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Is Urban and Rural Construction Land Quota Trading “Chicken Ribs”? An Empirical Study on Chongqing, China

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Abstract: Promoting market-oriented allocation of land has great significance in building a new pattern for high-quality development. As a market-oriented land allocation tool, land quota trading between urban and rural areas promotes spatial efficiency dynamically. In order to identify the contribution of land quota trading to economic efficiency, this paper uses a synthetic control method to evaluate the effect based on the practice of Chongqing, China. This study found that with the implementation of the land quota trading (LQT) program, the value of Chongqing’s economic output was 11.12% higher than the synthetic value, which indicates that the LQT program improved the spatial efficiency of land allocation, and eventually promoted economic growth. We suggest actively promoting land quota trading within and across provinces, and gradually deepening market-oriented reform in China’s construction land administration system.

Keywords: spatial efficiency; synthetic control method; land quota trading; market-oriented reform

1. Introduction

Developing countries are facing great challenges in the transformation of economic development due to limited resources. The market is supposed to have a decisive effect on resource allocation. As land is an indispensable production factor for economic development, the market allocation of land is key to building a high-quality system.

Under the Chinese land administration system, highly centralized construction land quota planning and allocation is a double-edged sword. Although the planned allocation of construction land controls the sharp decline tendency of cultivation [1], it has also caused unbalanced development rights among different regions [2], which decrease the efficiency of land allocation [3,4]. The Chinese government has implemented the coupling policy, which means that the increase in urban construction land equals the decrease in rural construction land for breaking through the barriers between urban and rural land markets, as well as balancing the cultivated land stock. In this way, the coupling policy achieves the target of cultivated protection, and provides extra construction land quotas to meet urban development. However, the land quota allocation under the coupling policy is still restricted to administrative regulation. In order to break through this limitation, the land quota trading (LQT) program introduced market mechanisms [5]. The LQT program is suitable for the background of Chinese economic transition, which aims to increase economic efficiency by coordinating regulation and marketization.

In fact, the LQT program takes influence from the concept of transfer of development rights (TDR). Previous literature on TDR has tended to focus on describing policy instruments and programs rather than evaluating their impacts [6–9]. Some analyses from a property rights perspective have reviewed the rights system involved in the policy and proposed the direction of reform [10], while policy effect evaluation analyses focus on farmland preservation and farmers’ rights and interests. Furthermore, empirically assessing the effect of TDR and quasi-TDR programs on accommodating development pressure with rigorous statistical methods and large-N datasets are lacking. Although these programs...
facilitate both preservation and development, program evaluation is primarily associated with land preservation [11]. Since the 1970s, the planning application and market trends of TDR have changed significantly, from the static protection of farmland and natural resources to the goal of the coordinated development of regional economies [12]. Therefore, study on the investigation of economic development is essential.

TDR is a market-oriented tool used to support urban development and rebalance development rights in order to add benefits from the perspective of spatial allocation [9,13]. The effects of market-oriented tools on land administration are strongly debated for in the literature, although a case study in Florida indicated that imperfect market conditions rendered the TDR program ineffective [14]. By contrast, implementation of market-oriented instruments such as the TDR program are unlikely to represent a suitable strategy for promoting urban regeneration in some contexts [15]. The presence of significant transaction costs decreases efficiency and can have a negative effect on the success of TDR programs [16]. Market forces in land administration are supposed to improve land marketization and coordinate land use among regions in developing countries [17,18]. Previous studies that pay attention to TDR or quasi-TDR programs in developing countries are still rare, and explore neither the levels of acceptability nor applicability as a transformation innovation in detail.

There is some doubt as to the effect of the LQT program, with some considering it mere “chicken ribs” which are tasteless and seem too wasteful to throw away. However, evidence demonstrates that the LQT program has improved the spatial efficiency of land use, as well as having helped protect farmland [19,20], functions well in a similar manner to tasty “chicken breast”, a kind of high protein diet. It is meaningful to evaluate the implications on land efficiency so that we can prove the LQT program is useful as “chicken breast” rather than “chicken ribs”. In addition to some of the literature’s focus on the background, operational form, and main characteristics of the LQT programs in detail [2,5,21], some studies confirm, from a micro perspective, that the quotas regarding development rights under market-oriented reform are re-allocated from areas with low marginal income on construction land to areas with high marginal income [22]. In this paper, we examine the changes in overall regional income after the implementation of the LQT program. Specifically, we are interested in accurately identifying the direct impact of the market mechanism on the macroeconomy. The LQT program in Chongqing, which explored the market-oriented reform during the land administration system, was successful. Therefore, we chose the LQT program in Chongqing as a sample and focused on the market forces in urban and rural development, including the market mechanism and its role in land allocation efficiency. The synthetic control method (SCM) was used to evaluate the impact of the LQT program, which not only avoids subjective selection bias, but also demonstrates the effect of market allocation of land resources, so as to provide a reference for improve the land administration system and build a high-quality market system in China.

Compared with previous studies, the main contributions of this paper are as follows: First, it enriches the international literature exploring the market force of quasi-TDR programs in land allocation and development. Second, empirical analysis of the LQT program fills a research gap regarding the impact of assessing TDR programs on economic growth. Third, a series of placebo tests confirm the reliability of the synthetic control results and ensures rigorous results. Fourth, this paper has reference significance regarding the policy of balanced farmland preservation and economic development in developing countries.

2. Research Background

2.1. TDR in Land Administration

Overall, TDR appears to be a tool that developed countries use to rationalize growth across large areas [7]. TDR was initiated in the 1960s in the US [23,24] and then practiced in European countries [15,25,26]. Nelson et al. defined TDR as a means of transferring development rights from a preserved area to another area proposed for higher-density residential development [27]. TDR programs are typically included among the lists of
tools used for growth management and sustainability planning [9]. It is thought to be the best technique for preserved areas, since it is a market-oriented transaction involving a low cost to the public and is more effective than zoning for the preservation of land and landmarks [28]. TDR can be used to offset the impact of property rights by providing restricted landowners with the opportunity to sever and sell development rights [27]. From a legal perspective, TDR may be seen as either mitigation or compensation for regulatory takings [9]. Regulatory planning instruments such as zoning may be seen as infringing on property rights, specifically the right to develop [29].

