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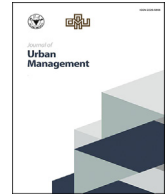
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Research Article

A study on promoting the intensive use of industrial land in China through governance: A game theoretical approach



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ABSTRACT

Extensive use of industrial land has been typical for many cities in China since the end of the previous century. One of the most important reasons is the local governments' strategy choice in land use. In this research, a governance structure from the view of the tax-sharing system and the performance appraisal system is constructed to explain the causes of extensive land use using game theory analysis. The key finding is that the governance structure in industrial land use is an organizational structure composed of the central government, local government and the market, and these three participants hold inter-conditioned relationships so as to form a closed loop. However, a bottom-up relationship chain from the market is absent in this structure, which makes it difficult to rely on local governments to implement intensive use of industrial land by themselves. Game equilibrium analysis shows that if a performance penalty coefficient is considered to refine the existing performance appraisal system to help produce a market feedback, the possibility of local governments adopting extensive land use strategies will be reduced.

1. Introduction

Land is the most critical issue in urban construction, and its efficient and intensive use is the basis for sustainable urban development. Private ownership system of land predominates in most developed countries, where the free land market has already formed. Whether it is state-owned land, public land, or private land, they can all be exchanged in the market. But unregulated land markets are easy to bring problem like “market failure”, because the value and related benefits that the land can produce are strongly influenced by the characteristics of the adjacent land (Sardaro et al., 2021). In this way, authorities also formulate relevant policies or strict plans to regulate land use activities. Public policy can correct some market failures. Government participation can greatly reduce the negative externalities of pollution and unreasonable land use, and defuse the situation of public services inefficiency and social inequality (Lai, 2020; Tang et al., 2020). As for China, the *Land Management Law* stipulates that “land in urban areas shall be owned by the state” and the land market is still in a developing stage. The government occupies a leading position in land market. However, government-dominated land market is coupled with extensive use of land and misallocation of resources. The reform and exploration of land systems and management methods should be further carried out.

Intensive land use has become an important issue since the central government of China listed it as a major task in promoting

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ecological civilization construction at the Party's 18th National Congress. The approach to industrial land use is a crucial issue in the debate on the intensive and economical use of land. For China's urban development, industrial land is one of the key cornerstones. The construction of industrial parks has spread out all over the country since the 1990s. This construction boom has promoted China's economic growth over the past few decades, but the adverse consequences that came with it are dispiriting (Liu et al., 2018; Xu & Heikkilä, 2020). The most obvious of these negative points is that local governments advocate the strategy of "attract investment by land", which means the governments sell large quantities of industrial land with "low land prices" or even "zero land price" in an attempt to make capital flows into their own jurisdictions (Du & Peiser, 2014; Luo et al., 2018; Wu et al., 2016). Such behavior has seriously interfered with the market allocation rules of land as a scarce resource (Chen, Shen, Wang, et al., 2018; Pan, Zhang, Zhu, & Wójcik, 2017). This results in the existing situation of extensive utilization in industrial land and even makes the contradiction among land, people and physical environment more acute (Kimura et al., 2011; Sun et al., 2020; Wang et al., 2017). The main manifestations of the extensive use of industrial land in most cities in China are the large number of development zones, planned area, and idle land.

Many studies have investigated the institutional factors that leads to the extensive use of industrial land or how to smooth the implementation of intensive land use. Attention has been given to the governance structure analysis relating to industrial land, which is believed as the determinant of the expansion speed and efficiency of industrial land development. Relative studies focus on the discussion of centralization and decentralization to expound connotation of the governance structure (Biitir & Nara, 2016; Pedersen, 2012; Tansel, 2019). The centralization of land management is responsible for China's extensive form of urbanization-a widespread conversion of rural land to construction land (Wei et al., 2017; Wu et al., 2017). Based on China's institutional environment, local government is the sole supplier of industrial land, and the central government is the regulator of the land market. In addition, regional competition for foreign direct investment tends to create conflicts over land because of the tax sharing system (Hsu et al., 2017; Hui et al., 2015; Wu & Heerink, 2016). It is generally recognized that local government transfers industrial land at a low price to attract investment and promote economic development (Chen, Shen, Wang, et al., 2018). To set appropriate governance structure for intensive use of industrial, urban land marketization should be pushed forward. Land market-oriented reform can rectify land resource mismatches and is conducive to improve the efficiency of industrial land (Du & Li, 2021). The significant roles played by government actions and institutions need to be taken into account in the reform of land marketization (Li et al., 2015). Weak market power is the main problem of urban land market. The improvement of the marketization of resource allocation through the land reserve system and the strengthening of the government's regulation of the land market can effectively promote the normal development of the land market (Fan et al., 2020; Jiang & Lin, 2021). Since land marketization is a bottom-up practice by authorities, encourage local officials to construct an efficient land market is an urgent issue for the central government (Li et al., 2020).

