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LAND SUPPLY MARKETIZATION, ECONOMIC FLUCTUATIONS AND WELFARE: A QUANTITATIVE ANALYSIS FOR CHINA

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Abstract. Land supply in China is planned by governments, and the supply ratios of various types of land are in relatively rigid administrative control. This paper constructs a DSGE model to study the relationship between land supply marketization in China and economic fluctuations. Moreover, this paper evaluates the social welfare gains from land marketization. We document that the government's land planning constraint impacts consumption and social welfare through the land price and final output, causing resource misallocation losses in aggregate investment and output. Quantitatively, the optimal upper limit of industrial land supply is about 40% to achieve the maximum social welfare. This paper stresses the necessity of revitalizing China's land market, and simultaneously speeding up the marketization of collectively operated construction land.

Keywords: land supply marketization, residential land, rural collectively operated construction land, economic fluctuations, social welfare.

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1. Introduction

Since the 2008 financial crisis, the relationship between the land market and economic cycles has been a hot issue (Chen & Wen, 2017). The literature mainly discusses the effect of land transaction marketization in promoting economic development and environmental resource allocation (Huang & Chan, 2018; Wang, 2022; Zhang et al., 2022). As most countries implement private land ownership, their governments do not own land ownership and will not make regular land plans as frequently as Chinese governments (Li et al., 2018; Le et al., 2022). Due to the particularity of China's land ownership (i.e., public land ownership) and land supply system, the research for understanding the marketization of China's land supply in the land planning stage of the primary market is still insufficient.

Compared with the marketization reform of labor and capital, the marketization reform of land in China lags (Jiang et al., 2021). Land supply in China is planned by governments, and the supply ratios of various types of land are in relatively rigid administrative control. Land marketization implies that the Chinese government's land supply policies have to be more market-oriented and demand-driven, instead of rigid administrative control of the supply ratios of various types of land. Land supply in China is planned by governments at all levels in advance, and then the land is traded in the market. Specifically, provincial governments draw up the overall land plans according to the needs of economic and social development. These plans are generally divided into long-term, medium-term, and annual, and mainly focus on urban construction land. Municipal and county governments make specific annual plans of land supply, which are required to be submitted to provincial governments for approval. On the whole, governments in China control the land supply to a large extent. Therefore, whether the government's land planning is optimal. If not, the Chinese government must carry out market-oriented reforms of land supply policies.

The supply of residential and industrial land will affect house prices and aggregate output in the general equilibrium, and eventually influence economic fluctuations and social welfare. The current land supply system in China might not be efficient for two reasons. First, the land supply mode and structure (i.e., planned supply) are solidified, which can weaken the role of land in optimizing resource allocation. Second, since the marketization of collectively operated construction land is not highly developed, the quantity of that entering the market may not satisfy the

market demand.[1] A natural question is whether the supply of residential land is insufficient, resulting in its high price. In addition, whether the current Chinese government's land planning is optimal regarding the proportion of kinds of land. If not, how can the government adjust it to the social optimum? To explore these questions, we construct a Dynamic Stochastic General Equilibrium (DSGE) model to study the relationship between land supply marketization and economic fluctuations in China.

This paper relates to two strands of literature. First, a line of research talks about the factors affecting land prices and the impact of land prices on economic fluctuations. The literature argues that monetary policies affect land prices, and result in economic fluctuations, in which firm collateral is likely to amplify this mechanism. In detail, the boom or collapse of the land market will lead to pro-cyclical fluctuations of investment and output by the collateral (Kiyotaki & Moore, 1997; Kwon, 1998; Christiano et al., 2005; Campbell & Hercowitz, 2006; Gan, 2007; Chaney et al., 2012). Other studies show that geographical position, business and unemployment can impact land price and economic fluctuations, and governments are able to smooth fluctuations and improve social welfare by implementing tax changes and monetary policy (Saiz, 2010; Miao et al., 2014; Liu et al., 2011, 2016b). Besides, land price is a determinant of the housing market, and the housing sector is closely connected to economic fluctuations (Campbell & Cocco, 2007; Piazzesi et al., 2007; Taylor, 2007; He et al., 2015). The studies also show that technological changes in the housing sector can influence housing prices and thus cause housing market spillover in business cycles (Greenwood et al., 1997; Iacoviello, 2005; Iacoviello & Neri, 2010).

This study is also closely related to the literature on land marketization. In China, urbanization, non-agricultural output and foreign direct investment are all the driving forces for the reform of land marketization (Fan et al., 2020; Wei et al., 2021). The level of urban economic growth, population density, urban size, and degree of openness also affect the spatial changes of land marketization (Jiang et al., 2021). However, the intensity of local government land policy implementation, the performance views of government officials, and the political cycles in the land transaction market can all affect the current process of land marketization in China (Tian & Ma, 2009; Liu et al., 2016a; Wang & Zhang, 2019; Sun et al., 2020). The literature shows that land marketization promotes the efficiency of land resource allocation, improves urban innovation capacity and accelerates economic transformation by easing credit constraints, optimizing the land structure and land pricing mechanism, and improving ecological efficiency (Wang & Tan, 2020; Jiang & Lin, 2021; Cheng et al., 2022; Jin & Zhou, 2022; Yao & Wang, 2022; Yang et al., 2023; Yu & Luo, 2023). However, government-led allocation of land may lead to unnecessary distortions, resulting in rapid increases in housing prices and risks of ineffective investment, leading to industrial overcapacity (Turner et al., 2014; Miao et al., 2015; Albouy & Stuart, 2020).

