable, 0 otherwise), captures demographic policy impacts; *Climate Physical Risk Index (CPRI)*, represents the possibility exposure to physical climate hazards (e.g., flooding, heatwaves) in a specific area, reflecting environmental vulnerability[41].

3.2.4. Mechanism Variables

According to the theoretical analysis mentioned above, the *Disposable income of rural residents* is used as a mediating variable to test how farmland tenure confirmation promotes urbanization by increasing rural populations' income. We select the *Incidence of land disputes* as another mediating variable to examine how farmland tenure confirmation promotes urbanization by providing livelihood security against counter-urbanization. Land disputes are often associated with ambiguities in, or violations of land rights. When land rights are stable, rural populations gain greater confidence in their land and are more inclined to view it as a livelihood safeguard[51]. Therefore, the incidence rate of land disputes reflects the extent to which land serves as a livelihood security measure. We calculate the incidence of land disputes using the formula: "Number of accepted land con-

tracting and transfer disputes/Transferred area." This indicator reflects the density of disputes per unit of transferred land area, providing a clearer picture of the disputes arising during the land transfer process.

3.3. Time-Varying DID Model

China's land titling policy has been promoted gradually nationwide. This study applies a time-varying DID model to estimate the impact of land titling on population urbanization [52]. Specifically, according to the year when the whole province promoted land titling, 2014, 2015, 2016, and 2017 are set as the policy time dummy variables, respectively. The time-varying DID model is used to examine the effect of land titling on population urbanization. Land titling is exogenously relative to urbanization, and thus there is no reverse causality between land titling and population urbanization. The time-varying DID model can eliminate the impact of omitted variables that do not vary over time on coefficient estimating, thus mitigating the problem of endogeneity caused by the bias of omitted variables. The benchmark regression model is as follows:

$$\begin{aligned} Urate_{it} &= \alpha + \beta treated_i \times post_{it} \\ &+ X_{it}\gamma + \nu_i + \nu_t + \varepsilon_{it} \end{aligned} \tag{1}$$

Where the dependent variable $Urate_{it}$ denotes the population urbanization rate of province i in year t. $post_{it}$ and $treated_i$ denotes the time and policy dummy variables respectively. If the year is before the implementation of land titling, then $post_{it} = 0$. If the year is after the implementation of land titling, then $post_{it} = 1$. In addition, $treated_i = 0$ denotes that the province i belongs to the control group, and $treated_i = 1$ denotes that the province i belongs to the experimental group. Besides, α denotes constant term, β denotes the coefficient of $treated_i \times post_{it}$, γ denotes the coefficients of control variables, X_{it}. ν_i and ν_t denote individual fixed effects and time fixed effects respectively, ε_{it} represents error term.

The application of time-varying DID model relies on the establishment of the parallel trend assumption, and the population urbanization rate trend between treatment group and control group must be parallel before land titling. In this study, the parallel trend test of time-varying DID model is implemented using the Event Study Model (ESM), which is as follows:

$$\begin{aligned} Urate_{it} &= \alpha + \sum\nolimits_{\tau=-6,\tau\neq-1}^{\tau=+4} \beta_\tau D_{it}^{\tau} \\ &+ X_{it}\gamma + \nu_i + \nu_t + \varepsilon_{it} \end{aligned} \tag{2}$$

Where $Urate_{it}$ is population urbanization rate for province i in year t and serves as the dependent variable. Event study indicators is the interaction term $post_{it} * treated_i$, and if land titling was implemented for the t th year targeting province i, $D_{it} = 1$. This study includes individual dummies for each of the first four years in which a province implements land titling within an episode (t_1 to t_4 and t_{-6} to t_{-1}) and it summarizes D_{it} after the four years in one dummy variable ($\tau = +4$) and before the six years in a dummy variable ($\tau = -6$). Then X_{it} denotes control variables and α denotes constant terms. Individual and time fixed effects are denoted by v_i and v_t respectively, and the error term is denoted by ε_{it}. Besides, β_τ denotes the coefficient of D_{it}, reflecting the difference in time trend between experimental group and control group. And γ denotes the coefficients of X_{it}.