Despite the extensive studies regarding the contributory factors of extensive use of industrial land, how to symmetrically propose and illustrate the governance structure of industrial land use and analyze the impact of the behavior of local governments, has rarely been discussed. Local governments are involved in the process of land use, and the game between them directly affects the result of land allocation (Zhang et al., 2020). Depicting characteristics of governance structure and coordinating interests of governments are extremely important in promoting the intensive use of industrial land.

This study constructs a governance structure with the case of China, starting from two nodes -"tax" and "performance", and uses a combination of qualitative and quantitative game theory to analyze the dilemma of industrial land caused by the tax-sharing system (tax node). For the achievement node, market feedback signals from the improved performance appraisal system will be explored to find out its impact on local government's strategic choice of land supply. Here, the term "node" is defined as a link, or junction point between institutional components. The remainder of this paper is organized as follows. Section 2 introduces the conceptual framework and illustrates the meaning of governance structure in the study. Section 3 discusses the game application between local governments through the perspective of the tax-sharing system. Section 4 analyzes the game equilibrium between local governments in industrial land use strategies with the consideration of the performance appraisal system. Section 5 discusses the research results and Section 6 provides conclusions of this study.

2. Conceptual framework

2.1. Self-interest: Local government

From the perspective of industrial land management, the relationship between the central government and local government can be described as "Principal-Agent". In the early era of highly centralized planning economy, the central government and the local government established contractual relations through administrative appointments. Centralized managements lack flexibility and could not fully motivate the enthusiasm and creativity of the subordinates. It is true that centralization did internalize the spillover effects between regions, but this unidirectional "administrative order" relation chain spawned an inefficient state of the entire economy and society. After the Chinese reform and opening up, the previous central and local relations were changed by wholesale reform of "decentralization and profit sharing" (Wu et al., 2016). Local governments then had more autonomy and decision-making power in dealing with local economic and social affairs. In other words, the local governments held greater financial power than before, so they could spare no effort to carry out economic construction. But relatively, the central government was unfortunately caught in a cash-strapped situation, in which its financial support on macroeconomic regulation and control was insufficient.

Effective macroeconomic regulation and control policy are the guarantee of social stability. In order to strengthen the states' fiscal functions and consolidate the central government's macro-control capabilities, the State Council introduced a fiscal and taxation system in 1994 to draw a line of demarcation between the central and local fiscal revenues and expenditures (Zhang, 2000). In the context of the new tax system, the grass-root government needs to continuously pay funds to the higher authorities while still taking the responsibility

for local public affairs and services, which produces a great pressure on local finance. Against that backdrop, the local government actively pursued investment attraction with the aim of increasing fiscal revenue. They take advantages of factor-markets like capital, land and population markets. For example, “low price industrial land” is treated as the bait by the local governments and used to lure capital from enterprises; then enterprises come and settle down in local industrial parks and provide more employment opportunities for citizens. Unlike the United States,¹ the enterprise’s *production and operation income tax* is shared by the central and local governments in China. The central government just takes 60% of this tax revenue, which means this tax is a considerable source of income for the local government, and this income is long-term (because enterprises are long-lived). From this perspective, it seems obvious that if the central government limits the industrial land transfer price as well as its amount, the local governments’ fiscal revenue will be badly affected. In addition, the shortage of money will also influence the enthusiasm of local governments to promote intensive use of industrial land, which requires a large number of capital inputs in land redevelopment, land supervision, and land consolidation.

