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Urbanization in Dynamics: The Influence of Land Quota Trading on Land and Population Urbanization

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Abstract: Establishing a unified urban–rural construction land market, facilitating factors flow within urban and rural areas, and promoting people-centered new urbanization are important strategies for China to achieve high-quality development in the new era. The land quota trading (LQT) system in Chongqing is an essential policy practice. This study analyzes the impact mechanism of the LQT policy on land and population urbanization through the lens of urban spatial expansion, population migration, and human–land coordination. Using the time-varying DID model and examining from both sending and receiving areas' perspectives, we assesses the impact of the LQT policy on the land urbanization, population urbanization, and urbanization coordination of Chongqing's 38 districts and counties since 2009. We also analyzes the spatial heterogeneity of the policy. The results indicate the following: (1) The implementation of the LQT policy has a significant positive effect on land urbanization, population urbanization, and urbanization coordination. (2) The impact of the LQT policy shows spatial heterogeneity; its influence on pure receiving areas' land and population urbanization is more substantial, reflecting the further concentration of land and population elements towards the urban center due to the LQT policy. (3) At the county level, the implementation of the LQT policy only significantly affects population urbanization, with no notable impact on land urbanization, which indicates that the LQT is an import practice to realize policies of the linkage of increase and decrease of construction land, and the citizenization of farmers.

Keywords: urbanization; urbanization coordination degree; time-varying DID

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1. Introduction

Since the beginning of the reform and opening-up policy, China has achieved significant progress in urbanization. From 1978 to 2022, the urbanization rate of the permanent resident population in China increased from 17.6% to 65.2% [1]. As China's urbanization transitioned from a high-speed development phase to a high-quality development phase, the issue of coordinating land urbanization and population urbanization has received increasing attention. In the past, the dual land system, low land acquisition costs, and the dual household registration system were important reasons for the faster pace of land urbanization in China compared to population urbanization [2]. The Third Plenary Session of the 18th Central Committee of the Communist Party of China proposed the establishment of a unified construction land market for both urban and rural areas. Under the premise of compliance with spatial planning and land use regulations, it allows for the transfer, leasing, and equity participation of rural collective construction land, implementing equal access to the market and equal rights and prices as state-owned land. The 20th National Congress of the Communist Party of China further emphasized the need to promote integrated urban–rural development and facilitate the flow of urban and rural economic resources. It emphasizes a new urbanization strategy centered around people and accelerating the rate of population urbanization.

The LQT policy in China originated from the implementation of exchanging newly added cropland quotas with land for construction, which aimed to protecting arable land. In 2004, the

amendment of the Law of Land Administration of the People's Republic of China fostered the system of compensations to cultivated land to be occupied. Subsequently, a series of policies were implemented to encourage the consolidation of rural construction land and testing of linking up increased land use for urban development with decreased rural, non-agricultural land use. In 2007, in order to address the imbalance in urban and rural development, the State Council approved Chengdu and Chongqing to be National Comprehensive Coordinated Reform Experiment Districts of Urban and Rural Unified Planning. In 2008, the Chongqing Country Land Exchange launched, marking the beginning of the LQT policy.

As part of comprehensive reform in Chongqing, the LQT system is closely linked with the reform of the household registration (hukou) system, making this policy intrinsically connected to both land urbanization and population urbanization. Concurrently, the coordinated development of population urbanization and land urbanization represents a critical issue for sustainable urban development. Based on these considerations, the primary question of this study is whether LQT policy can promote the aggregation of land and population factors, facilitating the coordinated development of land urbanization and population urbanization. To investigate this, we build a theoretical framework to explain the influence of LQT policies on land urbanization, population urbanization, as well as the urbanization coordination of land and population. Then, we employ a time-varying DID (Difference-in-Differences) approach to empirically examine the effect.

Chongqing, located in the southwestern part of China, consists of 26 districts and 12 counties, covering an area of 82,400 square kilometers, making it the largest directly administered municipality in China. Despite its vast size, a significant portion of Chongqing's land is unsuitable for cultivation, with mountainous terrain accounting for 76% of the total area and hilly terrain occupying 22%. Only a meager 2% of the land is flat and suitable for urban development and agriculture. In 2007, the total population of Chongqing was 28.16 million. Its rural residents accounted for 51.7%, close to the average level in the nation of 54.0% [1]. In 2007, the per capita disposable income for urban residents in Chongqing was 11,758 RMB, whereas for rural inhabitants it stood at 3560 RMB [1].

Chongqing is a unique example of an urban–rural interface, playing a pivotal role in the country's urbanization process [3]. The LQT is designed to address the challenges of rapid utilization, including the balance of cultivated land protection and construction land for urban development [4] and the fair participation of landless farmers [5]. Similar challenges are faced by other developing countries, such as India and various African nations [6,7]. Consequently, Chongqing's experience offers valuable insights for other regions in China and holds significant representational relevance on a global scale.

The marginal contributions of the study are twofold: In terms of theoretical innovation, a micro-level approach is undertaken to analyze the driving mechanisms of urbanization, together with the impact of the LQT policy on land and population urbanization. As for the empirical test, utilizing data from multiple sources, we conduct a comparative effects evaluation of LQT policy from various perspectives of sending and receiving areas as well as regions with different locations. These explorations may contribute to a more comprehensive understanding of the LQT policy.

The following sections are organized as follows: The second section reviews existing research on urbanization and the LQT policy. The third section analyses the mechanisms of the LQT policy on urbanization. The fourth section outlines materials and methods, including the econometric models, variable selection, and data source. The fifth section presents empirical results, including basic statistical descriptions, parallel trend tests, baseline regression, placebo tests, robustness checks, and heterogeneity analysis. The last section consists of discussions and conclusions.

2. Literature Review

2.1. Urbanization

2.1.1. Land Urbanization

Urbanization is a complex process that covers a wide range of topics, of which population and land urbanization are important aspects [8]. Land urbanization refers to the

process of transforming land conditions from rural to urban forms [9]. Previous research suggests that population agglomeration, economic growth, and land financing are import factors driving land urbanization [10,11]. Urban population agglomeration requires improvements in urban infrastructure such as housing, transportation, green spaces, education, and healthcare facilities [12]. Economic growth boosts the need for production, logistics, warehousing, and transportation, thereby generating more jobs [13]. These dynamics collectively contribute to a heightened demand for urban construction land, leading to an increasing level of land urbanization. In China, land finance is an import approach for local government to generate revenue to support public spending. Local government is eager to exploit the land and obtain land lease fee as an important part of the local budgetary revenue, so as to drive a fast speed of land urbanization [14].

2.1.2. Population Urbanization

Population urbanization is the process whereby rural people migrate to cities to live, work, and integrate into cities [15]. During the process, their occupations change from the agricultural section to industry and service sections; their identities and social welfare may change as well in China [9]. Population urbanization has the potential to enhance the living standards and consumption levels of rural populations, while also ensuring access to essential infrastructure and social public services [16]. Research on population urbanization primarily concentrates on areas of spatial distribution, influencing factors, and effects of land-use policies [16,17]. According to theories of population migration, income differences between urban and rural areas, unemployment rates in urban areas, and labor surpluses in the traditional agricultural sector are the general factors influencing rural–urban migration [18,19]. Low-origin income, unequal distribution of land, surplus labor in rural areas, and education years are also strongly associated with rural–urban migration [20,21]. In China, the rural residents were discouraged by the household registration system (hukou) for permanent rural–urban migration [22]. The relaxation of the hukou system began with the implementation of the New Urbanization Plan in 2014. The New Urbanization Plan's objective is to bridge the rural–urban divide by providing new rural–urban migrants with urban hukou and access to basic urban services and welfare [23,24]. These reforms may facilitate a freer flow of rural–urban migration.