The traditional stepwise method for testing mediation effects has issues such as confounding variable effects. A more reasonable approach to mechanism testing is to propose several mediating variables (M) whose causal relationship with the dependent variable (Y) has already been validated by existing literature. As a result, it is unnecessary to formally apply causal inference methods to examine the causal link from M to Y. Instead, the focus is placed solely on examining the effect of core independent variable (D) on M, thereby avoiding the need to formally distinguish whether there remains any unexplained direct effect beyond the indirect effect [53]. We conduct mechanism testing by combining Equation (1) and Equation (3). As the effects of mechanism variables on population urbanization has been widely proved [54–56], we identify the causal relationship between the core explanatory variable and the mechanism variables to test how land titling affects the urbanization population. the Equation (3) for testing the mechanism of land titling promote M is set as follows:

$$M_{it} = \alpha + \beta D_{it} + X_{it}\gamma + \nu_i + \nu_t + \varepsilon_{it} \tag{3}$$

Where M_{it} denotes the mediation variables of province i in year t. The variable D_{it} denotes the interaction term $post_{it} * treated_i$, X_{it} denotes control variables, α denotes constant term, and β denotes the coefficient of D_{it}, reflecting the difference in time trend between the experimental group and control group. Then γ denotes the coefficients of X_{it}, v_i and v_t denote individual fixed effects and time fixed effects respectively, ε_{it} denote error term.

4. Results

4.1. Parallel Trend Test

Figure 4 presents the dynamic treatment effects estimated using the heterogeneous treatment-timing event-study approach [57]. The horizontal axis denotes relative time (event time) in years, where zero represents the treatment year for each treated unit, negative values indicate years prior to treatment, and positive values indicate years after treatment. The vertical axis shows the estimated coefficients relative to the omitted reference period (here, the year immediately prior to treatment, k = − 1). Vertical bars represent 95% confidence intervals clustered at the unit level. The coefficients for the pre-treatment periods (k ≤ − 2) are small in magnitude and statistically indistinguishable from zero, suggesting no evidence of significant pre-treatment trends. This supports the validity of the parallel-trends assumption. From the treatment year (k = 0) onward, the point estimates gradually increase and become positive, with the largest effects observed in later post-treatment years (k ≥ 3), although some estimates have wide confidence intervals. This pattern indicates that the treatment is associated with a gradual and sustained positive impact on the urbanization rate over time. The widening confidence intervals in the longer post-treatment horizon likely reflect fewer observations contributing to those estimates, a common feature in staggered-adoption designs. Overall, the results indicate that the land titling policy's positive influence materialized shortly after implementation, growing in magnitude in the subsequent years.

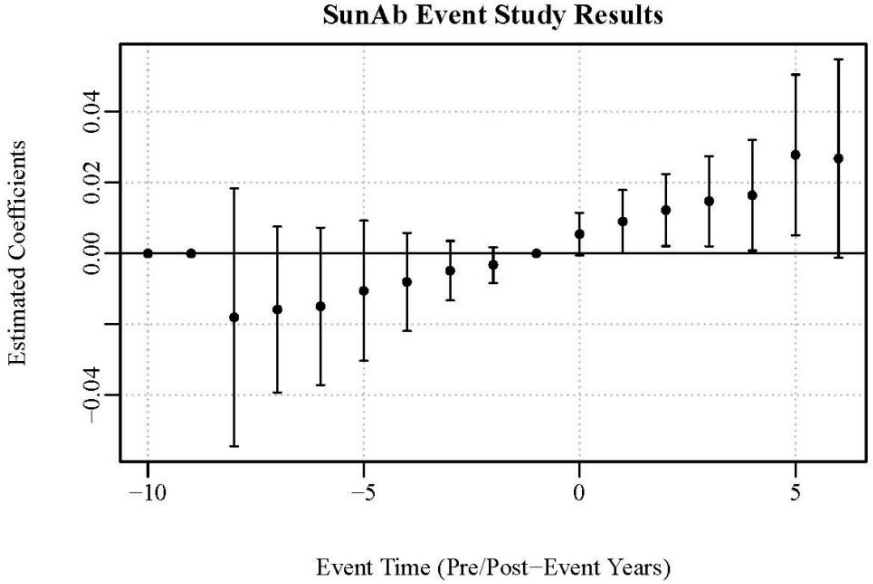

Figure 4. Event study test results.