This paper contributes to the literature in two ways. First, a pieces of literature mainly study land transaction marketization and its impact on the macroeconomy under the private ownership of land where the government does not own the land ownership and enacts regular land supply plans as frequently as the Chinese government does (e.g., Jacoby & Minten, 2007; Albouy & Stuart, 2020). Our research is devoted to the above research by introducing a unique element (i.e., China's government-designated land supply plan), and studying the relationship between Chinese land supply marketization and economic fluctuations. Second, although it is generally believed that the government's land policy exerts an impact on land prices, and thus economic cycles, there are few studies have quantitatively analyzed to what extent the government-designated land supply plan in a system of public ownership of land like China affects business cycles and social welfare through a general equilibrium framework.[2] This paper fills this gap in the literature by building and calibrating a DSGE model to provide quantitative evidence on this topic.

The rest of this paper proceeds as follows. Section 2 introduces the benchmark model. Section 3 conducts the quantitative analysis. Section 4 proposes the augmented model. Section 5 concludes.

2. Model

In order to study the impact of the Chinese government-designated land supply plan in a system of public ownership of land on economic fluctuation and social welfare, we construct a DSGE model based on the government's ex-ante land supply plan. The DSGE model is based on the business cycle theoretical framework (Kydland & Prescott, 1982), which is a standard macro tool for studying economic fluctuations (Iacoviello, 2005; Liu et al., 2013). In the DSGE model, the micro individuals make optimal inter-temporal decisions. It allows us to make counterfactual analyses with shocks on the basis of micro-optimal selection for policy evaluation. All the

[1] The land marketization in China has four main goals. First, improve the annual total amount control system of construction land. Second, improve the rural collective property rights system and standardize the transfer and transaction of rural collectively operated construction land. Third, explore ways to increase the supply of mixed industrial land. Fourth, carry out pilot cross-regional transactions of land quotas. This paper mainly focuses on the first point in the benchmark model, and studies how the marketization of the Chinese government's land supply policy affects economic fluctuations and social welfare in the land primary market. In the augmented model, this paper further introduces rural collectively operated construction land to check the robustness of the main mechanism.

[2] Most empirical studies focus on regressions by different econometric methods, which focus on analyzing causal relationships (e.g., Liu et al., 2016a; Fan et al., 2020; Sun et al., 2020). However, in a general equilibrium model with quantitative analysis, we can further do counterfactual exercises to study the dynamic path of land marketization.

shocks are exogenous variables and follow AR(1) distribution, and the fluctuation of any endogenous variable is driven by exogenous shocks.

China's land supply market is dominated by the government, and the government's ex-ante land supply plan is exogenously determined (may not be optimal), which conforms to the features of exogenous shocks (rather than endogenous variables). Therefore, it is reasonable to use the exogenous shock of the DSGE model as a disturbance to study the mechanism of government land supply on the economy and explore the optimal land supply. Besides, the DSGE model reflects the general equilibrium, including supply (firms) and demand (households). When supply equals demand, the market clears and the equilibrium price is determined. The above mechanism means that the DSGE model is not a local equilibrium, and can more comprehensively depict the supply and demand of the land market, as well as the complete production process of land entering the production function as a factor, and the final product flowing to households through consumption.

As land can enter both residential and production functions (Liu et al., 2013), the model in this paper makes two extensions to an otherwise standard DSGE model. First, a household holds residential land as a living function, and industrial land is used as an input to produce consumption goods.[3] Second, the model includes the government, which controls and adjusts the upper limit proportion of industrial land in each period. In the model, land does not depreciate.

Following this framework, the benchmark model in this paper includes the representative household (demand side), the representative firm (supply side), and government (supply side). A household provides labor to obtain incomes, and purchase residential land for housing. A firm inputs industrial land, capital and labor for production. The government controls land resources since it has the rights to specify the guiding proportion of residential and industrial land supply. Assume that the land stock of the whole society is $\bar{L}$.

In this model, the government controls land supply, and thus impacts social welfare through two channels. First, the direct final output channel. For example, the lower upper limit of industrial land supply limits firms' output directly, thereby reducing consumption and social welfare. Second, the land price channel. The upper limit of (residential or industrial) land supply quantity affects the demand for land by households and firms, which leads to land price fluctuations, thus affecting consumption and social welfare. For example, if the government sets a lower upper limit on the supply of industrial land, resulting in a relatively insufficient supply of industrial land. As a result, land price rises with increasing industrial land demand.[4] Increasing land prices leads to an increase in the marginal substitution rate of consumption and residential land, which further limits the improvement of consumption and social welfare. The detailed relationship is shown in Figure 2.