The theory and experience of TDR programs can modify the failure of administration regarding preservation and development through the market mechanism [30–33]. Prior works in the US and Europe investigating TDR programs have focused on the issue of preservation rather than development [6,7]. Several developing countries implemented the TDR program as an innovative market-oriented land administration system aimed at promoting urban development processes. TDR enables the redistribution of development rights by establishing a private market for rights exchanges. TDR policy drastically reduces transaction costs while only mildly reducing the amount of forest placed under protection in Brazil [34]. The land pooling strategy in India is a quasi-TDR program of land allocation, which provides public agencies with the ability to facilitate land assembly by landowners through market reform, and unlocks its large peri-urban land for urban development [35].

However, developing countries whose land administration systems introduce market-oriented reforms have received rare attention; empirical studies estimating efficiency of TDR programs are also inadequate.

2.2. Market-Oriented Land Administration System in China

In the Chinese context, cultivated land is collectively owned by villagers as a whole rather than individuals, which means that the construction land quota cannot be traded in the same manner as the TDR in the US. With the acceleration of urbanization, large numbers of rural laborers have moved to cities, and some of the rural areas have been wasted. The most serious puzzle is that the rural construction land stock has not decreased with rural depopulation but has shown an increasing trend over the past decades [36,37]. Moreover, the cultivated land in rural areas should be preserved. It is a great challenge for policy makers to balance cultivated land protection and economic development at the same time. Due to the responsibility of food security, the Chinese government focuses on cultivated land protection. Land quota control policies, such as the Annual Plan of Land Use, are strictly promoted in land use. In fact, the allocation of land quotas through administrative methods cannot express the degree of quota scarcity in different regions, eventually leading to efficiency loss. Through overall land use planning and annual land use plans in China, the quota stock of construction land supply is broken down layer by layer to the grassroots level, and the application of each piece of land is determined in advance. However, the planned distribution mode of construction land quotas cannot fully reflect the marginal output differences in different regions and cannot effectively meet the needs of land use, which will lead to a loss in efficiency.

Thus, the Decision on Deepening Reform and Strict Land Administration was published by the State Council of China in 2004. This reform of land development rights has eased the contradiction between urban and rural land use. Since 2006, the coupling policy has been carried out in pilot areas. The pilots should be strictly controlled in accordance with the planned circulating target issued by the state and province (autonomous regions/municipalities), and they should be arranged under the principles of total volume control, closed operation, regular assessment, and due return. Though the centralized management mode of the coupling policy has been criticized for ignoring farmers’ interests and failing to protect farmers’ property rights, there is no doubt regarding the need to reform the current land administration system by introducing a market-oriented mechanism to improve land use efficiency.
In practice, the idea of market-oriented allocation of surplus quotas is adopted to solve the spatial allocation problem, such as Chongqing’s land quota, or Henan’s reclamation trading policy. Both of them essentially coupled urban construction land and rural construction land surplus quota trading, i.e., an LQT program was implemented. The timeframe (Figure 1) of the process of land administration policy is shown below. To be specific, the LQT program remains the coupling policy that strictly oversees the quantity and quality of cultivated land; furthermore, the market forces in the LQT program make land allocation more flexible and effective. As an alternative to traditional regulatory instruments, TDR programs lead to effective land-use outcomes with greater efficiency and equity [16]. Similar to TDR programs, the LQT program is beneficial to improving land use efficacy in both urban and rural sectors. Ultimately, these programs are seen as an important tool for land use planning, in large part because it leverages a market mechanism [14]. To sum up, a market mechanism can adjust the loss of efficiency, and possess important value for related departments.

Figure 1. Evolution of the LQT program in China.

With the LQT program, rural construction land turns into cultivated land and urban sectors obtain land quotas for construction. The breakthroughs of the LQT program are mainly two aspects. First, it overcomes the restriction of coupling the increase and decrease of the project area. After the rural area generates the surplus quota, it is no longer limited to land use in the new construction area, but open to trade. Second, the price of surplus quotas is flexible as determined by the market mechanism, which can meet the requirement for the construction land resource’s effective allocation. Therefore, correctly understanding the role of the market mechanism and scientifically evaluating the role of marketization in improving the efficiency of land spatial allocation is essential.

3. Theoretical Framework

The economist Dales proposed a theoretical framework for the design of the permit trading mechanism in 1968 [38]. The liberalization of transfer rights of land leads to a marginal production equalization effect [39] and obtains gains from trade [40], which promotes the increase of resource spatial allocation efficiency. Eliminating the rigid constraints of land quotas in different regions through trading can facilitate the effective allocation of resources and contribute to the optimization of regional land use structures and high-quality economic growth. The influence of market forces on the efficiency of spatial land allocation is key to evaluating market-oriented reform of land quotas. To be specific, the region for quota replacement should be determined by market competition. Thus, land allocation is fully supported by the market mechanism. In the quota trading market, the demander must pay to obtain the right to use the quota. Due to the scarcity of the quota, there is fierce competition among demanders. Regions with high land utilization efficiency, which have an urgent demand for land quota, are willing and able to pay higher prices. Thus, the dominance of the market mechanism makes the quota spontaneously flow to the area with a high marginal income of construction land, and finally realizes the optimal allocation and utilization of land resources.
3.1. Theoretical Analysis

Assume that region \( A \) has two departments, urban and rural; that is, the marginal income of urban construction land is greater than the marginal income of rural construction land. Under the initial allocation condition of urban and rural market separation, the expansion of urban construction land can only rely on land expropriation, and the quota of construction land cannot flow between urban and rural areas. The results of construction land allocation are shown as \( Q_1 \) in Figure 2.