Note: Values less than 0 on the horizontal coordinate denote the year before land titling, values greater than 0 denote the year after land titling, and values equal to 0 denote the year when land titling was implemented.

4.2. Empirical Results

According to Equation (1), this study evaluates the impact of land titling on population urbanization, the benchmark regression results are summarized in **Table 3**. All regressions control for individual fixed effects and time fixed effects to account for unobserved heterogeneity across individuals and temporal trends. Column 1 shows the results free from the effects of any control variables, which indicates that land titling has a significant

positive effect on population urbanization. Columns 2~4 sequentially incorporate control variables to account for additional determinants of urbanization. The coefficient of *did* is significant in all regressions at a 10% level, more specifically, in Column 4, which includes the full set of control variables, the coefficient of *did* suggests that land titling increases the population urbanization rate by 1.8%. This result is consistent with the study's hypothesis that secure land tenure facilitates population urbanization by providing rural migrants with greater incentives and confidence to register in urban areas. The stability and significance of the coefficients across different model specifications reinforce the credibility of this finding. Therefore, the results show the importance of secure land tenure in reducing barriers to urban registration for rural migrants. Land titling may address concerns about property rights and provide a sense of stability, enabling migrants to shift their residency to urban areas more confidently. It should be noted that broader external factors, such as the economic disruptions caused by the demographic changes following the two-child policy, and climate change-induced shifts in agricultural livelihoods, may also influence rural-urban migration patterns. While these factors are beyond the scope of our empirical estimation, their potential impact is acknowledged as part of the wider context in which land titling operates.

Table 3. The effect of land titling on population urbanization.

Variable	(1)	(2)	(3)	(4)
	Population Urbanization Rate	Population Urbanization Rate	Population Urbanization Rate	Population Urbanization Rate
did	0.025*	0.014*	0.016**	0.018***
	(0.013)	(0.008)	(0.008)	(0.006)
ln Farmland area		0.094***	0.076***	0.068***
		(0.019)	(0.017)	(0.012)
ln Average price of housing		0.015	0.033*	0.027
		(0.021)	(0.018)	(0.019)
ln Average wage of employees in urban work units		0.063*	0.032	−0.011
		(0.035)	(0.039)	(0.037)
ln Per capita social security expenditures		0.014	0.012	0.008
		(0.017)	(0.015)	(0.013)
Industrial structure			0.019	−0.047
			(0.136)	(0.135)
ln Number of students in colleges			0.057***	0.044**
			(0.017)	(0.021)
ln Urban green space area				0.010
				(0.006)
ln Urban population density				0.010
				(0.008)
Per capita GDP				0.071*
				(0.036)
twoChildyn				0.005
				(0.043)
CPRI				0.000
				(0.000)
Constant	0.463***	−1.000**	−0.937**	−0.364
	(0.006)	(0.379)	(0.444)	(0.378)
Individual FEs	Y	Y	Y	Y
Time FEs	Y	Y	Y	Y
N	465	434	434	402
R^2	0.856	0.892	0.900	0.905

Note: Numbers in parentheses denote robust standard errors, *, ** and *** represent that coefficient is significant at the 10%, 5% and 1% levels, respectively, as below. Y denotes that fixed effects are controlled.

4.3. Placebo Test

To assess whether the observed increase in the population urbanization rate could be attributed to factors other than land titling, this study conducts a placebo test following the approach referring to literature[58]. In this procedure, the treatment and control groups are randomly assigned rather than based on the actual implementation of land titling. Specifically, 1,000 random samplings are performed, each time designating a randomly selected subset of provinces as the treatment group and the remaining provinces as the control group, and then estimating the baseline regression model for all provinces. The kernel density distribution of the estimated coefficients' *t*-values is presented in **Figure 5**. The results indicate that the absolute values of nearly all *t*-statistics from the random sampling are less than 0.018, suggesting no statistically significant effect in these placebo regressions. This finding supports the conclusion that unobserved factors are unlikely to have materially biased the estimated impact of land titling on population urbanization.