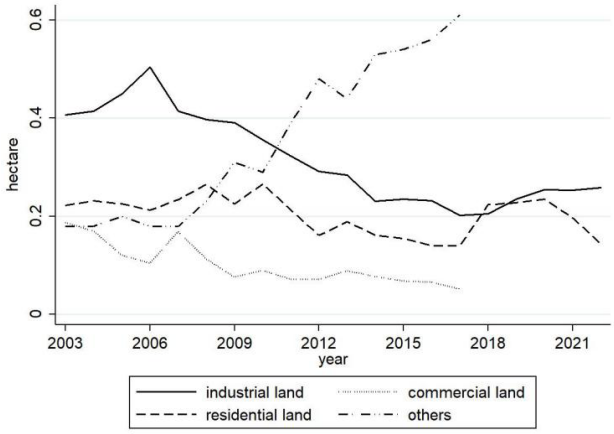

Figure 1. The ratio of land supply (2003–2022)
(Data source: Ministry of Natural Resources, 2003–2022)

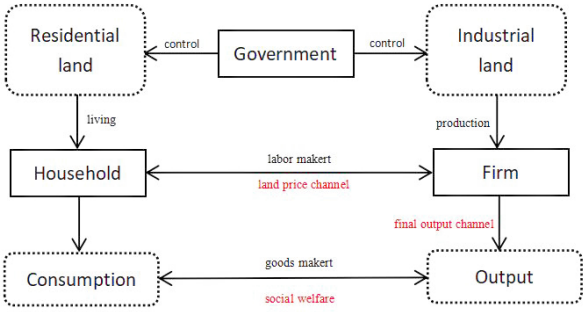

Figure 2. The framework of benchmark model

2.1. Government

According to the above typical facts and assumptions, suppose that the upper limit proportion of industrial land L_{et} to the land stock $\bar{L}$ is R, thus:

$$L_{et} / \bar{L} \leq R. \quad (1)$$

With the acceleration of the market-oriented land reform, the government pays more attention to the significant role of the land market. In the following analysis, the government will gradually adjust the upper limit R to achieve development goals.

[3] The supply of land in China is divided into industrial land, commercial land, residential land, and others. As shown in Figure 1, before the subprime crisis in 2008, industrial land and residential land were the two largest sources of land. After that, due to the four-trillion yuan stimulus program, the shares of industrial and residential land declined, while the share of other land rose rapidly. From 2003 to 2022, the average ratios of industrial and residential land supply accounted for about 31.69% and 20.36%, respectively.

[4] According to the *Civil Code of the People's Republic of China*, if it is necessary to change the use of land, it shall be approved by the relevant administrative department. Therefore, the two types of land can be converted (traded) under certain conditions, but this must meet the land plan and obtain government approval.

2.2. Households

All households are identical (with a unit mass). Households supply labor to firms. The final good is used as the numeraire. A representative household (h) has the following utility function:

$$E_t\sum_{t=0}^{\infty}\beta^t\left[\log(C_t)+\psi\log(L_{ht})-\varphi\frac{N_{ht}^{1+\eta}}{1+\eta}\right], \quad (2)$$

where: t denotes the time; C_t denotes consumption of final goods; L_{ht} denotes the stock of residential land; N_{ht} denotes labor hours. The parameter $\beta > 0$ is the discount factor, Ψ and $\varphi > 0$ control the utility weight on the stock of residential land and labor supply, respectively. According to Equation (2), the household prefers leisure, and working brings negative utility. Let q_t be the land price, w_t be the wage rate, π_t be the profits from firms, a representative household's budget constraint at each period is given by:

$$C_t+q_t(L_{ht}-L_{h,t-1})=w_tN_{ht}+\pi_t. \quad (3)$$

The household chooses $\{C_t, L_{ht}, N_{ht}\}$ to maximize Equation (2) subject to Equation (3). The first-order conditions are given by:

$$1/C_t=\lambda_t; \quad (4)$$

$$q_t=\psi/(\lambda_tL_{ht})+\beta E_tq_{t+1}\lambda_{t+1}/\lambda_t; \quad (5)$$

$$\varphi N_{ht}^{\eta}=\lambda_tw_t, \quad (6)$$

where λ_t is the Lagrange multiplier of Equation (3). Equation (5) means that the land price is equal to the marginal substitution rate of consumption and residential land plus the expected discount resale price of residential land in the future. Equation (6) indicates that wage is equal to the marginal substitution rate of consumption and leisure.

2.3. Firms

The firms are perfectly competitive. Output Y_t is given by:

$$Y_t=A_tK_t^{\alpha(1-\phi)}L_{et}^{\alpha\phi}N_{et}^{1-\alpha}, \quad (7)$$

where L_{et}, K_t and N_{et} are industrial land, capital and labor input, respectively. Parameters α and $\phi\in(0,1)$ represent the share of these inputs. A_t is the firm-specific total factor productivity (TFP). Firm productivity fluctuates over time, and we model it as an AR(1) stochastic process (Liu et al., 2013):

$$\log A_t=\rho_a\log A_{t-1}+\varepsilon_{at}, \quad (8)$$

where: $\rho_a\in(-1,1)$ measures the degree of persistence; ε_{at} is the standard deviations and is an i.i.d. standard normal process. Let I_t denote investment, and δ is capital depreciation rate. The capital accumulation function is:

$$K_{t+1}=(1-\delta)K_t+I_t. \quad (9)$$

The representative firm's problem is to choose $\{N_{et}, L_{et}, K_{t+1}\}$ subject to Equations (1), (7)–(9) to maximize:

$$E_t\sum_{t=0}^{\infty}\beta^t\frac{\lambda_t}{\lambda_0}\left[Y_t-w_tN_{et}-I_t-q_t(L_{et}-L_{e,t-1})\right]. \quad (10)$$