![Figure 2. Influence of construction land quota trading on efficiency of land allocation.](image)

The differences in land income between them provide the urban department with strong motivation to replace rural construction land for development. If the construction land quota can be traded between urban and rural areas, that is, the increase and decrease of urban and rural construction land are coupled, the result of construction land allocation moves from \( Q_1 \) to \( Q_2 \) in Figure 2. The urban sector receives development opportunities due to purchasing quotas and further increases economic output, while the rural sector receives reclamation compensation, including housing or financial compensation, which generally increases total social income. This process only flows from the rural sector of region \( A \) to the urban sector, and there is no resource flow between urban areas with different marginal benefits. For efficient spatial allocation of newly added urban construction land, the allocation of resources is most effective only when the marginal income of urban construction land is equal between regions. Otherwise, the overall efficiency of resource allocation can be further improved by the resource flow between regions, and finally the optimal Pareto can be realized.

In region \( B \), with rapid economic development, the marginal income of urban construction land is higher than that of region \( A \), and bids for the construction land quota will also be higher. In the market trading of construction land quota, if \( A \) considers that the quota trading price is higher than the self-use development income and opportunity cost, the quota will be traded with \( B \) at the highest bid. Therefore, in a win-win situation, \( A \) trades the surplus quota \( Q_1 Q_2 \) obtained from reclamation to the urban sector of \( B \), and the added value of total social income is \( EBCF \). Compared with \( A \), using the surplus quota for self-use, the total social income increases to \( EADF \). To sum up, the quota is spontaneously guided by market prices, flowing from areas with low marginal returns to areas with high marginal returns. Compared with administrative allocation, adopting a market mechanism would promote the efficient flow of resources, which is conducive to improving the efficiency of spatial land allocation, thus improving the total regional income.

3.2. Model Analysis and Research Hypothesis

Spatial land allocation is a dynamic process that is generally measured by the loss or improvement of land use efficiency in a certain area. However, we need to consider the input and output based on different purposes and objectives to improve land use efficiency. For construction land, the input land elements mainly meet the needs of economic devel-
opment, so measuring the utilization efficiency of construction land means calculating its economic output. Under certain conditions, the allocation of construction land to areas with high marginal returns improves allocation efficiency and increases total economic output. Considering that the contributions of new and existing construction land to the total economic output cannot be completely separated, the efficiency improvement can be judged by the differences between allocation methods.

Assume that there are two regions A and B; the marginal income of urban construction land is \( f_2 \) and \( g_b \), and \( f_3 < g_b \); the output of new construction land is \( \int f_a(Q)dQ \) and \( \int g_b(Q)dQ \); the original new construction land quota of A and B is \( Q_a \) and \( Q_b \), and the average output is expressed as \( AR_a \) and \( AR_b \), with an acreage of \( M_a \) and \( M_b \), respectively. Thus, the total output of construction land is \( \int_0^{Q_a} f_a(Q)dQ + AR_a \times M_a + \int_0^{Q_b} g_b(Q)dQ + AR_b \times M_b \).

Assume that A generates surplus quota \( Q_j \) through reclamation, and if it is only used in area A, the total output of construction land is \( Y = \int_0^{Q_a+Q_j} f_a(Q)dQ + AR_a \times M_a + \int_0^{Q_b} g_b(Q)dQ + AR_b \times M_b \). If market forces make the surplus quota \( Q_j \) trade from A to B, the total output of construction land will be \( Y = \int_0^{Q_a} f_a(Q)dQ + AR_a \times M_a + \int_0^{Q_b+Q_j} g_b(Q)dQ + AR_b \times M_b \). The difference between the two configurations is as follows:

\[
\Delta Y = Y^* - Y = \int_0^{Q_a} f_a(Q)dQ + AR_a \times M_a + \int_0^{Q_b} g_b(Q)dQ + AR_b \times M_b - \int_0^{Q_a} f_a(Q)dQ + \int_0^{Q_b+Q_j} g_b(Q)dQ = -AR_b \times M_b
\]

The marginal income of construction land in B is higher than in A; for increased construction land with the same area, the output of new construction land in B is higher than in A, which can be obtained as \( \Delta Y > 0 \).

Under a fully competitive market, quotas will always flow from areas with low marginal income of construction land to areas with high marginal income, and eventually reach an equilibrium state and achieve optimal configuration; specifically, marginal income of construction land will tend to be equal, and equal to the price of the quota, with total social income adding value to the maximum. Based on above mathematical deduction process, this paper puts forward the hypothesis that the increase in urban construction land and decrease in rural construction land under the market mechanism will improve the land allocation efficiency of the overall region, thus increasing the total economic output.

4. Methodology

4.1. Research Approach

The LQT program was introduced into the land administration system as a tool for enhancing the market mechanism in land allocation in Chongqing, China in 2008. This paper takes the LQT program in Chongqing (Figures 3 and 4) as a typical practice and analyzes whether implementing market reform for construction land allocation will have a positive impact on spatial efficiency in terms of increasing total social and economic output. In accordance with the requirements of the comprehensive pilot program supporting reform, Chongqing established the rural land exchange in 2008 and launched the LQT program. Land resources flow to higher utilization efficiency, so as to improve the overall spatial efficiency. Since other regions did not take the same reform measures before 2016, the land administration system can be regarded as a quasi-natural experiment, and the differences in economic output between the state of reform and no reform in Chongqing is the presence of land quota trading. It is important to note that when considering Chongqing as an experimental area for comprehensive reform, the LQT program is not completely
random, so we chose the control group as “counterfactual” Chongqing to avoid subjective and endogenous problems of the traditional double difference estimation method [41,42].