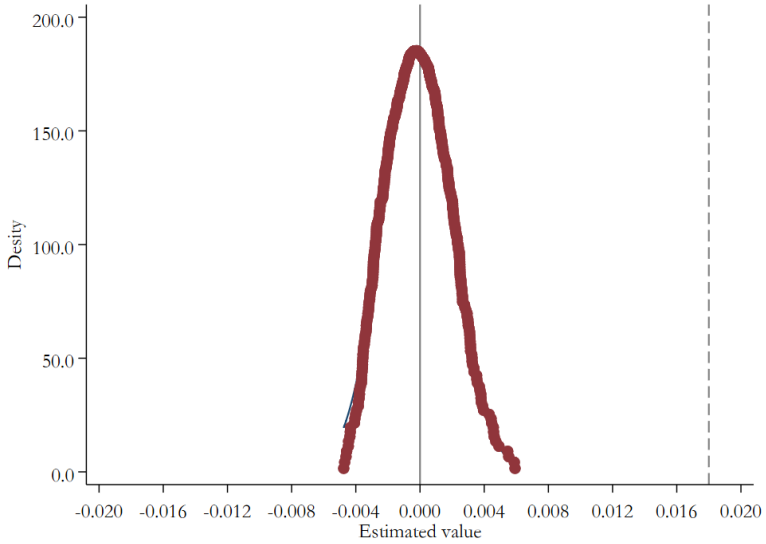

Figure 5. Placebo test result.

4.4. Robustness Tests

Table 4 presents the robustness test results. *Mitigating sequence-related issues.* While the time-varying DID approach can effectively capture policy effects in the presence of multiple shock events, it may suffer from potential serial correlation. To address this concern, we adopt a two-period DID framework to mitigate such risks. Specifically, the sample is divided into two subperiods using the year of the first pilot implementation as the cut-off. Column (1) reports the benchmark regression results, whereas Column (2) presents the estimates after addressing the sequence-related issue. The results confirm that the positive impact of land titling on population urbanization remains robust.

Table 4. Robustness test results.

Variable	(1)	(2)	(3)	(4)	(5)
	Population Urbanization Rate	Population Urbanization Rate	Population Urbanization Rate	Population Urbanization Rate	Ln Nuemip
did	0.018***	0.016**	0.012**	0.015***	0.095**
	(0.006)	(0.004)	(0.004)	(0.008)	(0.041)
Control variables	Y	Y	Y	Y	Y
Province FE	Y	Y	Y	Y	Y
Year FE	Y	Y	Y	Y	Y
Observations	341	402	341	402	402
R^2	0.905	0.687	0.900	0.655	0.864

Note: Numbers in parentheses denote robust standard errors, *, ** and *** represent that coefficient is significant at the 10%, 5% and 1% levels, respectively, as below. Y denotes that fixed effects are controlled.

Controlling for the Influence of Alternative Policies. In 2014, the State Council issued the *Opinions on Further Promoting the Reform of the Household Registration System*, which removed barriers to rural-to-urban migration and likely contributed to population urbanization. To rule out the confounding effects of this reform, we explicitly control for the household registration reform in the benchmark model. A comparison between Column (3) and Column (1) shows that controlling for this reform slightly attenuates the estimated effect of land titling, yet the coefficient remains positive and statistically significant, suggesting that the benchmark results are not driven by this concurrent policy.

Adopting an Alternative Estimation Strategy. To further validate the benchmark estimates, we employ a propensity score matching combined with DID (PSM-DID) approach. This method mitigates potential bias arising from differences in observable characteristics between treatment and control groups. The results demonstrate that land titling still exerts a significant positive influence on population urbanization, reinforcing the robustness of the benchmark findings.

Using an Alternative Dependent Variable. We further test robustness by replacing the dependent variable with the logarithm of the number of urban employee medical insurance participants (ln NUEMIP). As urban employee medical insurance primarily covers individuals with urban household registration, rural migrants who settle in cities and secure stable non-agricultural employment are more likely to enroll in this program to reduce healthcare costs. Thus, NUEMIP serves as a proxy for population urbanization. Column (5) shows that DID has a significant positive effect on ln NUEMIP, providing additional support for the robustness of the baseline estimates.