The fundamental reason behind the local governments’ pursuit of financial increase and investment attraction, is primarily in improving their political achievements. The evaluation of political achievements is closely related to the performance evaluation system. China’s performance evaluation system refers to the system that assesses the economic and political behavior actually produced by the leadership team during the term of service, and is also an important reference for the promotion of officials. Corresponding to economic and political behavior, the indicators in the existing assessment system can be divided into two types, “hard indicators” and “soft indicators”. The former refers to economically relevant quantifiable indicators, such as GDP, fiscal revenue, etc.; the latter represents socially relevant indicators such as medical care, education, and social security. In practice, the central government places more emphasis on the status of “economic output” and assessed local governments with “hard indicators” in the evaluation. Financial increase, as well as investment attraction, is a crucial thrust for economic development. Therefore, local governments begin to attract large-scale investment. In this process, land, especially industrial land, which is an important resource carrier for investment attraction, is extensively requisitioned for project development and construction.

Simply put, in the context of such tax sharing and the performance appraisal system, the locals are willing to take “land” as a bargaining chip to attract companies to settle in. Such kind of game driven by profit results in the extensive use of land at the cost of agriculture and other non-industrial activities.

2.2. Governance structure: Unclosed loop vs closed loop

Governance structure is a term often defined as “the institutional framework for the entire transaction process” or “institutional matrix for negotiation and execution of transactions” (Williamson, 1979). It is an approach to effective government and/or institutional management. What kind of governance structure should be chosen to promote intensive use of industrial land, in essence, is how to allocate government and market forces in the process of industrial land management. In the other words, it is the issue of centralization and decentralization.

The study describes the industrial land governance structure as an organizational structure composed of the central government, local government and market, and these three participants hold inter-conditioned relationships. Specifically, local governments and markets take tax as a node to form a top-down relationship chain; the central government and the local government are principal-agent relationships, forming a top-down relationship chain with political performance as the node. These two chains cannot form a closed loop. A feedback chain, namely the bottom-up relationship chain from the market is missing. The reason is that China is affected by certain historical conditions, and the state governance system is still a governance model with relatively high powers and an emphasis on government authority. In the case of excessive government control in “land” resource, the market vitality is not able to be effectively stimulated, resulting in the phenomenon of market “absence” (see Fig. 1).

In China, the government monopolizes industrial land supply market, and the lack of feedback from the market is not conducive to intensive use of industrial land. It seems necessary to make use of appropriate decentralization to play the role of the market in governance. The importance of the market role is not limited to the management of industrial land, or even just to the land. In the context of the transformation of the socialist market economy, suppressing the vitality of other governance entities is undoubtedly a stumbling block to the sustainable development of the urban economy. Therefore, there exists a failure of governance structure in industrial land use, which makes it difficult to achieve optimal configuration of resources. The central government can obtain valuable market information through a market-to-government bottom-up feedback relationship chain. Thus, we use the level of intensive use of industrial land as a market feedback signal and incorporate punishment indicators into the performance appraisal system to form a closed loop for governance structure (see Fig. 2). The closed loop, consisting of central government decision-making, local government implementation, and market feedback, can guarantee the integrity and systematicity of industrial land management, and thereby contributes to intensive use of industrial land.

3. Tax node: Game between local governments

The industrial land use pattern is closely related to the supply of industrial land. The existing governance structure makes the latter determined by the government rather than the market. Considering the low land pricing and large land supply, enterprises will tend to

¹ The United-States is a federal state that implements a three-tier government tax system. Governments at all levels have legislative and expropriation rights for their respective taxes: the federal government collects federal taxes, including production and operation income tax and social insurance taxes; the state government collects state taxes, mainly consumption taxes; the local government collects the local tax, mainly property tax.

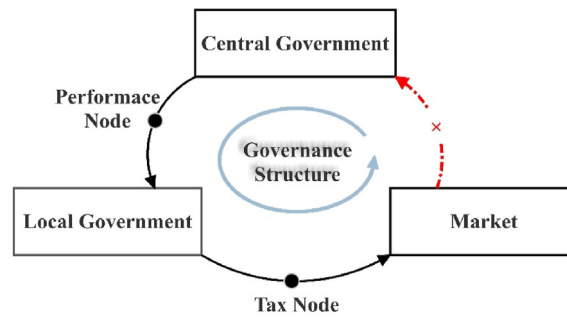


Fig. 1. Industrial land governance structure with unclosed loop.