In reality, the unreformed economic output of Chongqing cannot be observed, so the “counterfactual” in the area is needed to identify the policy effect. In this paper, the SCM was used to estimate the effect of the LQT program (Figure 5). The basic logic of this method is that it uses other areas with unimplemented policies as the control group to synthesize a processing group. The data-driven method was used to estimate the weight of the control group, and similarities between the control and treatment groups were measured according to predictive variables before the treatment, thus composing a synthetic group that matched the economic fundamentals of the treatment group [43,44]. Policy effects were identified by comparing the economic output differences between actual and synthetic regions after policy implementation.

Figure 3. The study area.

Figure 4. The development of LQT program in Chongqing, China, since 2008.

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A land quota trading market was established in Chongqing in 2008. This policy pilot area can be regarded as the treatment group, and other provinces and regions comprise the control group. Verifying the policy effect should consider the landing cycle. Chongqing’s LQT program started at the end of 2008, and there was only one batch of trading. The number of completed transactions was lower during 2009 and steadily increased from 2010 (Figure 4). It should be considered that the effect of the LQT program could be seen from 2010, so 2010 was selected as the processing year.

Assuming the observed economic growth in \( j + 1 \) regions, one region (Chongqing) was subject to policy intervention, suggesting that other regions \( (j) \) could be used as a control group. Let \( T_0 \) (2010) be the policy intervention time (\( 1 \leq T_0 < T \)). \( Y_{it} \) is the added value of the secondary and tertiary industries for measuring the economic output of construction land. For regions \( i = 1, 2, \ldots, j + 1 \) and \( t = 1, 2, \ldots, T \) indicates \( Y_{it}^N \) is the value of region \( i \) where it is not accepted in time \( t \), or \( Y_{it}^D \) where it is accepted. Thus, \( \alpha_{it} = Y_{it}^D - Y_{it}^N \) shows the processing influence of region \( i \) at time \( t \). For \( T_0 < t < T \), \( Y_{it}^I = Y_{it}^N \) in every region; for \( T_0 < t < T \), \( Y_{it}^I = Y_{it}^N + \alpha_{it} \). \( D_{it} \) is used as the dummy variable indicating whether to accept treatment; if region \( i \) accepts treatment at time \( t \), that variable is equal to 1, and it is otherwise equal to 0.

The model is set up as follows:

\[
Y_{it} = Y_{it}^I + \alpha_{it} D_{it}
\]  

(1)

where \( D_{it} = \begin{cases} 1 & i = 1, t > T_0 \\ 0 & \text{otherwise} \end{cases} \). The purpose of assessing the policy effect is to estimate \( \alpha_{it} \) when \( t > T_0, \alpha_{it} = Y_{it}^I - Y_{it}^N = Y_{1t} - Y_{1t}^N \). Chongqing’s economic income \( Y_{1t} \) can be observed when \( t > T_0 \), but the “counterfactual” variable \( Y_{1t}^N \) cannot be observed. Suppose that \( Y_{1t}^N \) is given by a factor model:

\[
Y_{1t}^N = \delta_t + \theta_t Z_i + \lambda_t \mu_i + \epsilon_{it}
\]  

(2)

Equation (2) is the termination equation of potential economic output value, where \( Z_i \) is a \( (r \times 1) \) vector of observed covariates (not affected by the intervention). The influencing factors of regional economic growth are: fixed capital stock of secondary and tertiary industries to reflect capital input, number of employees of secondary and tertiary industries to reflect labor input, and construction land and new construction land area to reflect land input; and the number of industrial enterprises above designated size and per capita GDP being used to control regional economic development differences. \( \delta_t \) is the time-fixed effect, which has a common factor with constant factor loadings across units. \( \theta_t \) is a \( (1 \times r) \) vector.
of unknown parameters, \( \lambda_i \) is an unknown common factor with varying factor loadings, \( \mu_i \) is across units, and the error item \( \epsilon_{it} \) represents unobserved transitory shocks at the regional level with zero mean for \( i \). It is important to point out that this model does not rule out the existence of time-varying measured determinants of \( Y^N_{it} \), and there is no need to limit the independence between \( Z_{it}, \mu_i, \epsilon_{it} \). In addition, the increases in the secondary and tertiary industries in 2000, 2004, 2007, and 2009 were used as four additional predictor variables.

Consider a \((f \times 1)\) vector of weights \( W = (w_1, \ldots, w_{J+1})' \) such that \( w_j \geq 0 \) for \( j = 2, \ldots, J+1 \) and \( w_1 + \ldots + w_{J+1} = 1 \). Each particular value of vector \( W \) represents a potential synthetic control, that is, a particular weighted average of Chongqing, the control region. The value of the outcome variable for each synthetic control indexed by \( W \) is:

\[
\sum_{j=2}^{J+1} w_j Y_{jt} = \delta_t + \theta_t \sum_{j=2}^{J+1} w_j Z_j + \lambda_t \sum_{j=2}^{J+1} w_j \mu_j + \sum_{j=2}^{J+1} w_j \epsilon_{jt} \tag{3}
\]

Suppose that we can choose \((w_2^*, \ldots, w_{J+1}^*)'\) such that:

\[
\sum_{j=2}^{J+1} w_j^* Y_{jt} = Y_{1t}, \sum_{j=2}^{J+1} w_j^* Y_{0t} = Y_{10t}, \sum_{j=2}^{J+1} w_j^* Z_j = Z_1 \tag{4}
\]

If \( \sum_{S=1}^{T_0} \lambda_S T_0^{-1} \neq 0 \), then,

\[
Y^N_{1t} - \sum_{j=2}^{J+1} w_j^* Y_{jt} = \lambda_t \left( \sum_{S=1}^{T_0} \lambda_S T_0^{-1} \right)^{-1} \sum_{j=2}^{J+1} w_j^* \frac{1}{T_0} \sum_{S=1}^{T_0} (\epsilon_{jt} - \epsilon_{1S}) - \sum_{j=2}^{J+1} w_j^* (\epsilon_{jt} - \epsilon_{1t}) \tag{5}
\]

Under general conditions, the right part of Equation (5) will approach 0 [41]. Therefore, when \( T_0 < t < T \), \( Y^N_{1t} \) can be approximately represented by \( \sum_{j=2}^{J+1} w_j^* Y_{jt} \), and \( \alpha^*_t = Y_{1t} - \sum_{j=2}^{J+1} w_j^* Y_{jt} \) can be regarded as a “counterfactual” outcome variable estimate in Chongqing. If weight vector \( W^* \) of the synthetic control can effectively replicate the policy characteristics of the treatment area and the outcome variables before the intervention, the synthetic control estimator is gradually unbiased when the pre-intervention number \( T_0 \) trends to infinity.