2.1.3. Coordination Urbanization

Coordination refers to the elements' interaction within systems [25]. Land and population are subsystems of urbanization [15], which reflects the interaction between human activities and the natural geographical environment. With the land nature changing from rural collective land to urban construction land via land acquisition, the original villagers transit from rural residents to urban residents [15]. The population flow to towns increases the demand for construction land, driving the expansion of cities [11]. At the same time, land provides spaces and constraints for urban populations and industrial development [8].

Since 1990, China has experienced rapid land urbanization development and lagging population urbanization, resulting in a lack of coordination between land and population urbanization [26,27]. There are two main reasons for this lack of coordination. Firstly, the land acquisition system in China compensates land-lost peasants with a relatively low price in the process of land conversion from farm to construction land [28]. The lucrative local government and fast urban sprawl drive land urbanization with a fast speed [29]. Secondly, local governments may have insufficient motivation to provide employment opportunities and social welfare [30], which reduces the expected income of rural labor migrating to cities and diminishes their incentive to move.

The uncoordinated development of land urbanization and population urbanization can lead to significant economic challenges, including a distorted economic structure and inefficient land use [31]. Furthermore, it may also cause social problems, such as urban spatial expansion, unequal allocation of public interests, and uneven regional growth [32]. Additionally, the environmental repercussions are profound, including the loss of agricultural

lands and an overburdened environment [33]. The existing literature shows that institutional factors are among the reasons for uncoordinated development of land urbanization and population urbanization. The hukou system [34,35], land financialization [31,36], and local government competition [37,38] obstruct population urbanization, leading to uncoordinated development of land and population urbanization. Market-based reforms in land to non-agricultural transformation and safeguarding the development rights of land requisitioned farmers are important avenues to enhance the coordination between land and population urbanization [39,40]. However, there is limited literature that empirically analyzes the impact of land system reforms on population urbanization, land urbanization, and their coordination.

2.2. Land Quotas Trading

2.2.1. Program Design of LQT

The LQT system, based on "Chongqing Municipal Regulations on Land Quotas", has three main stages: generation, transaction, and utilization, as illustrated in Figure 1. In the generation stage, rural organizations or households apply to the county-level land department to convert unused, rural, collective-owned land types into cultivated land, woodland, and grassland. After inspections, a portion of land is set aside for farmers' needs, and the rest is issued to users by the municipal land department. In the transaction stage, rural entities trade land quotas through the Chongqing Rural Land Exchange. Land quotas are sold to users, typically property developers, via listings or auctions. In the utilization stage, the land quota recipient gains the right to use specific land through an "invitation, listing, and bidding" process aligned with land use plans. They use this land quota alongside construction land in the same area to achieve the intended land use.

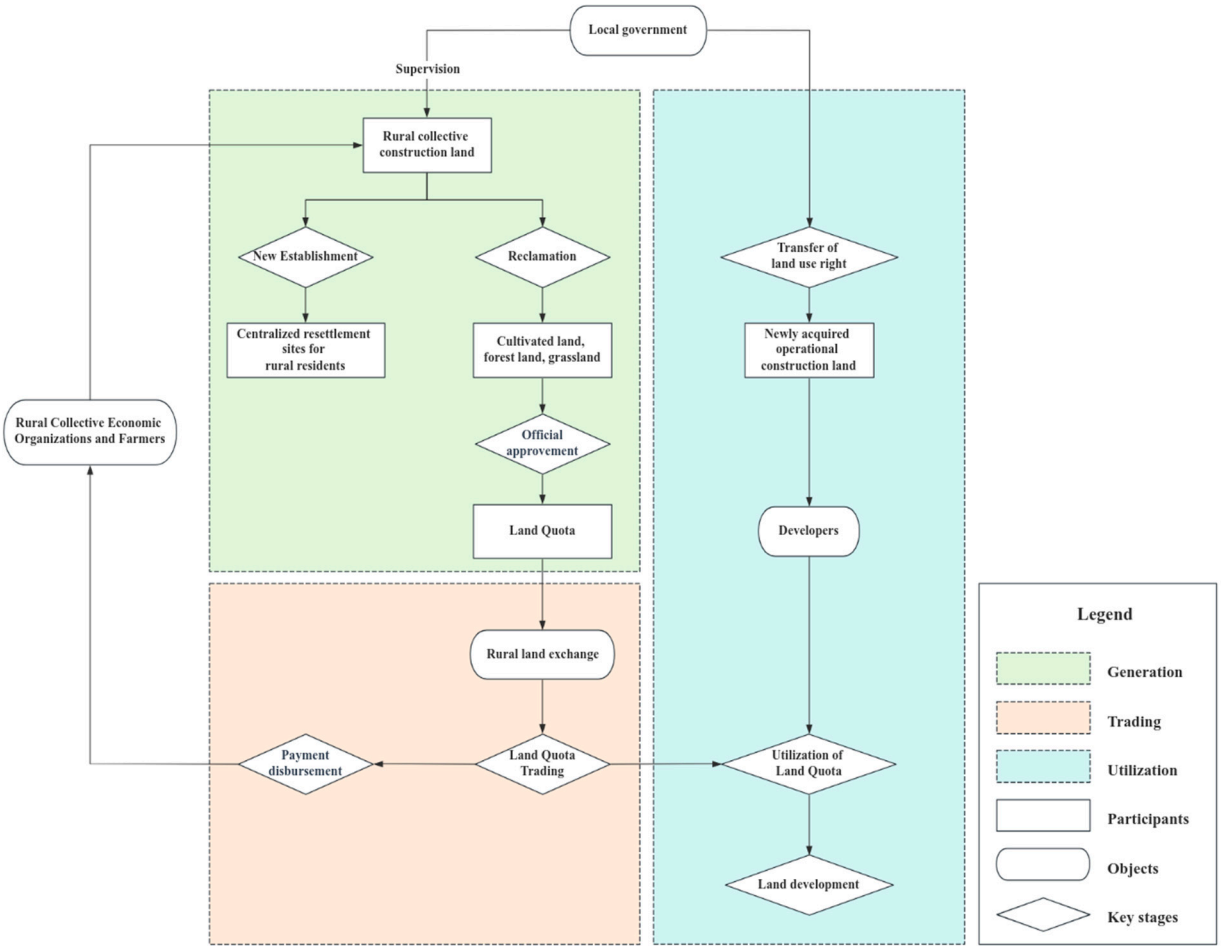


Figure 1. The process of LQT including three main stages: generation, trading, and utilization.

2.2.2. Research of LQT

The LQT policy is closely related to the concept of transferable development rights (TDR) [41]. Under market mechanisms, the LQT policy and TDR program can balance urban development and cultivated land protection with compensation for the devaluation caused by spatial zoning and land use regulation [42]. Concurrently, the Chinese government, aiming to balance economic growth with the demand for land for food security, has implemented policies of Balancing Cultivated Land Occupation and Replenishment and Linkage between Urban Land Taking and Rural Land Giving [43]. Zhejiang Province in China has implemented policies based on the trading of land, referred to as rewarded land conversion quotas (RLCQ) [44]. Existing studies use the methods of system GMM estimation, the DID model, and case study to evaluate the RLCQ policy [44–47]. Results show that the RLCQ policy has a positive impact on local economic growth and urbanization [44,47]. But, the impact on cultivated land preservation is contractible. Wang et al. (2010) finds that the RLCQ policy is positive for farmland preservation [47]. Li et al. (2016) finds that the RLCQ policy is negative to grain production and cultivated land preservation [45]. The policy in Zhejiang primarily centers on the trade-off between constructive land and cultivated land, wherein the balance between economic development and the protection of cultivated land is meticulously examined.