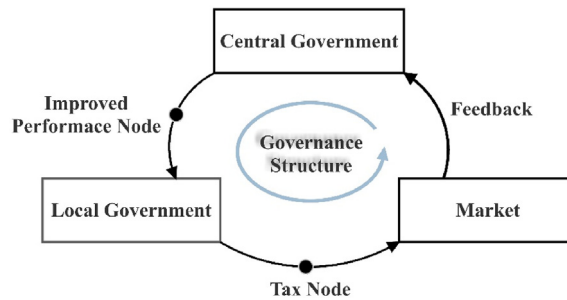


Fig. 2. Industrial land governance structure with closed loop.

acquire the most land with the least amount of capital as long as production technology allows. The phenomenon of extensive and inefficient use of industrial land is an inevitable result of the present policy.

3.1. Inter-regional supply game

This Section draws on the theory of “Prisoner’s Dilemma” (finite repeated games) and constructs a game model for local governments’ supply activities. A key assumption in this game is that bureaucrats are self-regarding utility maximizers. In order to simplify the model, two game players are named as region A and region B. The analysis makes the following assumptions:

- (1) The investment environment of A and B is similar;
- (2) The present value of future tax revenues brought by enterprises is U_1 , and the positive external income like economic growth brought by investment activity is quantified as U_2 . The total earning from investment attraction is assumed to be fixed and recorded as $2(U_1 + U_2) = 2U$; and
- (3) It costs government C to supply one unit of industrial land. Increasing the supply (n) of industrial land can attract more investment. ($n \geq 1$)

According to the above assumptions, when the local governments of A and B take different industrial land use strategies, the benefits of these two are shown as in Table 1.

The payoff matrices of A and B are:

$$A = \begin{bmatrix} U - nC & 2U - nC \\ 0 & U - C \end{bmatrix}$$

Table 1
Industrial land supply strategies and corresponding earnings.

		B	
		Extensive strategy	Intensive strategy
A	Extensive strategy	$U - nC, U - nC$	$2U - nC, 0$
	Intensive strategy	$0, 2U - nC$	$U - C, U - C$

$$B = \begin{bmatrix} U - nC & 0 \\ 2U - nC & U - C \end{bmatrix}$$

Extensive and intensive are relative concepts. It is assumed here that intensive strategy means providing one unit of industrial land and extensive strategy stands for providing n units of industrial land.

For the sake of analysis, we calculate the extreme return value. This means if A increases the land supply amount, B will lose all the investment. The earnings of A and B are $2U - nC$ and 0 respectively. In real life, the project investment earnings brought by increasing supply of industrial land is far greater than the supply cost of the land itself, that is $U > (n-1)C$, $2U - nC > U - C$. Supposing B chooses intensive strategy for industrial land, if A chooses the same strategy, A will get $U - C$; if A chooses the extensive strategy, A will get $2U - nC > U - C$. Supposing B chooses the extensive strategy for industrial land, if A chooses the same strategy, A will get $U - nC$; if A chooses the intensive strategy, A will get $0 < U - nC$. So regardless of the strategy chosen by B , A will choose the extensive strategy. Similarly, B will adopt the intensive strategy as well. The total earning of strategy profile {extensive strategy, extensive strategy} is lower than that of strategy profile {intensive strategy, intensive strategy}.

What if A and B set up an agreement beforehand and everyone adopts the intensive strategy, can {intensive strategy, intensive strategy} equilibrium be achieved? Actually, in a complex or uncertain environment, individuals tend to adopt contingency strategies, or also called scenario strategies. At this time, there is no fixed pattern for the behaviors' decision-making for their actions depend on specific cases. Thus, if breaking the rules yields more benefits than following them, the players may attempt to violate established rules (e.g. intensive strategy). It can be seen that Pareto equilibrium cannot be achieved without other external forces (e.g. market feedback). Since the equilibrium of finite repeated games is a repetition of a single game's equilibrium, the final equilibrium result will be {extensive strategy, extensive strategy}. In the end, two regions attract the same investment amount, but the supply of industrial land gets increased. Industrial land is utilized in an extensive way while overall earnings decline, which is not conducive to the social economy's long-term stable development.