To estimate \( \alpha^*_t \), first we need to know \( W^* \). In the calculation, it is possible there is no solution for the data, so that the system if the equation is exactly true, and then the synthetic control vector \( W^* \) needs to be determined by the approximate solution. Definition \( X_1 \) is the \((k \times 1)\) dimensional eigenvector in the Chongqing area before the implementation of the LQT program; \( X_0 \) is the \((k \times f)\) matrix, the same eigenvector in other regions before the point of policy implementation. Distance \( \| X_1 - X_0 W \| \) to minimize between \( X_1 \) and \( X_0 W \) can be chosen to determine weight vector \( W^* \). Referring to the Synth package running model estimation by Abadie, using a data-driven method to minimize the mean square error of synthetic control value, we obtained the economic output trajectory before implementation of the LQT program in Chongqing. The difference between the actual and synthetic values was the implementation of the policy.

4.3. Data

We selected Chinese national provincial panel data from 1998 to 2016. (Shanghai was excluded due to missing and abnormal data after 2008, and the remaining 30 provinces (autonomous regions/municipalities) were retained.) The data sources are from the Chinese National Bureau of Statistics, China Statistical Yearbook, China Fixed Asset Investment Yearbook, and Provincial (Autonomous Regions/Municipalities) Statistical Yearbook.
The explained variable is the added value of the secondary and tertiary industries. In order to eliminate the influence of price factors, this paper used the index method to adjust the GDP of the secondary and tertiary industries, with 1998 set as the base period. The GDP data of secondary and tertiary industries of provinces (autonomous regions/municipalities) are from the National Bureau of Statistics.

Capital investment is expressed as the fixed capital stock in the secondary and tertiary industries. Capital stock in this paper refers only to material capital in a strict sense. Based on the perpetual inventory method initiated by Goldsmith in 1951, and assuming that the relative efficiency of capital goods follows a geometric decreasing mode, under which the depreciation rate and reset rate are the same, the estimation formula can be expressed as:

\[ K_{it} = K_{i(t-1)}(1 - \delta) + I_{it} \] (6)

where \( i \) represents the province (autonomous region/municipality) and \( t \) represents the year. Based on Equation (6), we can account for capital stock including the following four variables: annual investment \( I \), depreciation rate \( \delta \), investment price index to convert to the constant price, and capital stock of base year \( K \).

As for the selection of the investment amount, since we focused on secondary and tertiary industries, and considering the acquisition of investment data by industry, the fixed asset investment data were selected as the investment amount of the current year. The price index means the regional fixed asset investment price index and constructs the price index from the investment reduction index using a three-step method [45]. This paper calculated the fixed asset investment price index from 1998 to 2016. At present, there are different opinions on the choice of depreciation rate. Considering the differences between provinces and the availability of data, this paper directly adopted the value of variable depreciation rate of provinces (autonomous regions/municipalities) estimated by the maximum likelihood method [46]. We used the geometric average of the increased investment of the base year plus the ratio of the depreciation rate to determine the capital stock of the base year [47]. In this paper, \( \delta \) is the same as above, and \( g_t \) is the geometric average of real fixed asset investment growth in the secondary and tertiary industries in all provinces (autonomous regions/municipalities) from 1998 to 2016.

Labor input is measured by the total number of people employed in the secondary and tertiary industries. The panel data on the number of employees in the secondary and tertiary industries from 1998 to 2016 came from the statistical yearbook of each province (autonomous regions/municipality). Land input mainly refers to the investment in construction land, including both stock and increment. The area of construction land last year was used to indicate the stock land investment, and the area of new construction land was used to indicate the incremental land investment. The urban built-up area of the provinces (autonomous regions/municipalities) was used to calculate the construction land area and was compiled according to the China Statistical Yearbook. In order to further control economic gaps between regions, regional per capita GDP and the number of industrial enterprises above a designated size were selected as the control variables, and the data were all obtained from the Chinese National Bureau of Statistics.

5. Results

5.1. Synthesis Results

The calculation results of the weight vector show that the optimal scheme is composed of five provinces (autonomous regions/municipalities): Hunan, Tibet, Inner Mongolia, Tianjin, and Jiangxi (the weight of the other 24 provinces (autonomous regions/municipalities) was 0), and their weights are shown in Table 1. The feasibility and effectiveness of the fitted scheme can also be judged by comparing the predictive variables differences between the actual and synthetic Chongqing; a smaller difference indicates better synthetic results. The values of predictive variables in actual and synthetic Chongqing and the mean values of predictive variables in other provinces (autonomous regions/municipalities) are shown in Table 2. In the table, the difference is smaller between the actual and synthetic values.
of predictors in Chongqing than between the mean and actual values of predictors in
other provinces (autonomous regions/municipalities). The comparative results show that
synthetic Chongqing fits the characteristics of actual Chongqing well, which can be used as
the processing group without implementing the LQT program.

Table 1. Weight components of Chongqing.

<table>
<thead>
<tr>
<th>Province</th>
<th>Hunan</th>
<th>Tibet</th>
<th>Inner Mongolia</th>
<th>Tianjin</th>
<th>Jiangxi</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight</td>
<td>0.459</td>
<td>0.28</td>
<td>0.143</td>
<td>0.089</td>
<td>0.029</td>
</tr>
</tbody>
</table>

Table 2. Comparison of predictor variables: actual and synthetic values of Chongqing, and average
values of other provinces (autonomous regions/municipalities).