The LQT policy in Chongqing is not only a land use policy but also a vital tool for promoting rural and urban development. The existing literature has empirically analyzed the policy effects of the LQT policy from multiple dimensions, including policy implementation, agricultural land preservation, income distribution, and regional integration. Wang et al. (2020) found that the LQT policy has reduced the loss of farmland and stimulated local economic growth, striking a balance between the farmland preservation and urbanization [41]. Chen et al. (2020) studied the influencing factors of the LQT market, which included higher cost, uncertainty and decreases in benefits, developers' unfulfilled expectations, and accessibility to alternatives [48]. Liu et al. (2022) identified the contribution of land quota trading to economic efficiency, finding that the implementation of LQT contributes to an increase in economic output [42]. Hu (2022) investigated the impacts of the LQT system on farmers [5]. In the rapid urbanization process in China, LQT provides equal opportunities for all farmers to engage and share in the benefits of urbanization. However, lower socioeconomic status and limited non-agricultural skills still make them face social risks of rural–urban migration. Cheng (2023) focuses on the impact of the LQT policy on farmers' income [49]. It has uncovered that the policy exhibited a substantial initial surge in farmers' income. However, the effectiveness of the policy gradually diminished. Wang et al. (2023) analyzed the effects of the LQT project on urban–rural integration [50]. The results indicate that the LQT project has a positive effect on urban–rural integration, especially in regions with lower agricultural land values.

In terms of research methodology, existing studies primarily employ methods such as the interview [5,48], synthetic control method [41,42,49], and time-varying DID model [50] to investigate the policy effects of LQT. The interviews were conducted to gain in-depth understanding of the perspectives and experiences of participants and mechanism [48]. But, the interview method often relies on small samples and may not be representative of a broader population [51]. Given that the LQT policy is implemented exclusively in China, the use of the synthetic control method has its advantages. The synthetic control method created a counterfactual unit to estimate the pure effect of policy implementation with transparency, flexibility, and robustness [41]. However, due to some areas focusing on land quotas sending while others emphasize receiving them, the synthetic control method cannot reflect the differing policy impacts between these regions. The difference-in-differences (DID) model, which is also grounded in natural experiments, accounts for variations before and after the implementation of a certain policy [50], thereby enhancing the precision of the policy effect evaluation.

To summarize, the LQT policy could facilitate the mobility of land and population elements, leading to a spatial reallocation. The existing literature on the impact of LQT on

the dynamics of urbanization remains relatively limited. Addressing the existing research gap, this study employs the time-varying DID model to extensively analyze the impact of the LQT policy on land and population urbanization as well as urbanization coordination at the county level.

3. Theoretical Analysis

3.1. The Mechanisms of LQT on Land Urbanization

Based on theories of urban spatial expansion, the LQT system affects land urbanization in three ways. First of all, the LQT system links urban and rural construction land, homestead land, and arable land, facilitating the cross-regional allocation of land resources. This helps to address the shortage of land quotas in the main urban areas and meets the effective demand for new construction land in urbanization development [47]. Secondly, the LQT system grants farmers autonomy in disposing of their land assets, which can reduce conflicts in demolition and relocation and lower the transaction cost [4]. Thirdly, the LQT system incentivizes land use planning and provides financing support for local governments, expanding investments in urban infrastructure projects [46]. Therefore, the LQT system, by optimizing the spatial allocation of construction land, increasing the willingness for land reclamation, incentivizing urban planning, and promoting infrastructure development, has contributed to the level of land urbanization in urban areas.

3.2. The Mechanisms of LQT on Population Urbanization

According to theories of migration of the Harris–Todaro model, rural–urban migration is based on the expectation of a rural–urban income gap [19,52], influenced by economic push and pull factors. The unemployment in rural areas, low agriculture wages, and inadequate social amenities are push factors that drive people away from rural areas into urban areas [53,54]. The superior wages in the urban areas, better employment opportunities, and improved living condition are pull factors that attract people to urban areas [55]. When the non-agricultural income reaches a certain level, farmers tend to abandon farming, exit rural land, and migrate into urban areas to make a living. The LQT influences the rural–urban migration mainly through three approaches. Firstly, through LQT, rural residents share the differential land rent of suburban land and increase their property income [4]. The proceeds from LQT are shared by rural households and rural collectives in an 80:20 ratio [56]. Secondly, since the LQT system is closely related with the reform of hukou system in Chongqing [5], rural residents as new urban residents can transit their hukou from rural to urban, which grants them equal social welfare in urban areas. In addition, residents who sell their land quotas are still entitled to cultivate the arable land transformed from land reclamation. Increased land productivity is attainable due to the land having undergone land consolidation. With enhanced production efficiency [42], the residents are expected to experience an increase in wage income. In summary, the LQT may enlarge the property revenue and working income of residents and improve their ability and desire for rural–urban migration, which contributes to the level of population urbanization.

3.3. The Mechanisms of LQT on Urbanization Coordination

By adjusting the profit distribution mechanism of land urbanization, LQT builds an equitable development to promotes the coordinated development of land and population urbanization [4]. Firstly, the LQT is based on the market mechanism, which improve the economic cost of land conversion, so as to reduce the speed of urban sprawl. Secondly, LQT grants rural residents the right to dispose of land freely. Decisions to reclaim land, generate land quotas, and exit from homestead land are on rural residents. The local government serves as a supervisor and only collects a small management fee [57]. Farmers and rural collectives could balance the cost and benefit of taking part in LQT. Therefore, the local government cannot implement the land conversion forcefully and the speed of land urbanization will be slowed. In addition, in order to facilitate the implementation of LQT, Chongqing has reformed the hukou system to provide social welfare benefits to

rural residents who partake in the trading [58]. This may improve the speed for population urbanization. As a results, with the lower speed of land urbanization and faster speed of population urbanization, LQT affects land and population urbanization in a coordinated way.

The impact pathway of LQT policy on urbanization depicted in Figure 2. Based on the analysis provided, the following three hypotheses can be formulated:

Hypothesis 1. *Land quota trading enhances the level of land urbanization.*

Hypothesis 2. *Land quotas trading enhances the level of population urbanization.*

Hypothesis 3. *Land quota trading enhances the coordination level between land urbanization and population urbanization.*

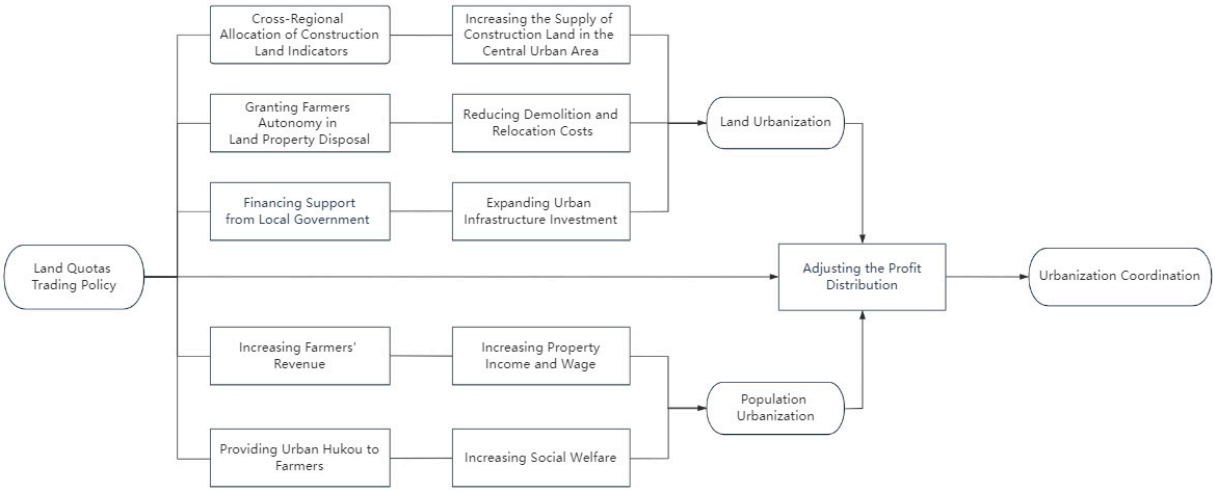


Figure 2. The impact pathway of LQT on urbanization.