4.5. Influence Mechanism Analysis

Studies have demonstrated the positive effects of strengthened livelihood security and increased income on population urbanization [54–56]. **Table 5** presents the mechanism test results. We use the *Incidence of land disputes* and *ln Disposable income of rural residents* as mechanism variables representing livelihood security and income, respectively. Land disputes typically arise from controversies, ambiguities, or violations of land rights. When land rights are secure, rural populations gain confidence in using their land as a stable livelihood asset [49,59]. Thus, the incidence of land disputes reflects the role of land as a livelihood security mechanism. As reported in Column (1), *did* has a positive effect on *Population urbanization rate* at the 5% significance level, and the results in Column (2) shows that *did* has a significant negative effect on *Incidence of land disputes* at the 5% level, indicating that land titling enhanced livelihood security. This supports the hypothesis that secure land tenure strengthens livelihood security, boosting rural migrants' confidence to settle in urban areas. Column (3) shows that *did* has a significant positive effect on *ln Disposable income of rural residents* at the 1% level, indicating that land titling promotes higher income, consistent with evidence that tenure security lowers conflict and promotes investment and earnings [60]. This aligns with the hypothesis that secure land tenure raises income, enabling rural migrants to afford urban living costs. In conclusion, these findings demonstrate that land titling promotes population urbanization by enhancing livelihood security and increasing income.

Table 5. Influence mechanism test results.

Variable	(1)	(2)	(3)
	Population Urbanization Rate	Incidence Of Land Disputes	Ln Disposable Income Of Rural Residents
did	0.018***	– 4.688**	0.037***
	(0.006)	(1.634)	(0.011)
Control variables	Y	Y	Y
Provinces FE	Y	Y	Y
Year FE	Y	Y	Y
N	402	389	402
R^2	0.905	0.605	0.990

Note: Numbers in parentheses denote robust standard errors, *, ** and *** represent that coefficient is significant at the 10%, 5% and 1% levels, respectively, as below. Y denotes that fixed effects are controlled.

4.6. Heterogeneity Analysis

This study investigates the heterogeneous effects of land titling on population urbanization across regions with different levels of economic development in China. Following the classification of the National Bureau of Statistics, provinces are grouped into eastern, central, and western regions. **Figure 6** presents three regions with different economic development levels in China. The regression results in **Table 6** (columns 1–3) indicate that land titling significantly promotes population urbanization in all three regions. However, the magnitude of the effect varies, being strongest in the eastern region, moderate in the central region, and weakest in the western region. This finding aligns with Hypothesis 3, which posits that the influence of land titling on urbanization strengthens with economic development. Two main factors explain this pattern. First, economically advanced provinces exhibit more dynamic farmland markets, characterized by greater participation from enterprises and cooperatives and the widespread adoption of innovative land transfer mechanisms. These vibrant markets facilitate smoother land transactions, enabling rural residents to transition more easily to urban areas. Second, developed regions possess more abundant non-agricultural employment opportunities due to the strength of their secondary and tertiary industries, which generate higher labor demand. Enterprises in these regions tend to offer better wages and welfare benefits, further enhancing their attractiveness to rural migrants. Additionally, superior infrastructure and public services, such as advanced education and healthcare systems, strengthen the pull factors for migration. In contrast, less developed regions, such as those in western China, are constrained by underdeveloped farmland markets, limited off-farm employment opportunities, and weaker infrastructure and public services. These limitations dampen the capacity of land titling to stimulate population urbanization, resulting in the observed regional disparities.

Figure 6. Three regions with different economic development levels in China.
Map Source: Based on the standard map service website of the Ministry of Natural Resource with the approval number GS (2020) 4619, and the boundary of the base map has not been modified.

To further examine the heterogeneous impacts of land titling on population urbanization, provinces are classified into major and non-major grain-producing areas. **Figure 7** presents non-major grain-producing areas and major grain-producing areas in China. Major grain-producing areas play a vital role in safeguarding national food security and receive substantial policy support from the government to sustain agricultural production. The

regression results in columns (4) and (5) of **Table 6** indicate that land titling significantly promotes population urbanization in both categories. However, the estimated effect is larger in non-major grain-producing areas than in major grain-producing areas. Specifically, the coefficient for land titling in non-major grain-producing areas is 0.023 and statistically significant at the 5% level, whereas the corresponding coefficient for major grain-producing areas is 0.016 and significant at the 1% level. This suggests that land titling exerts a stronger influence on urbanization in regions where agricultural production is less dominant. This divergence can be explained by differences in opportunity costs associated with remaining in agriculture. In major grain-producing areas, favorable natural endowments combined with strong policy incentives, such as subsidies and guaranteed purchase programs, make agricultural production more profitable and stable, thereby reducing rural residents' motivation to exit farming. As a result, even with improved tenure security from land titling, the incentive to transition into urban employment is relatively weaker. By contrast, non-major grain-producing areas lack comparable policy support and natural advantages, making agricultural livelihoods less attractive. In these regions, land titling mitigates uncertainty over land use rights, enabling rural households to lease out their farmland and pursue more lucrative non-agricultural employment opportunities in urban areas with greater confidence.