<table>
<thead>
<tr>
<th>Variables</th>
<th>Meaning (Unit)</th>
<th>Chongqing</th>
<th>Average Value of Others</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Actual Value</td>
<td>Synthetic Value</td>
</tr>
<tr>
<td>Capital input</td>
<td>Fixed capital stock of secondary and tertiary industries (billion yuan)</td>
<td>3136.857</td>
<td>3191.654</td>
</tr>
<tr>
<td>Labor input</td>
<td>Employees of secondary and tertiary industries (thousand)</td>
<td>7777.183</td>
<td>100,053.160</td>
</tr>
<tr>
<td>Land input</td>
<td>Construction land area in last year (km²)</td>
<td>466.818</td>
<td>603.765</td>
</tr>
<tr>
<td></td>
<td>Added construction land area (km²)</td>
<td>41.732</td>
<td>28.879</td>
</tr>
<tr>
<td>Economic development</td>
<td>Number of units of industrial enterprises above designated size</td>
<td>3133.500</td>
<td>4567.306</td>
</tr>
<tr>
<td></td>
<td>Per capita GDP (yuan/person)</td>
<td>11,730.750</td>
<td>11,454.600</td>
</tr>
</tbody>
</table>

Comparing the gap in economic output between actual Chongqing and synthetic Chongqing, the effect of the LQT program can be analyzed, as shown in Figure 6. Figure 6a shows the tendency of the added value of secondary and tertiary industries in actual and synthetic Chongqing from 1998 to 2016, and Figure 6b shows the difference in added value during the research period. Before the implementation of the LQT program, the economic output curves of actual and synthetic Chongqing almost completely overlapped, and synthetic Chongqing very well fit the economic growth path of Chongqing. After 2010, the economic output curves for actual and synthetic Chongqing were significantly different. The actual and synthetic values of secondary and tertiary industries in Chongqing showed a steady upward trend, but the economic output of actual Chongqing was higher than that of synthetic Chongqing, and the gap between the two continued to expand. Specifically, with no land quota trading, the synthetic added value of secondary and tertiary industries increased from RMB 601.3 billion in 2010 to RMB 11,102.7 billion (83.4%) in 2016; however, the actual added value of the secondary and tertiary industries increased to RMB 1316.7 billion (113%). It can be seen that the implementation of the LQT program increased the added value of the secondary and tertiary industries in Chongqing by RMB 214 billion (19.4%) in 2016 compared with the synthetic value. The value of Chongqing’s economic output was 11.12% higher than the synthetic value between 2010 and 2016. Obviously, the policy implementation promoted the economic development of Chongqing, which verified the hypothesis that the construction land quota can improve the efficiency of construction land allocation, and the quota flows to areas with high marginal income, improving the economic output of construction land.
Figure 6. Results of synthetic control analysis: (a) actual value V.S. synthetic value; (b) gap between actual and synthetic value.

5.2. Placebo Test

A preliminary calculation found that there was a significant difference between the actual and synthetic economic output of Chongqing, but was this difference caused by some unobserved external factors? The estimated results required further testing. In this paper we conducted a series of placebo tests to exclude interference and the contingency of other factors and to verify the statistical significance of the estimated policy effect [41].

5.2.1. Permutation Test

Based on the permutation test method, we analyzed the statistical significance of the estimation effect of the policy. Assuming that other provinces besides Chongqing implemented the LQT program, a synthetic control was used on the treated province and other provinces to calculate the gap between actual and synthetic values in secondary and tertiary industries. As a statistical test, it is supposed to determine whether the difference between the actual economic output of construction land and the synthetic economy in other provinces (autonomous regions/municipalities) present the same characteristics as Chongqing. If the policy effect on Chongqing is obvious, that is, the gap between actual and synthetic values in secondary and tertiary industries are obviously different from that of any other province (autonomous region/municipality), it means that the difference in Chongqing is caused by the LQT program, and the estimated results are statistically significant.

The gaps between actual and synthetic values in every region under the policy are shown in Figure 7a. If a region has a weak synthetic fitting effect before the policy intervention, this means the root mean square prediction error RMSPE is high, which leads to an obvious wave in the policy effect. (In this case, RMSPE measures the degree of fit between a region and its synthetic control object before the policy implementation, \( \text{RMSPE}_{\text{pre}} = \sqrt{\frac{1}{T_0} \sum_{t=T_0+1}^{T} \left( Y_{1t} - \sum_{j=2}^{l+1} W^* Y_{jt} \right)^2} \), and after implementation, \( \text{RMSPE}_{\text{post}} = \sqrt{\frac{1}{T-T_0} \sum_{t=T_0+1}^{T} \left( Y_{1t} - \sum_{j=2}^{l+1} W^* Y_{jt} \right)^2} \). That obvious wave indicates that the final policy effect differences are not credible, so such provinces (autonomous regions/municipalities) should be deleted before the permutation test. Specifically, after calculating the RMSPE of every province (autonomous region/municipality), we deleted the six that had an RMSPE value 10 times higher than that of Chongqing (Guangdong, Inner Mongolia, Jiangsu, Shandong, Tibet, and Hebei). The permutation was taken for the remaining provinces to check the location of the target region and calculate its significance.
(autonomous regions/municipalities) to check the location of the target region and calculate its significance.

The distribution of the policy effect gap after removing the six provinces (autonomous regions/municipalities) is shown in Figure 7b. Before 2010, the economic output gap between Chongqing (black line) and other provinces (autonomous regions/municipalities) was not large, but after 2010, the gap gradually widened, and the difference in added value of the secondary and tertiary industries was higher in Chongqing than in other provinces (autonomous regions/municipalities). The results show that the LQT program improved the economic output of Chongqing construction land. Assuming the LQT program had no effect, the probability of estimating a gap of the magnitude for Chongqing under a random permutation of the intervention in our data is 4.2%. This is similar to the statistical inference of significance level; therefore, it can be considered that the effect of the LQT program on economic output at the 5% level is significant.