4. Materials and Methods

4.1. Econometric Model Specification

To test the three hypotheses on land urbanization and population urbanization, the study takes Chongqing's LQT policy as a quasi-natural experiment. Drawing upon relevant research [41], we have chosen prefecture-level cities in the surrounding provinces of Chongqing as control groups. These provinces encompass Sichuan, Hubei, Hunan, Guizhou, Jiangxi, and Shaanxi. The reasons to select these cities as control groups are the resemblance to Chongqing's districts and counties in their geographical proximity, economic development levels, and population size. Furthermore, these cities have not implemented the LQT system. Given the variation in the timing of LQT implementation across districts and counties, we have opted for a time-varying DID model to assess the impact of the LQT policy on land urbanization and population urbanization. The basic model is specified as follows:

$$Y_{it} = \alpha_0 + \beta_0 County_{it} \times Year_{it} + \lambda X_{it} + \mu_i + \nu_t + \varepsilon_{it}. \quad (1)$$

Within the formula, Y_{it} represents the dependent variable, denoting the land urbanization rate, population density, and urbanization coordination degree, respectively. The core variable, $County_{it} \times Year_{it}$, signifies the interaction between county-level dummy variables and year dummy variables, serving to identify the samples impacted by the policy in year t. X_{it} encompasses a series of control variables, while μ_i and ν_t represent fixed effects at the county and time levels, with the aim of mitigating the influence of specific county and time-related factors. Additionally, ε_{it} represents the random error term. Furthermore, this study employs cluster-robust standard errors at the county level for adjustment.

4.2. Variable Selection

(1) Dependent Variables

The measurement indicators of land urbanization include indicators such as the built-up area growth rate [9], the proportion of built-up area to the total land area [26], the proportion of construction land area to the total land area of the administrative region [26], and the ratio of urban construction land to administrative land area [25].

The measurement indicators of population urbanization reflect the population structure, employment structure, and residents' living standards in urban and rural areas, including the growth rate of urban population [9], the ratio of the household registered population at year-end in the districts under the city to the household registered population at year-end in the total city [26], the population density [59], and the ratio of urban population to the total population [25].

The measurement indicators of urbanization coordination include the coordination degree [8,15] and land urbanization growth rate relative to the population urbanization growth rate [31]. Among these, the coordination degree primarily focuses on assessing whether the development of land and population urbanization is synchronous, while the other indicator focus on measuring the relative levels of development between land and population urbanization.

Considering the data availability, the study employs the land urbanization rate, population density, and urbanization coordination degree as proxy variables for land urbanization, population urbanization, and urbanization coordination. The land urbanization rate is the proportion of construction land to the total land area. population density is the ratio of the permanent urban resident population to the total land area. Since the implementation of the LQT policy officially commenced in 2008, the urban permanent population data for most of the prefecture-level cities and counties within the scope of this study were not publicly available until 2010. Additionally, urbanization is a process characterized by the gradual concentration of the population in urban areas [60] and population density reflects the degree of aggregation of urban populations. Therefore, to ensure consistency in the statistical measures before and after policy implementation, this study adopts population density as a proxy variable for population urbanization.

The urbanization coordination degree is computed based on the standardized values of the land urbanization rate and population density. The formulas are as follows:

$$L = \frac{Lurb - Lurb_{min}}{Lurb_{max} - Lurb_{min}}, \; P = \frac{Purb - Purb_{min}}{Purb_{max} - Purb_{min}}, \tag{2}$$

$$C = 2 \times \left[\frac{L \times P}{(L + P)^2} \right]^{\frac{1}{2}}, \tag{3}$$

$$T = a \times L + b \times P, \tag{4}$$

$$co_urb = \sqrt{C \times T}. \tag{5}$$

Within the formulas (2) to (5), L and P represent the standardized values of the land urbanization rate and population density. These values are standardized employing the Min–Max normalization method. $Lurb_{min}$, $Purb_{min}$, $Lurb_{max}$ and $Purb_{max}$ represent the minimum and maximum values of land urbanization rate and population density, respectively. With a = b = 0.5, C represents the value of coupling degree; T represents the value of the comprehensive coordination index; co_urb represents the value of coupling coordination degree, which corresponds to the value of urbanization coordination degree in this study.

(2) Independent Variables

The study selects time dummy variables for LQT, county dummy variables, and their interaction terms as explanatory variables. Time dummy variables for LQT measure the differences in land urbanization, population urbanization, and urbanization coordination

between the treatment group and the control group before and after the implementation of the LQT policy. County dummy variables for LQT measure the differences in land urbanization, population urbanization, and urbanization coordination within counties. Interaction terms are crucial explanatory variables in the analysis, which quantify the implementation impact of the LQT policy on land urbanization, population urbanization, and urbanization coordination between the treatment and control groups.

(3) Control Variables

Despite the partial mitigation of endogeneity issues when using the DID method, in order to provide a more precise characterization of spatial changes between the two groups of cities, this study selects the following indicators as control variables: ① Per Capita GDP—reflects the level of economic development, with higher economic development corresponding to higher wage income in the region, improved infrastructure, and better provision of public services, thereby enhancing the region's ability to attract people and increase urbanization level. ② The Per Capita Local Government General Budget Expenditure—reflects the government's capacity to facilitate infrastructure development and deliver public services. The government's commitment to executing regional development strategies significantly impacts infrastructure construction, the provision of public services, and the urbanization process [61]. ③ Non-agricultural Industry Value Added Ratio-reflects the city's industrial structure and level of industrialization. The industrial structure influences the long-term economic development of the city, with higher levels of industrialization resulting in more employment opportunities and higher urbanization levels [62]. ④ Fixed Asset Investment—can enhance urban infrastructure, improve the layout of urban functional zones, and enhance the region's capacity to provide public services, thereby attracting population migration to urban areas [63]. ⑤ Road Density—indicates the level of regional transportation infrastructure. Increasing road density helps reduce travel costs, improve residents' social welfare, and attract population migration to towns with higher road density [64]. ⑥ Per Capita Primary Schools—reflects the region's level of basic education. Improving the basic education level contributes to enhanced labor efficiency, promotes economic growth and income increases, and attracts rural–urban migration to urban areas [61].

(4) Data Processing

Drawing inspiration from the research of Zhang Jun et al. (2004) [65], the Perpetual Inventory Method have been employed to estimate the Fixed Asset Investment Stock. This method provides a sustainable approach to measuring the accumulated investment in fixed assets over time. The computation of other variables is presented in Table 1.

Table 1. Variable descriptions.