The first-order conditions for the firm optimizing problem are given by:

$$w_t=(1-\alpha)Y_t/N_{et}; \quad (11)$$

$$q_t+\lambda_t^l/\lambda_t=\alpha\phi Y_t/L_{et}+\beta E_tq_{t+1}\lambda_{t+1}/\lambda_t; \quad (12)$$

$$1=\beta E_t\lambda_{t+1}/\lambda_t[\alpha(1-\phi)Y_{t+1}/K_{t+1}+1-\delta], \quad (13)$$

where λ_t^l is the Lagrange multiplier of Equation (1). Equation (11) is the labor demand function, and wage is equal to the marginal product of labor. Equation (12) is the Euler equation of industrial land. With the upper limit constraint, industrial land price in t is equal to its marginal product plus the expected discount resale land price in $t + 1$. Equation (13) is the Euler equation of capital. The purchase price of the capital in t is equal to the expected discount value of its future marginal product plus the undepreciated capital.

2.4. Market clearing

In a competitive equilibrium, goods, labor and land markets are clear. The goods market clearing condition implies that:

$$C_t+I_t=Y_t. \quad (14)$$

The labor market clearing condition implies that labor demand is equal to labor supply:

$$N_{ht}=N_{et}. \quad (15)$$

The land market clearing condition implies that:

$$L_{ht}+L_{et}=\bar{L}. \quad (16)$$

Without loss of generality, this paper assumes $\bar{L}=1$. A competitive equilibrium consists of sequences of prices $\{q_t, w_t\}$ and allocations $\{C_t, L_{ht}, L_{et}, N_{ht}, N_{et}, I_t, Y_t, K_t, \lambda_t\}_{t=0}^{\infty}$, such that (1) taking the prices as given, the allocations solve the optimizing problems for the household, firm and government, and (2) all markets clear.

3. Quantitative analysis

3.1. Parameter calibration

In this section, we show the parameter calibration. The data sources are from the *China Land and Resources Statistical Yearbook* (Ministry of Natural Resources, 2003–2022) (for land market data to calibrate R) and the *China Statistical Yearbook* (National Bureau of Statistics, 2003–2022) (for other macro data). We take China as the research object to conduct the quantitative analysis. We start with calibrating three sets of parameters as reported in Table 1. The first set of parameters includes five basic parameters in the model, $\{\alpha, \beta, \eta, \delta, \phi\}$. Following Chang et al. (2015), we set the capital share α = 0.5; subjective discount factor β = 0.995, which means that the annual (deposit) interest rate is about 2% from 2003 to 2022; inverse Frisch elasticity η = 2, which implies a Frisch elasticity of labor supply

Table 1. Calibrated parameters (Data source: Ministry of Natural Resources, 2003–2022; National Bureau of Statistics, 2003–2022)

Parameter	Value	Description
α	0.5	Share of capital
β	0.995	Subjective discount factor
η	2	Inverse Frisch elasticity
δ	0.025	Depreciation rate
ϕ	0.6	Share of industrial land relative to capital
ρ_a	0.9	Persistence of TFP shock
ε_{at}	0.2	Standard Deviation of TFP shock
R	0.5308	Steady-state industrial land supply upper limit
c / y	0.376	Steady-state consumption-output ratio

of 0.5, and depreciation rate δ = 0.025. Following Guo et al. (2015), we set the share of industrial land relative to capital in firms' production ϕ = 0.6, which implies that the output elasticity of industrial land is 0.3. The second set of parameters describes the persistence and standard deviation of TFP shock, $\{\rho_a, \varepsilon_{at}\}$. These parameters are calibrated consistent with extant papers (e.g., Aguiar & Gopinath, 2007). The third set of parameters have two steady states, the steady-state industrial land upper limit R and the steady-state consumption-output ratio c / y. By calculating the mean of indicators from the *China Land and Resources Statistical Yearbook* (the first quarter of 2003 to the fourth quarter of 2022), we get R is equal to 0.5308 (relative to residential land). Similarly, we use the nominal final consumption expenditure and nominal gross domestic product (GDP) measured by expenditure method from the *China Statistical Yearbook* (the first quarter of 2003 to the fourth quarter of 2022) to calculate that the steady-state consumption-output ratio is equal to 0.376. Table 2 and Table 3 are simulated based on the calibration.

3.2. Impulse response

In this section, we analyze how the upper limit of industrial land affects the main endogenous variables by impulse response. According to the national land supply data from the first quarter of 2003 to the fourth quarter of 2022, this paper selects the quarter with the smallest proportion as the initial value of the proportion of industrial land in the quantitative simulation, which is equal to 0.4783. When the initial value is less than the upper limit R specified by the government, we can clearly observe the impact of the government's land supply constraint on endogenous variables in the impulse response.