3.2. International supply game

Industrial investment competition is not limited to the domestic market. The international market, especially the surrounding countries of China, whose distribution and changes in its trend of industrial land can impact upon China's industrial land supply strategy significantly. Southeast Asian countries such as Vietnam, Malaysia, and Thailand have great potential to attract foreign investment. A certain number of manufacturing companies have moved to these Southeast Asian countries instead of the central and western regions of China (Zhang et al., 2017). Of course, one reason is the inflation in Chinese labor costs. Another reason is the land prices in cities in China are higher than the average level of that in Southeast Asian cities. For example, the net land price of industrial land in Thailand is about 250–500 yuan/square meter, which is equivalent to the lower limit of the industrial land price in major cities in China.² Meanwhile, government also provides investors with tax breaks and start-up funds. Affected by the international land market, it is quite difficult to forcefully increase the price of industrial land in China. Local governments are more willing to lower land prices to ensure strong competitiveness and promote industrial development. This kind of behavior can easily cause industrial land to be sold in large quantities at a low price.

Local governments' quandary is obvious: on the one hand, excessive competition creates more land supply. On the other hand, if an extensive supply strategy is not adopted, enterprises will move out. From a sustainable development perspective, whether it is for the central or the local governments, the extensive use of industrial land is not a good choice. Breaking the deadlock of vicious competition requires a complete and reformative governance structure.

4. Performance node: Game between local governments

As mentioned above, the central and local governments have a top-down relationship chain with respect to the achievement's node. The economic growth brought by investment attraction is directly linked to the government's performance evaluation. In order to further understand the impact that performance appraisal system has on industrial land supply strategy and add "market feedback" into governance structure, the term "performance appraisal benefit" is introduced.

4.1. Constraint condition of model

The basic model here follows the prisoner's dilemma model in game theory. A and B are two players in the game. Since economic growth is directly linked to the government's performance valuation, the performance gains can be quantified as an increase in economic growth. To simplify the model, the following constraint conditions are proposed:

- (1) The investment environment of A and B is similar;
- (2) Both players in the game expect to attract investment by expanding industrial land investment;
- (3) There is still some flexibility in local governments' supply on industrial land even though there is a "total quantity control" policy constraint from the central government on construction land; and

² Data source: <http://m.fang.com/newsinfo/taiyuan/5578073.html>.

(4) The enterprises will choose the person who provides the most industrial land (The cost of land acquisition is fixed).

Two comparison scenarios are set: one is the game under the original performance appraisal system focusing on economic growth; the other is the game under the improved performance appraisal system in which the negative impact of extensive use is considered. The economic benefits obtained by the local government from investment attraction under the original performance appraisal system can be completely converted into political achievements, and the performance gain under the improved performance appraisal system is calculated as “performance achievements from economy growth + extensive land use performance punishment”. Introducing “extensive land use performance penalty” is actually adding a transaction cost variable to the model to quantify the negative externalities of extensive land use.

4.2. Game under the original performance appraisal system

Supposing government can gain economic benefits $2T$ from investment attraction, per unit industrial land acquisition cost is C_1 , per unit land price subsidy for enterprise is C_2 , total cost of per unit industrial land is $C=C_1+C_2$. The land leasing amount for the intensive strategy is 1 , for the extensive strategy is q , and the capital transfer coefficient $k \in (1,2]$.

The payoff matrices of A and B are:

$$A = \begin{bmatrix} T - qC & kT - qC \\ (2 - k)(T - C) & T - C \end{bmatrix}$$

$$B = \begin{bmatrix} T - qC & (2 - k)(T - C) \\ kT - qC & T - C \end{bmatrix}$$

Define the ratio of the economic benefits T to the total cost of per unit industrial land C as benefit-cost coefficient m , namely $m = T/C$. The above payoff matrices can be simplified as:

$$A = \begin{bmatrix} m - q & km - q \\ (2 - k)(m - 1) & m - 1 \end{bmatrix}$$

$$B = \begin{bmatrix} m - q & (2 - k)(m - 1) \\ km - q & m - 1 \end{bmatrix}$$

Usually, the project investment earnings brought by increasing the supply of industrial land is far greater than the supply cost of the land itself, so $(k - 1)mC \gg (q - 1)C$ and we get $(k - 1)m \gg q - 1$. The earnings of A and B with different strategies are as follow:

(1) If B adopts the intensive strategy, the difference in earnings between A’s choices of extensive strategy and intensive strategy is:

$$km - q - (m - 1) = (k - 1)m - q + 1$$

Since $k \in (1,2]$ & $(k - 1)m \gg q - 1$, $(k - 1)m - q + 1$ must be much larger than zero. This indicates that when B adopts an intensive strategy, the earnings of A’s choice of extensive strategy is higher than that of the intensive strategy.