Variable	Code	Calculation
Land Urbanization Rate	*lnLurb*	log(Construction Land Area/Total Land Area)
Population Density	*lnPurb*	log(Permanent Resident Population/Total Land Area)
Urbanization Coordination Degree	*lnCurb*	$lnCurb = \log(co_urb)$
Per Capita GDP	*lnPGDP*	log(Per Capita GDP)
Per Capita Local Government General Budget Expenditure	*lnPGov*	log(Local Governments' General Public Budget Expenditure/ Permanent Resident Population)
Non-agricultural Industry Value Added Ratio	*lnNVA*	log(1−the Value Added of the Primary Industry/GDP)
Fixed Asset Investment	*lnInv*	log(Fixed Asset Investment Stock)
Road Density	*lnDH*	log(Road Mileage/Total Land Area)
Per Capita Primary Schools	*lnPsch*	log(Number of Primary Schools/Permanent Resident Population)

In order to mitigate the impact of heteroscedasticity on the model estimation results, we conducted the procedures of imputation, deflation, and logarithmic calculation. Firstly, to address missing data at the regional level, interpolation techniques were applied to complete the dataset. This step ensured that missing values were filled in a manner

consistent with the surrounding data points. Secondly, Per Capita GDP, Per Capita Local Government General Budget Expenditure, and Fixed Asset Investment were adjusted for inflation using the 2001 price index. Thirdly, all variables were transformed by taking logarithms to reduce variance. The descriptive statistics of the variables are displayed in Table 2.

Table 2. Descriptive statistics.

Code	Observations	Mean	Standard Deviation	Minimum	Maximum
lnLurb	2220	−4.454	1.501	−8.833	−0.071
lnPurb	2220	−3.429	1.019	−7.605	1.102
lnCurb	2220	−2.259	0.696	−6.238	−0.002
lnPGDP	2220	9.618	0.780	7.431	12.048
lnPGov	2220	7.802	0.953	5.104	10.302
lnNVA	2220	−0.181	0.108	−0.639	0
lnInv	2220	16.166	1.275	12.284	19.899
lnDH	2220	−0.093	0.725	−3.178	1.573
lnPsch	2220	0.524	0.785	−1.446	2.912

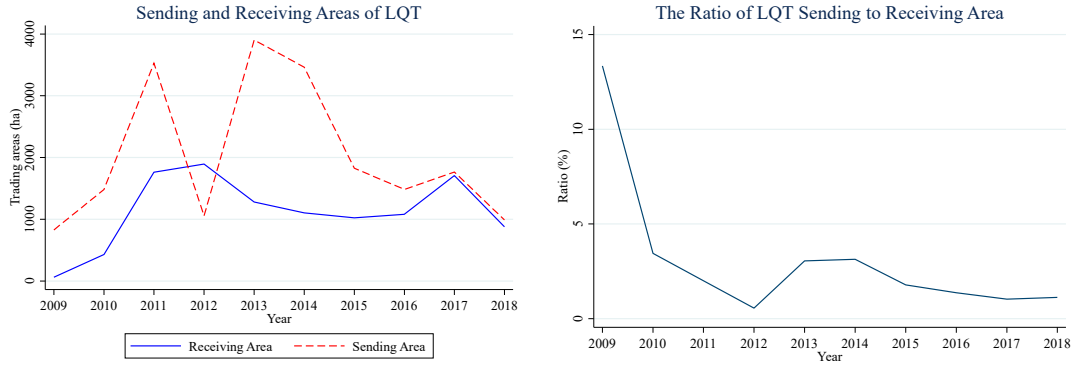
4.3. Data Source

The data on construction land area and total land area were obtained from the MODIS Global 500 m Land Cover Product (MCD12Q1). The 13th land cover class of land cover type 1, "Urban and Built-Up Lands", was used for construction land. The total land area was calculated by summing the areas of various land cover types. The LQT data for the sending area[1] were sourced from the website of Chongqing County Land Exchange (https://www.ccle.cn, accessed on 15 January 2023). The receiving area's land parcel data were obtained from the Chongqing Municipal Planning and Natural Resources Bureau. Other data used in the study were extracted from various provincial statistical yearbooks.

5. Results

5.1. Descriptive Statistics Results

(1) Implementation of LQT policy: The implementation of LQT in Chongqing began in 2008. In 2009, the transactions of land quotas in the sending area was 13.34 times that of the receiving area. Later, the ratio of LQT in the sending area to receiving area continued to decline, reaching only 0.56:1 in 2012. After 2013, the ratio of the LQT area in the sending area to the receiving area gradually stabilized. In 2018, this ratio was 1.13:1. Chongqing's LQT evolved from a situation of surplus supply to gradually achieving a balance between supply and demand (as shown in Figure 3).



(**a**) (**b**)

Figure 3. LQT in sending and receiving areas from 2009 to 2018: (**a**) Describes the LQT in sending areas and in receiving areas separately. (**b**) Describes the ratio of LQT in sending areas to receiving areas.

From a spatial perspective, the central urban area serves as the primary destination for LQT, while the suburban and county areas are the main sources of LQT.[2] From 2009 to 2018, the cumulative land quotas for receiving areas amounted to 112.18 km^2, whereas the cumulative land quotas for sending areas amounted to 203.21 km^2 in Chongqing. Specifically, the land quotas for receiving areas in the central urban area, suburban area, and county areas were 73.20 km^2, 33.77 km^2, and 5.21 km^2, accounting for 65.3%, 30.1%, and 4.6% of the total land quotas for receiving area in Chongqing during the same period. On the other hand, the LQT in the suburban, county, and central urban areas were 103.93 km^2, 93.16 km^2, and 6.13 km^2, constituting 51.1%, 45.9%, and 3.0% of the total land quotas for sending area in Chongqing during the same period. Over time, the proportion of land quotas for receiving area in the central urban area decreased from 100% in 2009 to 60.1% in 2018, indicating a spatial overflow of land quotas from the city center to peripheral areas. Meanwhile, the proportion of land quotas for sending area in the suburban and county areas accounts consistently for above 90% of the total sending areas (as shown in Figure 4).

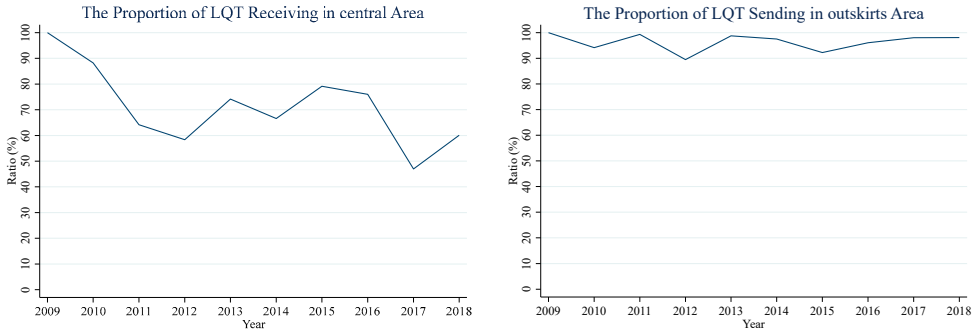


Figure 4. Spatial proportion of LQT areas in sending and receiving areas. (**a**) Describe the proportion of LQT receiving in urban central areas. (**b**) Describes the proportion of LQT sending in outskirts of urban areas.

(2) Regarding land urbanization and population urbanization. Since 2009, the average land urbanization rate in various districts and counties of Chongqing has increased from 0.076 to 0.089, marking a growth of 17.7%. The average population density has risen from 0.145 to 0.152, which represents a growth of 4.8%. Additionally, the average urbanization coordination degree has increased from 0.166 to 0.183, indicating a growth of 10.2% (as shown in Figure 5a). Since 2009, in central urban, suburban, and county areas, the average land urbanization rates have increased from 0.402, 0.116, and 0.060 to 0.448, 0.126, and 0.064, respectively (as shown in Figure 5b).