The results of impulse response are shown in Figure 3.[5] We find that when facing a positive TFP shock, firms' total factor productivity rises and output presents a positive impulse response. According to Equation (12), the marginal output of industrial land increases, which leads to an increase in firms' demand for industrial land. Therefore,

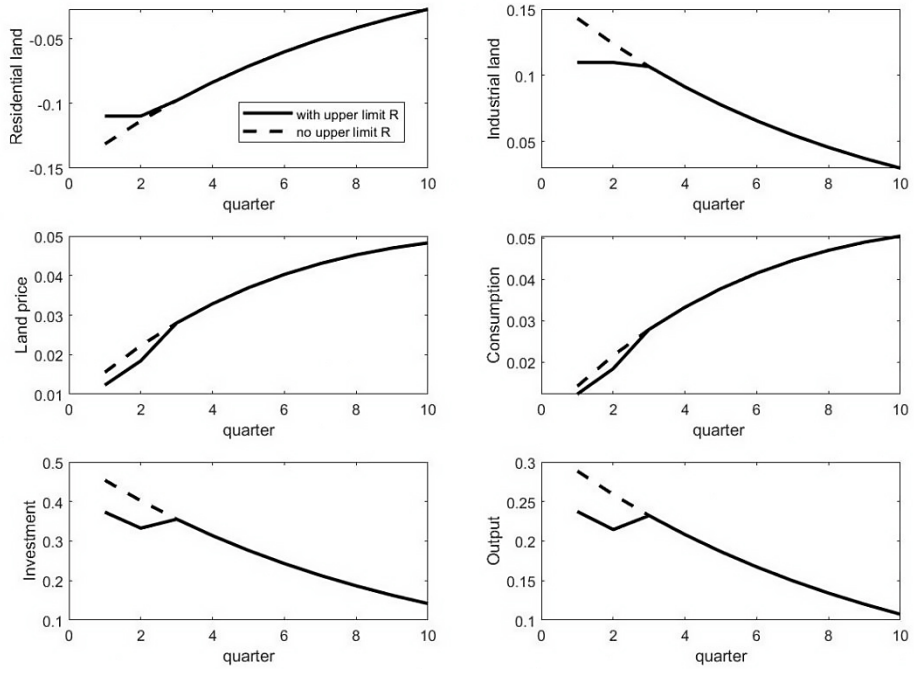

Figure 3. Impulse responses (benchmark model)

[5] In the impulse response, we show six variables. The residential land and industrial land correspond to L_{ht} and L_{et} respectively. Land price, consumption, investment and output are q_t, C_t, I_t and Y_t in the model. The six variables selected can comprehensively reflect the fluctuations of the land market (L_{ht}, L_{et} and q_t) and major macroeconomic fluctuations (C_t, I_t and Y_t).

industrial land increases and residential land decreases correspondingly when the aggregate land remains unchanged. This means that land is gradually transferred from households to firms. At this time, households sell land and increase consumption. According to Equation (5), increasing the land price q_t leads to an increase in costs for households to purchase a unit of land today. Hence, the marginal substitution rate of consumption and residential land rises, and households sell land to increase consumption until Equation (5) reaches a new equilibrium.

It is worth noting that the government will set an upper limit on industrial land in the model. We report the impacts of this constraint on each variable in Figure 3. It shows that industrial land increases by 14.32% under a positive TFP shock when no constraint exists. In comparison, industrial land in the first two quarters is subject to the upper limit and only increases by 10.98% with an upper limit. Correspondingly, residential land decreases by 10.98%. Due to the upper limit constraint set by the government, the role of the market in resource allocation is restrained in the first two quarters. Land transactions are affected by policy intervention, and land price is underestimated. Besides, compared with the situation without constraint, the investment and output of the whole society also suffer losses.

3.3. Optimal ratio of residential and industrial land

Based on these findings, a question is how to alleviate the loss brought about by the land supply constraint set by the Chinese government. We seek to answer this question by exploring whether there is an optimal supply ratio (the upper bound) of residential and industrial land, which can maximize social welfare. Following Chang et al. (2015), welfare gains with market-oriented reform in our analysis are measured by consumption equivalence relative to the benchmark model. Denote the benchmark welfare as V_b, and the welfare with market-oriented reform as V_a:

$$E\sum_{t=0}^{\infty}\beta^t\left[\log C_t^i(1-\Delta)+\psi\log L_{ht}^i-\varphi\frac{\left(N_{ht}^i\right)^{1+\eta}}{1+\eta}\right]=V_b, \quad (17)$$

where C_t^i, L_{ht}^i and N_{ht}^i are the endogenous variables under different cases denoted by i, with log-utility in consumption. The welfare gains Δ satisfy $\ln(1-\Delta)=1/(1-\beta)\left(V_b-V_a\right)$.

Table 2 summarizes the impact of industrial land upper limits on social welfare with a positive TFP shock with respect to different ratios of land supply R. In particular, we take R = 0.5308 as the benchmark, and calculate welfare gains for different R. The results show that with R gradually increasing from 0.2, social welfare shows an inverted-U shape. Importantly, when R = 0.4, welfare gains reach a maximum. That is, the optimal ratio of industrial land to residential land is about 4:6, and the social welfare level is the highest.[6]

Table 2. Welfare gains

R	Welfare gains (%)	R	Welfare gains (%)
0.2	–1.0068	0.5308	0
0.3	1.6845	0.6	–0.7302
0.4	1.7686	0.7	–1.9721
0.5	0.3331	0.8	–3.0558