(2) If B adopts the extensive strategy, the difference in earnings between A’s choices of extensive strategy and intensive strategy is:

$$km - q - (m - 1) = (k - 1)m - q + 1$$

Since $k - 1 \in (0,1]$, $-k + 1 \in [-1,0)$, $(k - 1)m - q + 1$, $(k - 1)m - q - k + 2$ must be larger than zero. This indicates that when B adopts the extensive strategy, the earnings of A’s choice of the extensive strategy is higher than that of the intensive strategy.

Due to the symmetry of the game, regardless of the strategy adopted by A, the optimal strategy of B is the extensive strategy as well.

4.3. Game under the improved performance appraisal system

The performance appraisal system plays a pivotal role in the process of urbanization in China. Building a sustainable development-oriented performance appraisal system and introducing market signals to rebuild incentives and constraints is imperative. The economy-oriented performance appraisal system, to some extent, led to the extensive land use pattern. The construction of industrial parks and duplication of similar projects emerge one after another. It seems quite unrealistic to anchor hope in local government itself to solve this problem spontaneously.

In the improved performance appraisal system, the level of intensive utilization of industrial land will be added as a new factor to establish contact with “market feedback”. Given the benchmark economic benefit of per unit industrial land, T_0 . If A or B adopts intensive land strategies, the per unit industrial land economic benefit $T = T_0$. To simplify the calculation, define σ as the performance penalty coefficient, and record $B = \sigma T$ to represent that B unit of performance loss is equivalent to σT of the economic loss. When the economic benefit of per unit industrial land in the region is T_0 , no performance penalty will be imposed; when the economic benefit of per unit industrial land is zero, the punishment will to reduce the performance of the B unit. Then if the region expands the land transfer

amount to q , the economic benefit will be kT and economic benefit of per unit industrial land will be kT/q , so the penalty is reducing $(1 - kT/q)$ B unit performance, and the equivalent economic benefit loss is $(1 - k/q)\sigma T = \alpha T$, $\alpha = (1 - k/q)\sigma$. Correspondingly, the payoff matrices of A and B can be transformed into:

$$A' = \begin{bmatrix} (1 - \alpha)m - q & km(1 - \alpha) - q \\ (2 - k)(m - 1) & m - 1 \end{bmatrix}$$

$$B' = \begin{bmatrix} (1 - \alpha)m - q & (2 - k)(m - 1) \\ km(1 - \alpha) - q & m - 1 \end{bmatrix}$$

If B adopts an intensive strategy, the difference in earnings between A's choices of the extensive strategy and the intensive strategy is:

$$km(1 - \alpha) - q - (m - 1) = (k - 1)m - q + 1 - \alpha km$$

Since $k \in (1, 2]$ & $(k - 1)m \gg q - 1$, $(k - 1)m - q + 1$ must be much larger than zero. This indicates that when B adopts the intensive strategy, the earning of A's choice of an extensive strategy is higher than that of an intensive strategy.

If B adopts the extensive strategy, the difference in earnings between A's choices of an extensive strategy and an intensive strategy is:

$$(1 - \alpha)m - q - (2 - k)(m - 1) = (k - 1)m - q - k + 2 - \alpha m$$

Based on the above results, there are three situations in the industrial land strategy selection in these two places:

(1) Situation 1: Both adopt extensive strategies

When $\begin{cases} (k - 1)m - q + 1 - \alpha km \geq 0 \\ (k - 1)m - q - k + 2 - \alpha m \geq 0 \end{cases}$, namely $\begin{cases} \alpha \leq \frac{(k - 1)m - q + 1}{km} \\ \alpha \leq \frac{(k - 1)m - q - k + 2}{m} \end{cases}$, the earning of A's choice of an extensive strategy is

always greater than that of an intensive strategy. Since $(k - 1)m - q + 1 \gg 0$, $-k + 1 \in [-1, 0)$, we can infer $\frac{(k - 1)m - q + 1}{km} \approx \frac{k - 1}{k} \cdot \frac{(k - 1)m - q - k + 2}{m} \approx k - 1$, and then the value range of α for A with the extensive strategy can be further simplified to

$$\begin{cases} \alpha \leq 1 - \frac{1}{k} \\ \alpha \leq k - 1 \end{cases} \Rightarrow \begin{cases} \sigma \leq \frac{kq - q}{kq - k^2} \\ \sigma \leq \frac{kq - q}{q - k} \end{cases} \Rightarrow \sigma \leq \frac{kq - q}{kq - k^2}. \text{ The value range of } \sigma \text{ for B with an extensive strategy can be calculated in the same way.}$$