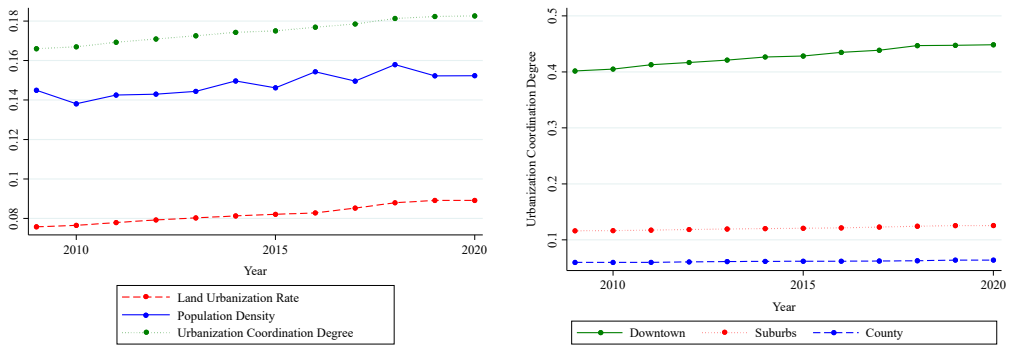


Figure 5. Changes in various urbanization in various locations. (**a**) Describes changes in the land urbanization rate, population density, and urbanization coordination degree in Chongqing; (**b**) Describes the changes in urbanization coordination degree across central urban, suburban, and county areas in Chongqing.

5.2. Econometric Analysis Results

(1) Parallel Trend Test: Referring to the study by Beck et al. (2010) [66], a parallel trend test was conducted using the event analysis method. This method is based on the equation to assess the changes in land urbanization rate, population density and urbanization coordination degree before and after the implementation of the LQT policy.

$$Y_{st} = \alpha + \beta_t D_{st}^{-n} + \gamma_t D_{st}^{+m} + A_s + B_t + \varepsilon_{st} \quad (6)$$

Within the formula, Y_{st} represents the land urbanization rate, population density, and urbanization coordination degree. D_{st}^{-n} represents the dummy variable for the number of year before the implementation of LQT, n = 1, 2, 3. D_{st}^{+m} represents the dummy variable for the number of year after the implementation of LQT, m = 1, 2, 3. A_s represents the fixed effects of county-level, B_t represents the fixed effects of time, and ε_{st} is the random disturbance.

The coefficient estimations for Equation (2) are shown in Figure 6. In the two years prior to the implementation of the LQT policy, there was no significant change in the land urbanization in Chongqing. In the three years before the implementation of the LQT policy, there were no significant changes in population density and urbanization coordination degree. After the third year of implementing the LQT policy, Chongqing's land urbanization rate showed a significant difference from zero, while population density and urbanization coordination degree showed a significant difference from zero after the first year of implementing the LQT policy. In general, in the two years before the implementation of the LQT policy, the samples from the treatment group and the control group satisfied the assumption of parallel trends.

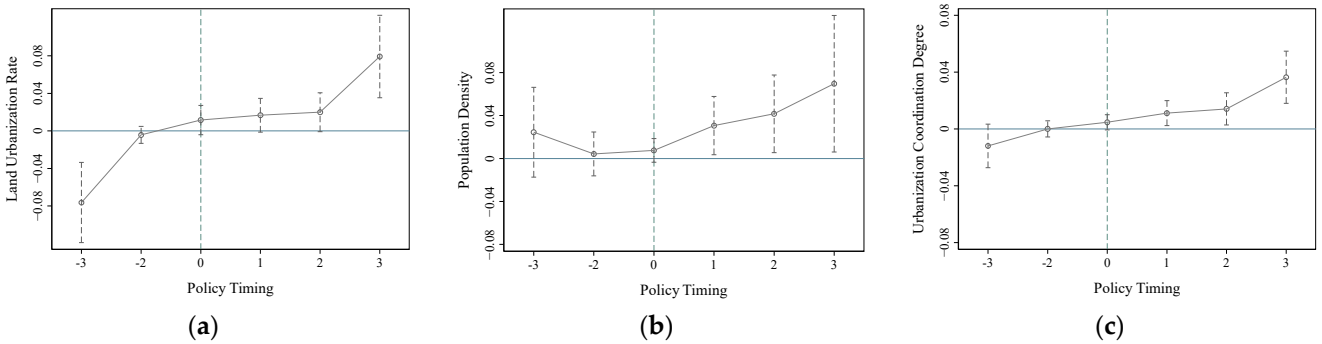


Figure 6. Results of the parallel trend test: (**a**) Describes the parallel trend test of the land urbanization rate; (**b**) Describes the parallel trend test of population density; (**c**) Describes the parallel trend test of the urbanization coordination degree.

(2) Baseline Regression Results: In Table 3, columns 1, 2, and 3 report the impact of the LQT policy on the land urbanization rate, population density, and urbanization coordination degree. The estimated coefficients for the dummy variables representing this policy are 0.089, 0.068, and 0.036, and all pass significance tests at the 1% level. With other conditions constant, one year after the implementation of the LQT policy, the land urbanization rate in the implementing counties increased by 8.9 percentage points, population density increased by 6.8 percentage points, and the urbanization coordination degree increased by 3.6 percentage points. This suggests that the implementation of the LQT policy not only significantly increased the level of land urbanization and population urbanization in Chongqing, facilitating population migration from rural to urban areas, but also significantly promoted the coordination level between land urbanization and population urbanization. Wang et al. (2020) found that after the implementation of the LQT policy the scale of urban employment population increased [41]. This result supports the findings of our research to some extent.

Table 3. The impact of LQT policies on urbanization.

Variable	*lnLurb*	*lnPurb*	*lnCurb*
	(1)	**(2)**	**(3)**
DID	0.089 *** (3.59)	0.068 *** (3.02)	0.036 *** (4.11)
Control Variables	Yes	Yes	Yes
Regional and Year Fixed Effects	Yes	Yes	Yes
Observations	2200	2200	2200
Adjusted R-squared	0.997	0.994	0.997

Note: The numbers in parentheses represent the *t*-values. *** denotes significance at the 1% level.

(3) Placebo Test: A placebo test was conducted to address the potential influence of unobservable omitted variables on the baseline regression results. This was achieved by created virtual policy implementation timeline and substituted control group counties with placebos. A total of 38 counties were randomly selected as virtual treatment group counties, while the remaining counties were designated as virtual control group counties. The coefficient estimates were calculated for the impact of the virtual treatment group counties on the land urbanization rate, population density and urbanization coordination degree for 500 times each. By visualizing the kernel density distribution of these estimates and *p*-values, the majority of regression results clustered around zero and followed a normal distribution, as shown in Figure 7. This pattern indicated that most of the results were not statistically significant. In the baseline regression, the coefficient estimates were situated in the high tail of the placebo regression coefficient distribution, making them a rare occurrence in the spatiotemporal placebo test. Consequently, this diminishes the likelihood that the baseline estimates in this study are driven by unobservable factors.