We are now in a position to interpret the mechanism of the optimal ratio of land marketization. The land is categorized into industrial land and residential land, entering the final output and household utility functions, respectively. The upper limit of industrial land R impacts social welfare through two channels as shown in Figure 2, the land price channel and final output channel. On the one hand, with R increasing, both the marginal substitution rate of consumption and residential land (housing) and land price gradually increase. Thus, consumption is crowded out by housing expenditures, which has a negative impact on social welfare. On the other hand, increasing industrial land, as a production input, promotes output, consumption and social welfare. When R > 0.4, the high upper limit promotes industrial land L_e and output. However, the decline of residential land leads to an increase in the marginal substitution rate of consumption and residential land (housing). According to Equation (5), land price q is positively correlated with the marginal substitution rate of consumption and residential land (housing) $\psi C/L_h$ in the steady state. Because $\psi C/L_h=q(1-\beta)$, the marginal substitution rate of consumption and residential land (housing) increases. It means that land price increases, given that other conditions are unchanged. Residential land (housing) becomes relatively more valuable with increasing land prices. At this time, households' consumption replaced by each unit of residential land (housing) becomes larger, and the proportion of housing expenditure increases. As household consumption is smooth, this process continues until household expenditure allocation reaches another local equilibrium. During the above process, residential land (housing) expenditure crowds out consumption, thus reducing social welfare. On the contrary, when R < 0.4, the low upper limit decreases industrial land, reduces the output of final goods and consumption, and has a negative impact on social welfare. Assuming that, in extreme cases, all land is residential land, firms will not be able to produce, and the welfare level will become very low. Taken together, there is an optimal structure of land supply in the model that maximizes social welfare.

[6] Following Chang et al. (2015), this paper uses Taylor's first-order approximation of the representative household utility function to calculate social welfare. As it omits the higher-order approximations, the actual improvement will be greater than 1.77% mathematically.

4. Extension: Rural collectively operated construction land

4.1. Institutional background

On August 26, 2019, the Standing Committee of the National People's Congress of the People's Republic of China voted and passed the resolution on the entry of collectively operated construction land into the market. The resolution has broken the legal barriers to the entry of rural collective construction land into the market, and allowed collective commercial construction land to enter the market for industrial or commercial purposes. On July 2, 2021, China's State Council issued the *Opinions on Accelerating the Development of Affordable Leased Housing*, stipulating that collectively-owned construction land can be used to construct affordable rental housing. On January 6, 2022, the *Notice on Printing and Distributing the Overall Plan for the Comprehensive Reform Pilot of Factor Marketization Allocation* mentioned again that it is allowed to change the use of existing collective construction land into the market for trading under the premise of adhering to the law, voluntary and paid. Since then, rural construction land can be traded as industrial land, residential land, and other construction land. Overall, this reform greatly activates the rural collective construction land market, enhances the value of rural collective construction land, and thus playing a significant role in realizing farmers' land property rights and interests and strengthening the rural collective economy. For example, eighteen pilot cities, including Beijing, Shanghai, Nanjing, Hefei, and Hangzhou, have immediately explored the path of using collective construction land to build rental housing since the reform.[7]

[7] In practice, the strength of collectively operated construction land reform has been vigorous. We collect and present a number of events occurred in these pilot cities. Beijing has successively selected five collectively operated construction land plots in Chaoyang District, Haidian District, and Changping District to carry out pilot rental housing projects. By the end of 2021, Beijing has initiated 51 collective land rental housing projects, providing about 75,000 housing units. In 2018, Songjiang District of Shanghai successively entered the market for five collective rental housing lands, with a total transfer area of about 113,400 square meters and 4,653 rental housing units provided. The construction area of the Sijing Station Project, the first to enter the market, is about 58,000 square meters, with a total planned number of 258 units. It was officially into operation on March 26, 2021. In addition, cities such as Wuhan, Hefei, and Hangzhou have made certain progress. Wuhan has launched the Canglong Island Project in Jiangxia District and the Shekou Village Project in Huangpi District. Hefei officially opened the Binfen Apartment Project in October 2020, and the Changfeng County Project and Yaohai District Project were advancing in order. In 2018, Hangzhou started conducting pilot projects in five districts. The Jianhua Apartment is the first collective land rental housing project put into use in Fuyang District of Hangzhou with 211 housing units. The project on collectively operated construction land not only revitalizes the idle assets of the village collective, but is expected to increase the incomes of the village collective by 3 million yuan per year, helping to stabilize local growth and employment. Up to now, Fuyang has raised a total of 13 affordable rental housing projects, with 14,571 units (rooms).

4.2. Augmented model

According to the above facts, we assume that the government (collective) plans to put $\bar{L}_c \geq 0$ collective operated construction land into the market for each period, and signs the lease contracts with the lessees and firms, respectively. Suppose ρ is the proportion of collectively operated construction land determined by the government to be used for housing demand.

Denote q_{ht}^j and q_{et}^j are the primary market transaction prices of residential and industrial collectively operated construction land, respectively. Now, the objective function of a representative household considers the additional collectively operated construction land L_{ht}^j as a part of residential demand. Thus, the utility function changes to:

$$E_t \sum_{t=0}^{\infty} \beta^t \left[\log(C_t) + \psi \log(L_{ht} + L_{ht}^j) - \varphi \frac{N_{ht}^{1+\eta}}{1+\eta} \right]. \tag{18}$$

The budget constraint is:

$$C_t + q_t(L_{ht} - L_{h,t-1}) + q_{ht}^j L_{ht}^j = w_t N_{ht} + \pi_t. \tag{19}$$

The representative household chooses the optimal L_{ht}^j, which satisfies:

$$q_{ht}^j = \psi C_t / (L_{ht} + L_{ht}^j). \tag{20}$$

Equation (20) means that the price of residential land of the newly increased collectively operated construction land is equal to the marginal substitution rate of consumption and the aggregate demand for residential land. The representative household chooses L_{ht}, and the first-order condition becomes: $q_t = \psi C_t / (L_{ht} + L_{ht}^j) + \beta E_t q_{t+1} C_t / C_{t+1}$.