Figure 7. Non-major grain-producing areas and major grain-producing areas in China.
Map Source: Based on the standard map service website of the Ministry of Natural Resource with the approval number GS (2020) 4619, and the boundary of the base map has not been modified.

Table 6. Heterogeneity test results.

Variable	(1)	(2)	(3)	(4)	(5)
	Eastern China	Central China	Western China	Major Grain-Producing Areas	Non-Major Grain-Producing Areas
did	0.017* (0.009)	0.011** (0.004)	0.008** (0.003)	0.016*** (0.003)	0.023** (0.010)
Control variables	Y	Y	Y	Y	Y
Province FE	Y	Y	Y	Y	Y
Year FE	Y	Y	Y	Y	Y
N	132	112	144	195	270
R^2	0.565	0.950	0.974	0.957	0.844

Note: Numbers in parentheses denote robust standard errors, *, ** and *** represent that coefficient is significant at the 10%, 5% and 1% levels, respectively, as below. Y denotes that fixed effects are controlled.

4.7. Spillover Effects Test

The regression results in **Table 7** examine the impact of land titling on urbanization, accounting for potential spatial spillover effects across neighboring provinces [61]. The coefficient for did is positive and statistically significant at the 1% level, indicating that provinces implementing land titling experienced a significant increase in urbanization rates relative to those without titling. Importantly, the coefficient for the spatial spillover variable (spill_did) is also positive and significant at the 5% level, suggesting that land titling in neighboring provinces contributes positively to a province's urbanization, reflecting the presence of meaningful cross-province spillover effects.

Table 7. Spillover effects test results.

Variable	(1)
	Population Urbanization Rate
did	0.019***
	(0.007)
spill_did	0.016**
	(0.007)
Control variables	Y
Province FE	Y
Year FE	Y
N	402
R^2	0.902

Note: Numbers in parentheses denote robust standard errors, *, ** and *** represent that coefficient is significant at the 10%, 5% and 1% levels, respectively, as below. Y denotes that fixed effects are controlled.

5. Conclusions, Implications, Limitations, and Future Research

The unbalanced development of urban and rural areas has become a bottleneck restricting China's economic development [62]. Promoting population urbanization is an effective way to alleviate the problem [63]. Different from prior studies exploring factors that influence population inflow to urban areas, this study tries to explore factors that break down the restrictions on rural population outflow from rural areas. Specially, this study empirically examines the impact of land titling on population urbanization by a time-varying DID model using 15-year panel data covering 31 provinces in China.

This study provides robust empirical evidence that land titling significantly promotes population urbanization, primarily by enhancing livelihood security and increasing both the level and stability of rural incomes. These findings align with the established literature that underscores secure land tenure as a critical factor incentivizing rural households to engage in off-farm employment and migration [64,65]. Moreover, the observed regional heterogeneity, whereby the impact of land titling strengthens progressively from western to eastern China, corroborates previous research demonstrating that the effectiveness of land rights reforms is closely tied to regional economic development and market maturity [66]. The relatively weaker effect in major grain-producing areas supports the notion that favorable agriculture conditions and targeted agricultural support policies can reduce rural populations' incentives to abandon farming. This nuance contributes to a more refined understanding of how place-based factors mediate land policy outcomes.