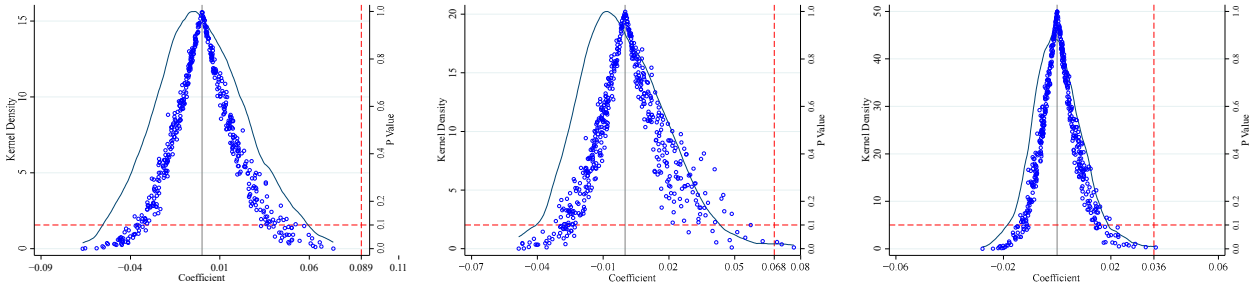


Figure 7. Spatiotemporal placebo test: (**a**) Describes the spatiotemporal placebo test of the land urbanization rate; (**b**) Describes the spatiotemporal placebo test of population density; (**c**) Describes the spatiotemporal placebo test of urbanization coordination degree. The red dashed vertical line symbolizes the coefficient estimates of the LQT policy within the actual treatment group. Meanwhile, the red dashed horizontal line denotes a significance threshold of 10% level.

(4) Robustness check: In order to ensure the reliability of empirical results and mitigate the potential impact of sample data selection on the baseline regression results, a robustness check was performed. This involved employing a method that removes the top 1% of extreme values in the dependent variable and then estimating the coefficients for the impact of the LQT policy on the land urbanization rate, population density, and urbanization coordination degree separately. The estimation results indicate that the coefficient estimates for policy implementation remain statistically significant at the 1% level, consistent with the baseline regression results, as shown in Table 4.

Table 4. Result of robustness test.

Variable	*lnLurb*	*lnPurb*	*lnCurb*
DID	0.084 ***	0.064 ***	0.038 ***
	(3.36)	(2.84)	(4.60)
lnPGDP	0.002	−0.240 **	−0.058 **
	(0.04)	(−2.36)	(−2.24)
lnPGov	0.047 **	−0.273 ***	−0.057 **
	(2.00)	(−3.27)	(−2.59)
lnNVA	0.191	−0.422 ***	−0.050
	(1.33)	(−3.27)	(−0.94)
lnInv	0.010	−0.001	0.002
	(0.35)	(−0.03)	(0.23)
lnDH	0.086 ***	−0.016	0.019 **
	(3.30)	(−0.76)	(2.01)
lnPsch	−0.021 *	−0.047 **	−0.019 ***
	(−1.79)	(−2.13)	(−2.88)
Constant	−4.942 ***	0.949	−1.288 ***
	(−6.87)	(1.19)	(−4.87)
Regional and Year Fixed Effects	Yes	Yes	Yes
Observations	2156	2156	2156
Adjusted R-squared	0.996	0.991	0.997

Note: The numbers in parentheses represent the *t*-values. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

(5) Heterogeneity analysis: The heterogeneity analysis explores the impact of the LQT policy across different regions. Table 5 presents the impact of the LQT policy on the land urbanization rate in columns 1 and 2. The coefficient estimates for policy implementation in pure receiving areas and sending–receiving areas are 0.111 and 0.085, respectively, both passing significance tests at the 1% level. In columns 3 and 4, the impact of the LQT policy on population density is shown. The coefficient estimates for policy implementation in pure receiving areas and sending–receiving areas are 0.118 and 0.062, respectively, both passing significance tests at the 5% level. Columns 5 and 6 display the effect of the LQT policy on urbanization coordination degree. The coefficient estimates for policy implementation in pure receiving areas and sending–receiving areas are 0.048 and 0.034, respectively, both passing significance tests at the 1% level.

Table 5. Result of spatial heterogeneity assessment in different areas.

Variable	*lnLurb*		*lnPurb*		*lnCurb*	
	PRA	**SRA**	**PRA**	**SRA**	**PRA**	**SRA**
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
DID	0.111 ***	0.085 ***	0.118 **	0.062 **	0.048 ***	0.034 ***
	(3.62)	(3.16)	(2.28)	(2.25)	(3.83)	(3.37)
observations	1560	1920	1560	1920	1560	1920
Ad R^2	0.998	0.996	0.993	0.991	0.998	0.997

Note: The numbers in parentheses represent the *t*-values. *** and ** denote significance at the 1% and 5% levels, respectively.

The pure receiving area[3] is primarily located in the central urban area and is characterized by a stronger economic foundation and higher levels of land urbanization and population urbanization. The utilization of the land quota meets the effective demand for new construction land in the central urban area, further stimulating investment in the

central urban area, creating more employment opportunities, and attracting population concentration towards the city center. Consequently, this enhances both land urbanization and population urbanization levels within the central urban area, thereby contributing to an overall improvement in urbanization coordination across the region.

The sending–receiving area, which encompasses both the generation and utilization of land quotas, is primarily situated on the outskirts of the city. In terms of land urbanization, LQT effectively meets the demand for newly constructed land in the sending–receiving area. Simultaneously, this region plays a pivotal role in safeguarding cultivated land after land reclamation. Consequently, the implementation of the LQT policy has significantly heightened the level of land urbanization in this area, although its impact coefficient is somewhat lower in comparison to the central urban area. Regarding population urbanization, the execution of the LQT policy has activated the rural workforce, making the population move from rural to urban areas, thereby increasing population urbanization. However, because this region combines both urban and rural characteristics, and with the population shifting from rural to urban areas, the impact of the LQT policy on population urbanization in this area is less pronounced than in the central urban area. Concerning urbanization coordination, LQT has amplified this region's share of differential land rent revenue in the market for converting agricultural land to non–agricultural purposes, thereby enhancing urbanization coordination. However, since LQT has a relatively modest impact on population urbanization in the sending–receiving area, its effect on urbanization coordination is also relatively subdued.

Table 6 presents a spatial heterogeneous assessment of the impact of LQT policy in central urban, suburban and county areas. Columns 1 to 3 represent the effects of policy implementation on the land urbanization rate. For the central urban area and suburban area, the estimated coefficients of policy implementation are 0.110 and 0.095, both passing the significance test at the 1% level. However, for county areas, the estimated coefficient of policy implementation is 0.045, failing to pass the significance test at the 10% level. Columns 4 to 6 represent the effects of LQT policy implementation on population density. For the central urban area, suburban area, and county areas, the estimated coefficients of policy implementation are 0.163, 0.095, and 0.046. The first two estimated coefficients pass the significance test at the 1% level, while the third estimated coefficient passes the significance test at the 10% level. Columns 7 to 9 in Table 6 represent the effects of LQT policy implementation on urbanization coordination degree. For the central urban area and suburban area, the estimated coefficients of policy implementation are 0.057 and 0.029, both passing the significance test at the 1% level. However, for county areas, the estimated coefficient of policy implementation is 0.027, failing to pass the significance test at the 10% level. The central urban area serves as the primary region for the utilization of land quotas, boasting higher levels of land urbanization, population urbanization, and urbanization coordination compared to other areas, due to its strong attractiveness for land and population factors. Additionally, the central urban area has already achieved a high level of land urbanization, leaving more room for improvement in population urbanization relatively. Therefore, LQT further promotes the enhancement of urbanization coordination. The suburban area, on the other hand, functions as both a region for generation and utilization of land quotas. Its levels of land urbanization, population urbanization, and urbanization coordination fall between those of the central urban area and the county areas.