The representative firm has the following production function:

$$Y_t = A_t K_t^{\alpha(1-\phi)} (L_{et} + L_{et}^j)^{\alpha\phi} N_{et}^{1-\alpha}. \tag{21}$$

Compared with the benchmark model, Equation (21) has another part of the additional industrial demand of collectively operated construction land L_{et}^j. The firm chooses L_{et}^j to maximize the objective function:

$$E_t \sum_{t=0}^{\infty} \beta^t \frac{\lambda_t}{\lambda_0} \left[Y_t - w_t N_{et} - I_t - q_t(L_{et} - L_{e,t-1}) - q_{et}^j L_{et}^j \right]. \tag{22}$$

The first-order condition is as follows:

$$q_{et}^j = \alpha\phi Y_t / (L_{et} + L_{et}^j). \tag{23}$$

Equation (23) is the Euler equation of industrial land. The price of residential demand for collectively operated construction land in t is equal to the marginal output of the aggregate industrial land. The first-order condition of L_{et} becomes: $q_t + \lambda_t^l / \lambda_t = \alpha\phi Y_t / (L_{et} + L_{et}^j) + \beta E_t q_{t+1} \lambda_{t+1} / \lambda_t$.

Defined $\bar{G}$ as total government expenditures, which means that the government's budget constraint is:

$$q_{ht}^j L_{ht}^j + q_{et}^j L_{et}^j = \bar{G}. \tag{24}$$

Rural collectively operated construction land market clearing condition implies that:

$$L_{ht}^{j} + L_{et}^{j} = \bar{L}_c, \tag{25}$$

where $L_{ht}^{j} = \rho L_t$, $L_{et}^{j} = (1-\rho)L_t$. The goods market clearing condition implies that:

$$C_t + I_t + \bar{G} = Y_t. \tag{26}$$

4.3. Impulse response

To perform the quantitative analysis, there are two other parameters to be calibrated in the augmented model. According to statistical data from the first quarter of 2003 to the fourth quarter of 2022, this paper sets the steady-state investment-output ratio to 0.4873. And the residential proportion of collectively operated construction land ρ is set to 0.4692 (=1-0.5308), which refers to the calibration value in the benchmark model.[8] Figure 4 shows that, when facing a positive TFP shock, the pattern is similar to the benchmark model. Compared with the case without the government's upper limit constraint, both the transaction prices of the stock land and the newly increased collectively operated construction land in the first four quarters with policy constraints are underestimated, and output is lower.

4.4. Optimal ratio of collectively operated construction land supply

Taking ρ = 0.4692 as the benchmark, Table 3 reports the impact of different values of ρ on social welfare with a positive TFP shock.[9] The results show that when 1 – ρ = 0.4, the improvement in social welfare is the largest. With 1 – ρ gradually increasing from 0.2, social welfare first rises and then decreases, showing an inverted-U shape. When 1 – ρ < 0.4, the proportion of the stock of residential land plus the newly increased collectively operated construction land (residential part) is high. According to Equation (20), the marginal substitution rate of consumption and residential land demand decreases, the marginal utility of consumption increases, and every additional unit of household consumption becomes relatively more valuable. In this process, land price q_{ht}^{j} decreases. Therefore, too much residential land supply affects household consumption, while too little industrial land supply reduces final output and consumption, which has a negative impact on social welfare. When 1 – ρ > 0.4, the proportion of the stock of industrial land plus the newly increased collectively operated construction land (industrial part) is