Another way to evaluate the relative difference between the virtual policy effect in each province and the actual policy effect in Chongqing is to compare the ratio of RMSPE before and after the reform. RMSPE reflects the goodness of the synthetic samples’ fit. Before the LQT program, smaller \( \text{RMSPE}_{\text{pre}} \) indicate better fitness of a province’s value. After the reform, larger \( \text{RMSPE}_{\text{post}} \) reflect a greater impact on the economic output of the region. According to Figure 8, the \( \text{RMSPE}_{\text{post}} \) in Chongqing is about 95 times higher than \( \text{RMSPE}_{\text{pre}} \), the RMSPE ratio is higher than the other 29 provinces (autonomous regions/municipalities). If the LQT program is completely invalid, and the maximum probability of this value in all 30 provinces (autonomous regions/municipalities) is only \( 1/30 \approx 0.033 \), the value also indicates that the policy effect is significant at the 5% level.

According to the two permutation test results, the policy influence effect in Chongqing is significant, and the policy effect of LQT program can be preliminarily excluded from the interference and contingency of other factors.

**Figure 7.** Distribution of prediction gaps: (a) Chongqing and other areas; (b) Chongqing and the valid fitting provinces.
we applied a time-based placebo test. Specifically, we moved policy implementation to any year before the intervention and then re-estimated it with the synthetic control.

5.2.3. Transforming the Time

SCM was used to conduct a similar synthetic analysis of the provinces (autonomous regions/municipalities) that did not implement the LQT program outside of Chongqing municipality, and transformation of the disposal group was used to select more representative areas for analysis. If the gaps between the actual and synthetic values of other provinces (autonomous regions/municipalities) are same as Chongqing, the analysis of Chongqing cannot be used as evidence that the LQT program effects land allocation efficiency. To test the impacts, we were supposed to select other areas which similar to Chongqing as the disposal group.

Hunan Province has the largest weight in the synthetic Chongqing area, so as a suitable disposal group. Figure 9a shows the changes in actual and synthesis values of the secondary and tertiary industries in Hunan. Before 2010, the actual value of economic output in Hunan fit well, and the synthetic value was close to the actual value after 2010. Besides Hunan, we selected Tianjin as a disposal group to test. Since both Tianjin and Chongqing are municipalities, they have similar economic and policy environments. Figure 9b shows that the gap between actual and synthetic economic output in Tianjin before 2013 was small, and from 2013 it was higher than the actual value. The gap between the actual and synthetic values of Hunan and Tianjin did not show a tendency consistent with Chongqing. Therefore, it can be considered that the impact in Chongqing was caused by the improved land allocation efficiency as a result of the LQT program.

5.2.3. Transforming the Time

To exclude the interference of policy effects by periodicity or other time-related factors, we applied a time-based placebo test. Specifically, we moved policy implementation to any...
year before the intervention and then re-estimated it with the synthetic control. Assuming that the LQT program was advanced to 2004, the fitting results of the SCM are shown in Figure 10. It can be seen that before 2004, the actual value of the economic output in Chongqing almost coincided with the synthetic value, but for a period of time after 2004, the actual value was still close to the synthetic value. That is to say, advancing the placebo LQT program to 2004 did not have a significant impact compared with the actual policy implementation. This suggests that the estimated gap in Figure 6 reflects the impact of the LQT program.

Figure 10. Placebo test result of synthetic control supposing LQT program implemented from 2004.

5.2.4. Testing Impacts of the Coupling Policy

Although we fully demonstrated the effect of implementing the LQT program in Chongqing, we excluded the effect of the coupling policy, which may improve efficiency of land allocation between urban and rural areas. In 2006, the Chinese government established the first batch of pilot projects to couple such increases and decreases, and by 2012, 29 provinces (autonomous regions/municipalities) had carried out such projects. We used time-varying DID to analyze the policy effect of the areas outside Chongqing to judge whether the economic output increased significantly under the traditional quota allocation plan. The model is:

\[ Y_{it} = \beta_0 + \beta_1 \text{DID}_{it} + \beta_2 \text{control}_{it} + \gamma_i + \gamma_t + \epsilon_{it} \]

where \( i \) and \( t \) indicate region and year, respectively. \( Y_{it} \) is the economic output, which is the sum of the added value of the secondary and tertiary industries. Dummy variable \( \text{DID}_{it} \) describes the implementation of the coupling policy in \( i \) provinces (autonomous regions/municipalities) in year \( t \). If the coupling policy is implemented in the current year, the value is 1; otherwise, it is 0. \( \text{control}_{it} \) indicates the control variables, including the working population and fixed capital stock of secondary and tertiary industries, existing and new construction land area, units of industrial enterprises above designated size, and per capita GDP. \( \gamma_i \) indicates the regional fixed effect, \( \gamma_t \) indicates the time fixed effect, and \( \epsilon_{it} \) indicates error items. \( \beta_1 \) reflects the impact of the policy.

The regression results of the time-varying DID are shown in Table 3. Except Chongqing (limited by the data, Shanghai was also excluded), the coupling policy did not have a significant positive influence on the economic output of other regions. To eliminate the impact of interregional differences, further time-varying DID analyses of western, central and northeastern, and eastern regions were conducted separately. The western region includes 11 provinces (autonomous regions/municipalities): Shaanxi, Sichuan, Yunnan, Guizhou, Guangxi, Gansu, Qinghai, Ningxia, Tibet, Xinjiang, and Inner Mongolia. The central and northeastern region includes 9 provinces: Shanxi, Henan, Anhui, Hubei, Jiangxi, Hunan, Liaoning, Jilin, and Heilongjiang. The eastern region includes 9 provinces (autonomous regions/municipalities): Hebei, Beijing, Tianjin, Shandong, Jiangsu, Zhejiang,
Fujian, Guangdong, and Hainan. Obviously, the results in Table 3, columns 2–4 are still not significant. The empirical results show that the coupling policy did not contribute to economic output, and the strict administration leading regional land allocation between urban and rural sectors was inefficient, and also verifies that the LQT program promotes economic growth by improving land allocation efficiency. The reform of market allocation of land resources has great practical significance.