However, despite these positive effects, the implementation of land titling policies may also produce unintended negative consequences that warrant careful consideration. Existing studies suggest that formalizing land rights can sometimes exacerbate rural inequality by facilitating land consolidation among wealthier households while marginalizing smallholders and vulnerable groups [67,68]. Furthermore, as land titling accelerates population urbanization, there is a risk that rural migrants may face urban marginalization due to inadequate access to social services and stable employment opportunities in cities [69]. These challenges highlight the complexity of land reform impacts and underscore the importance of complementary policies aimed at protecting disadvantaged populations and promoting inclusive urban integration. Future research should thus

investigate the socio-economic heterogeneity of land titling effects and design safeguards to mitigate potential inequalities, ensuring that land reforms contribute to sustainable and equitable rural-urban transitions.

Based on the conclusions presented earlier, the policy implications derived from this paper can be summarized as follows: Firstly, in economically developed eastern regions, county-level land rights adjustment committees should be established to regularly review disputes, publish clear adjustment rules, and mediate conflicts, with compensation calculated using market-based valuation methods and disbursed via secure payment platforms to ensure transparency; in less developed central and western regions, periodic land rights verification campaigns and free legal aid services should be provided to protect farmers' contract rights. Secondly, standardized land transfer platforms should be integrated with existing e-government systems to disclose transaction prices, provide legal contract templates, and offer offline kiosks or mobile service in areas with poor infrastructure; all transfers should be notarized, and fraudulent transactions penalized. In major grain-producing areas, land trusteeship cooperatives should be set up to pool land for professional management, share profits with absentee owners, and receive initial government subsidies. Finally, land titling should be linked to tailored non-agricultural employment support: in the east, expand public-private vocational training partnerships in high-demand industries and offer housing and childcare subsidies for skilled migrants; in central and western regions, strengthen county-level employment information centers, regularly publish job vacancy data, and design region-specific training programs to match urban labor demand.

The main contributions of this study are as follows: First, it shifts the analytical focus of population urbanization research from the widely studied pull factors, such as industrial upgrading, housing security, and public service provision [22,70], to the push-side institutional barriers that restrict rural out-migration. In particular, it examines how land titling reforms address the long-standing constraint of insecure farmland rights, an aspect that remains underexplored in both the Chinese and international migration literature. By doing so, the study provides new insights into how tenure security in agrarian economies can facilitate labor mobility, offering policy relevance beyond China to other developing countries facing similar rural land tenure issues. Second, methodologically, it advances the evaluation of land reform effects by adopting a time-varying difference-in-differences (DID) framework, rather than the conventional binary DID models commonly used in this field [71,72]. This approach leverages the staggered rollout of land titling across regions to capture dynamic and heterogeneous treatment effects, thereby producing more precise and credible estimates of policy impacts. The methodological contribution has broader applicability for assessing gradual policy implementations in other institutional contexts worldwide.

This study acknowledges certain limitations that may affect the robustness of our findings. On the one hand, the timing and effectiveness of the policy's implementation varied not only across provinces but also within smaller administrative units such as counties, towns, and villages. As a result, evaluating the policy's effects at the provincial level may not fully capture the heterogeneity in its rollout and impact, the lack of granular data restricts our ability to conduct detailed empirical analyses and fully capture the localized and time-sensitive heterogeneous effects of the policy. On the other hand, the potential impact of county-to-district reclassification on household registration urbanization rates. Nevertheless, this impact is expected to be minimal due to the relatively small scale and regional concentration of such adjustments. At the same time, it is important to note that the policy was implemented on a province-wide scale across 28 pilot provinces in three batches during 2014, 2015, 2016 and 2017. This province-wide implementation helps address some challenges related to administrative division adjustments, as it ensured that all prefectures and counties within a given province adopted and implemented the policy simultaneously, providing consistency in its application. Future research could address these limitations by utilizing more disaggregated data, such as county-level household registration urbanization statistics, to better capture the nuances of administrative adjustments and their implications for urbanization trends. This would enable

a more precise evaluation of the policy's effects and its heterogeneity across different regions and time periods.

Author Contributions

C.J.: Conceptualization, Methodology, Writing — original draft, Software, Writing—review & editing. L.Z.: Conceptualization, Methodology, Writing—original draft, Writing—review & editing, Validation. S.Y.: Methodology, Writing—review & editing, Validation. J.R.-M.: Writing—review & editing. All authors have read and agreed to the published version of the manuscript.

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Informed Consent Statement

Informed consent was obtained from all individual participants included in the study.

Data Availability Statement

Data will be made available on request.

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Conflicts of Interest

The authors declare no conflict of interest.

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