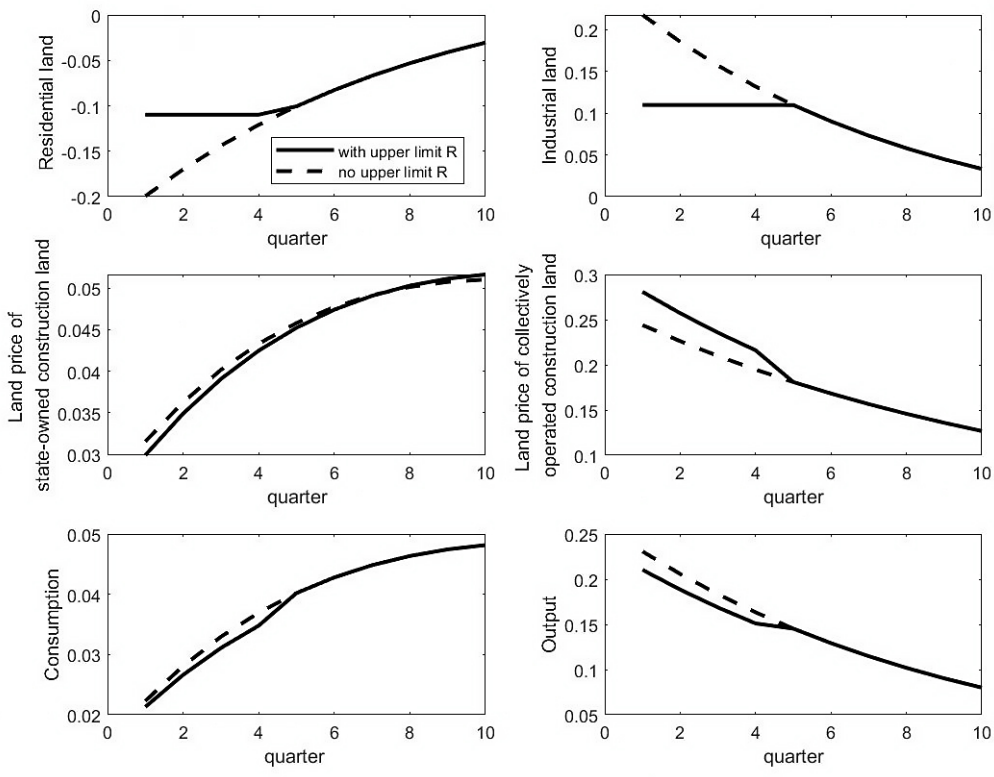

Figure 4. Impulse responses (augmented model)

[8] Since the reform of collectively operated construction land was just passed in August, 2019, so far there is no accurate data to calibrate ρ. This paper can only do simulations and quantitative analysis based on the land supply data in the existing the *China Land and Resources Statistical Yearbook*.

[9] The simulations for the augmented model mainly focus on the optimal supply proportion of collectively operated construction land by assuming that the stock land market has been optimized.

Table 3. Welfare gains from the augmented model

1 − ρ	Welfare gains (%)	1 − ρ	Welfare gains (%)
0.2	0.5282	0.5308	0
0.3	0.6670	0.6	–0.0653
0.4	0.8035	0.7	–0.3486
0.5	0.2800	0.8	–0.7752

high, and it can be seen from Equation (23) that the marginal output of industrial land decreases. Meanwhile, the low stock of residential land leads to high land prices and crowds out consumption, which hinders the improvement of social welfare. It means that, from the perspective of collectively operated construction land, the optimal ratio of industrial land is about 40% at the highest social welfare level. This further proves the robustness of the main results in this paper. Whether it is the allocation of urban construction land (benchmark model) or the incremental collectively operated construction land (extended model), quantitative analysis with Chinese data shows that maintaining a ratio of 6:4 between residential and industrial land can reach the first-best social welfare.

This paper enriches the literature, which mainly focuses on secondary land market transactions rather than the land supply led by the government in the primary market. The main results in this paper are in line with Wang and Tan (2020), Cheng et al. (2022) and Yang et al. (2023), in which land marketization reform helps improve resource allocation. Besides the theoretical model, this paper further provides quantitative numerical analysis to clarify the policy suggestion. This paper also provides useful insights for countries with public land ownership, like China, to regulate the economy by adjusting land supply. When local government can control the quantity and type of land supply, land policy can become a major tool affecting macroeconomic fluctuations. Since the establishment of the first 14 national industrial zones in 1984, various types of industrial zones in China have developed rapidly. In 2006, the central government released the "*Catalogue of Review Announcements for China's Industrial Zones*", which announced 1568 industrial zones that met the conditions. In March 2018, the number of industrial zones in China increased to 2543. In 2021, there were a total of 2728 national and provincial-level industrial zones in China. The rapid development is supported by a large amount of industrial land from the local government. However, while local governments vigorously promote industrial investment, it cannot be ignored that some industrial zones lack large-scale projects and enterprises with agglomeration effects, leading to an increasing phenomenon of hollowing out. This also leads to inefficient use of a large amount of industrial land and land resource misallocation. Properly increasing the supply of residential land and lowering the upper limit of industrial land can achieve Pareto improvement.

5. Conclusion

Based on the scope of land supply marketization, this paper studies the following three issues: first, the mechanism of land supply structure constraint stipulated by the government on land price, investment and output. Second, the optimal proportion of residential land and industrial land in the land (stock) market. Third, the optimal structure of collectively operated construction land when it is introduced into the model.

By constructing a DSGE model and conducting quantitative analysis, we find that the government's land planning constraint affects consumption and social welfare through the land price and final output. The trade-off leads to an inverted-U shaped social welfare path. The numerical simulations show that the optimal upper limit of industrial land is about 40%. Besides, we embed the collectively operated construction land into the model, and find that the optimal ratio of industrial land to residential land is about 4:6 to reach the first best.

In fact, we find that the ratio of industrial land to residential land during the sample period is higher than 40% all the time. Although the Chinese government has launched a number of policies to mitigate the misallocation of land supply, including providing affordable houses, it still has a gap in achieving maximum social welfare. This paper provides a benchmark for policymakers to understand the triangulation of marketization, economic fluctuation and social welfare. The market-oriented land reform is an important measure to promote economic development in China. This paper argues that in addition to the financial, tax, investment, legislation and other means emphasized in the traditional literature, more attention should be paid to implementing land supply policy. In cities under tremendous pressure of rising house prices, the government should reasonably increase land supply and the proportion of residential land, revitalize idle and inefficient urban land, and simultaneously speed up the marketization of collectively operated construction land.

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