Table 3. Impacts of the coupling policy.

<table>
<thead>
<tr>
<th>Variables</th>
<th>(1) Total</th>
<th>(2) Western</th>
<th>(3) Central and Northeastern</th>
<th>(4) Eastern</th>
</tr>
</thead>
<tbody>
<tr>
<td>DID</td>
<td>−322.993 (0.425)</td>
<td>316.727 (0.653)</td>
<td>−206.5422 (0.472)</td>
<td>−874.088 (0.219)</td>
</tr>
<tr>
<td>Controlled variable</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Regional fixed effect</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Time fixed effect</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Sample number</td>
<td>547</td>
<td>205</td>
<td>171</td>
<td>171</td>
</tr>
<tr>
<td>$R^2$</td>
<td>0.986</td>
<td>0.977</td>
<td>0.990</td>
<td>0.991</td>
</tr>
</tbody>
</table>

6. Discussion

6.1. Findings

People are familiar with that China’s urban land marketization accumulating adequate capital for urban development and accelerating China’s economic development [18,48–51], but this paper demonstrated that the implementation of the LQT program improved the spatial efficiency of land use in Chongqing, China, which implies that market-oriented reform is necessary in land administration system innovation. Some would argue that the market-oriented mechanism in land administration is biased toward development over conservation [9]. However, the transaction price set by the government is far lower than the equilibrium price. Without market forces, the land administration policy restrains the income of the economically underdeveloped regions, and even weakens their potential for development [12]. In conclusion, moderate deregulation and the introduction of market forces for coordinating the development rights and land administration are important steps to weaken administrative restrictions, set reasonable transaction prices, and improve the market mechanism.

6.2. Limitations

In consideration of the original aim of quasi-TDR programs, both economic development and environmental improvement are important. This study focuses on developing regions that prefer to increase spatial efficiency and total social economic output. There are also limitations in our research: (a) even though the case study proves the function of market-oriented reform in the land administration system of Chongqing, the impact of such a program in other regions requires further study with special reference to local circumstance; (b) only the effects of implementation the LQT program were assessed, and optimization of the implementation process was neglected. Further studies on improving the market trading mechanism, reducing implementation costs, and setting reasonable trading prices may valuable.

6.3. Future Studies

Market forces play an important role in the land administration system. The most difficult challenge of urban and rural land use is revealing how to balance economic development and ecological environmental protection. Though the LQT program indicated market-oriented reform works well, there are also some aspects that need to be discussed in the future studies. On the one hand, fair compensation is a difficult issue in practice. The authors will continue to expand the research on the compensation for the loss of agricultural rural lands due to them being turned into urban settings. The key points will include reducing the government’s intervention in pricing mechanisms, removing regulations among
transactional actors, scope, and methods. As for the details of policy design, we insist an introduction of the market-oriented mechanism into the land administration system. On the other hand, the sustainable development measurement of land administration is a much more comprehensive issue. According to some of the literature pertaining to sustainable land use and its economic implications globally and in China [52–56], sustainable land use involves using land resources while maintaining an optimal equilibrium between economic growth and environmental protection. For the whole region, the ecological output is influenced by land use. The conversion of urban construction land is equal to the conversion of rural construction land in the LQT program, so this influence is not obvious. Fortunately, no trouble affecting sustainable development occurred in the sample area of this study. However, sustainable development is a comprehensive problem. We should not ignore sustainable development when discussing this issue. In addition, we need to pay more attention to the sustainable development issues that based on local situations in future studies.

7. Conclusions and Policy Suggestions

Based on the synthetic control method, this paper uses Chongqing’s LQT program to test the influence of market forces on the efficiency of land allocation and economic output. Results show that land quota trading is more “chicken breast” than “chicken ribs”, for it promotes the spatial efficiency of land allocation. As quotas flow from low marginal income areas to high marginal income areas, the total output increases and eventually drives high-quality economic development. The empirical results show that: (1) Due to the influence of market forces, the efficiency of land spatial allocation was improved, and eventually led to increased total social income. (2) The value of Chongqing’s economic output was 11.12% higher than its synthetic value between 2010 and 2016. In 2016, the actual added value of the second and tertiary industries in Chongqing increased by RMB 214 billion compared with the synthetic value, reaching 19.4%. (3) A series of placebo tests showed that the growth effect of the LQT program is significant and robust to the growth effect of the economic output in Chongqing, verifying the positive effect of the market mechanism on the efficiency of land spatial allocation.

It is clear that market-oriented reform of the land administration system is an important strategy that supports the building of a new economic development pattern in both urban and rural areas. The allocation of limited resources through the market mechanism can not only make the best use of the resources and improve upon the disadvantages of the existing method, but can also make an effective connection with current management framework. Based on the empirical findings, we put forward the following suggestions: (1) to expand the range of application of the LQT program and deepen the market-oriented reform on land administration in China; (2) to support the strength of market-oriented tools in land allocation, especially the quasi-TDR program, so as to promote economic growth in developing countries; (3) to eliminate the regional restrictions of coupling quotas and expand the scope of trading areas; (4) to support the establishment of a construction land planning quota trading mechanism, to encourage provincial land resource administrative departments to promote coupled provincial and inter-provincial surplus quota trading in particular; (5) to initiate supporting policies that enhance the market mechanism of quota trading and expand the market allocation mode gradually into the construction land allocation system.

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