The county area serves as the main region for land quotas sending and implements more land reclamation for preserving cultivated land. Therefore, the impact of LQT policy implementation on land urbanization in the county area is not significant. In practice, the area of cultivated land generated through land quotas reclamation is greater than the area of cultivated land used for spatial expansion of urban area, reflecting the function of the land quotas system in linking land for construction use with land reclamation. The implementation of LQT policy significantly affects population urbanization in the county area. LQT allows reclamation households to gain a net income of about 70,000 RMB per household and provides a basis for the assessment of mortgage loans for rural houses [67],

leading to a substantial increase in the valuation of rural houses. This increases farmers' property income and provides policy support for rural–urban migration. In summary, the implementation of the LQT policy significantly promotes levels of land urbanization rate, population density, and urbanization coordination degree in the central urban area and suburban area. It also significantly promotes population concentration in county areas.

Table 6. Result of spatial heterogeneity assessment in different locations.

Var	*lnLurb*			*lnPurb*			*lnCurb*		
	Downtown	**Suburbs**	**County**	**Downtown**	**Suburbs**	**County**	**Downtown**	**Suburbs**	**County**
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**	**(9)**
DID	0.110 ***	0.095 ***	0.045	0.163 ***	0.095 ***	0.046 *	0.057 ***	0.029 ***	0.027
	(3.01)	(3.22)	(0.74)	(3.91)	(3.22)	(1.84)	(4.02)	(2.82)	(1.65)
observations	1620	1780	1680	1620	1780	1680	1620	1780	1680
Ad R^2	0.998	0.996	0.997	0.994	0.996	0.991	0.998	0.997	0.997

Note: The numbers in parentheses represent the *t*-values. *** and * denote significance at the 1%, and 10% levels, respectively.

6. Discussion and Conclusions

6.1. Discussion

6.1.1. Findings

This study is closely related with previous studies on the LQT and related policies. Firstly, the time-varying DID method demonstrates that the LQT policy significantly and positively impacts land urbanization. Since land is crucial productive elements in local economic development, this finding indirectly suggests that the LQT policy positively contributes to local economic growth and efficiency, which is related with previous studies [41,42]. Secondly, the LQT policy significantly fosters population urbanization and the coordination of urbanization processes, aiding in the facilitation of rural–urban population mobility. This aligns strongly with studies on the LQT policy's role in urban–rural integration [50]. Thirdly, the impact of the LQT policy on urbanization varies across regions. This is echoed by research which also highlights the spatial heterogeneity of the LQT policy in terms of urban–rural integration [50]. Fourthly, the LQT policy's impact is lager in the pure receiving area (buying side) than the sending–receiving (selling and buying side) area. Zhang et al. (2014) founds that the trading effect is stronger and more lasting on the quota buyers than on the sellers in terms of economic growth [44]. Although the dependent variables in the two studies differ, the impact of the LQT policy on both buyers and sellers appears to be similar in magnitude. Overall, this research evaluates the effect of LQT policy on urbanization from a multidimensional perspective.

6.1.2. Limitations and Future Studies

This paper attempts to make a thorough exploration of the LQT policy's impact on land urbanization, population urbanization, and urbanization coordination. There are also limitations in our research and future studies could provide more in-depth insights within this domain. Firstly, although the study assessed land urbanization and population urbanization at a overall level, deeper explorations with more specific indicators on the built environment and public services are expected. Secondly, the theoretical analysis indicates that LQT can affect the revenue distribution of land urbanization, ultimately promoting the harmonious development of both land and population urbanization. However, due to data limitations, this study did not quantitatively analyze this mechanism. Future research endeavors could delve into the differential land rent associated with land conversion and investigate how LQT shapes the distribution of these benefits. Thirdly, despite employing methods like time-varying DID and selecting control variables to mitigate endogeneity issues, it remains a challenge to completely eliminate endogeneity, particularly in the

context of Chongqing's unique status as the only centrally-administered municipality in the western region in China. Lastly, this study primarily evaluated the policy effects of LQT from an economic perspective. However, it is important to acknowledge that the concept of land quotas is evolving, with an increasing emphasis on ecological functions. Ecological land quotas are gaining prominence, and future research should adopt a multidimensional approach, assessing the policy effects of LQT from economic, social, and ecological viewpoints to provide a more comprehensive assessment.

6.2. Conclusions

The LQT system has emerged as a policy experiment designed to integrate the construction land market and promote the coordinated development of urban and rural areas. This paper examines the impact mechanism of LQT on urbanization, considering both land and population perspectives. To investigate this, we use Chongqing's districts and counties as the experimental group and neighboring prefecture-level cities in Sichuan, Guizhou, Hunan, Hubei, Jiangxi, and Shaanxi provinces as the control groups. A time-varying DID model was employed to test the theoretical hypotheses.

The research conclusion can be summarized as follows:

(1) The implementation of the LQT policy has had a significant positive impact on land urbanization rate, population density, and urbanization coordination degree at the 1% significance level. The estimated coefficients are 0.089, 0.068, and 0.036, indicating that the implementation of the LQT policy has had significant positive effects on land urbanization, population urbanization, and urbanization coordination within the region.

(2) The impact of LQT policy implementation is more pronounced in pure receiving areas. For pure receiving areas and sending–receiving areas, the estimated coefficients of land urbanization rate are significantly positive at the 1% significance level, with values of 0.111 and 0.085, respectively. Estimated coefficients of population density in pure receiving areas and sending–receiving areas are also significantly positive at the 5% significance level, with values of 0.118 and 0.062. Estimated coefficients of urbanization coordination degree in pure receiving areas and sending–receiving areas are positive at the 1% significance level, with values of 0.048 and 0.034. Since pure receiving areas are primarily located in the city center, the implementation of the LQT policy significantly promotes the further concentration of land factor and population factor flow into the city center.

(3) The implementation of LQT policy significantly promoted an increase in population urbanization levels. But, it does not significantly affect land urbanization in county areas. The county areas are both for land quota sending and cultivated land preservation. The coefficient for the impact on population density in county areas is 0.046, significant at the 10% level, while the impact on land urbanization rate is not significant. This reflects the dual role of county areas in the LQT system.

These results confirm the three propositions, demonstrating that the implementation of the LQT policy has facilitated the flow of land and population factors in the region, promoting levels of coordination in land urbanization and population urbanization.

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Data Availability Statement: All the data are contained within the paper.

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Conflicts of Interest: The author declares no conflicts of interest.

Notes

[1] The sending area is the region where land reclamation is carried out to produce land quotas, the receiving area is the region where land quotas are utilized for land development, and the sending–receiving area is a region that combines both land quota production and utilization.

[2] Central urban area of Chongqing includes the districts of Yuzhong, Dadukou, Jiangbei, Shapingba, Jiulongpo, Nan'an, Beibei, Yubei, and Ba'nan. Suburbs include the districts of Wanzhou, Nanchuan, Hechuan, Dazu, Kaizhou, Liangping, Wulong, Yongchuan, Jiangjin, Fuling, Tongnan, Bishan, Qijiang, Rongchang, Tongliang, Changshou, and Qianjiang. Counties include Chengkou, Dianjiang, Fengdu, Fengjie, Pengshui, Shizhu, Wushan, Wuxi, Xiushan, Youyang, Yunyang, and Zhong County.

[3] The pure receiving area (PRA) includes the Nan'an District, Dadukou District, Dazu District, Jiangbei District, Shapingba District, and Changshou District, while the rest are sending–receiving areas (SRA).

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