(2) Situation 2: Both adopt intensive strategies

When $\begin{cases} (k - 1)m - q + 1 - \alpha km \leq 0 \\ (k - 1)m - q - k + 2 - \alpha m \leq 0 \end{cases}$, namely $\begin{cases} \alpha \geq \frac{(k - 1)m - q + 1}{km} \\ \alpha \geq \frac{(k - 1)m - q - k + 2}{m} \end{cases}$, the earning of A's choice of an intensive strategy is

always greater than that of an extensive strategy. The value range of α for A with the extensive strategy can be further simplified to

$$\begin{cases} \alpha \geq 1 - \frac{1}{k} \\ \alpha \geq k - 1 \end{cases} \Rightarrow \begin{cases} \sigma \geq \frac{kq - q}{kq - k^2} \\ \sigma \geq \frac{kq - q}{q - k} \end{cases} \Rightarrow \sigma \geq \frac{kq - q}{q - k}. \text{ The value range of } \sigma \text{ for B with the intensive strategy can be calculated in the same way.}$$

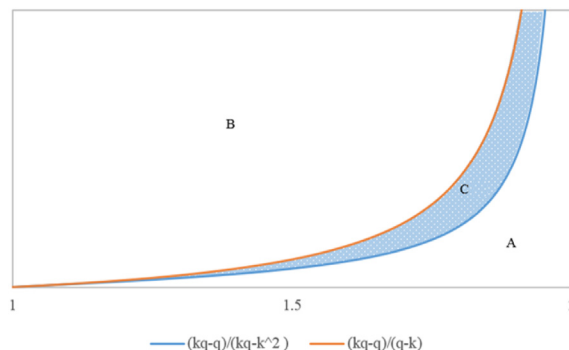


Fig. 3. Game equilibrium.

(3) Situation 3: Both adopt mixed strategies

When the performance penalty coefficient σ is outside the above two ranges of values ($\frac{kq-q}{kq-k^2} < \sigma < \frac{kq-q}{q-k}$), if B adopts the intensive strategy, the earning of A's intensive strategy is better than that of the extensive strategy; if B adopts the extensive strategy, the earning of A's extensive strategy is better than that of the intensive strategy. The same is true for B's optimal choice.

Assuming that the industrial land leasing amount for an extensive strategy is $q = 2$, the value of σ in above three situations can be visually represented in Fig. 3. The horizontal axis represents k and the vertical axis represents σ . If the values of σ and k fall in the A zone, situation 1 occurs, that is, no matter which strategy will be adopted by one player, the other player adopts the industrial land extensive utilization strategy. If the values of σ and k fall in the B zone, situation 2 occurs, that is, regardless of the strategy adopted by one player, the other player adopts the industrial land intensive strategy. If the value of σ and k fall in the blue zone C, situation 3 occurs, that is, one player selects the industrial land extensive strategy, then the other player also adopts the industrial land extensive strategy; one player adopts the intensive strategy, then B also adopts the intensive strategy. It can be seen that the land use strategy of the two players is mutually influential in the C area. In a static game, the possibility of one player choosing an intensive strategy depends on how much he believes that the other player also chooses the intensive strategy.

4.4. An application of equilibrium strategy

Local governments are inclined to pursue an extensive strategy under the original performance system. Therefore, it is difficult to effectively implement intensive use of industrial land by relying on the local government itself. External restriction should be introduced. A threshold value of per unit industrial land economic benefit and performance penalty coefficient can be helpful tools for the market to send a signal back to the central government. The closed loop of the governance structure then becomes complete and is ready to promote intensive use of industrial land.

When the benchmark economic benefit of the per unit industrial land is determined, the effectiveness of the improved policy performance appraisal system is dependent on the specific values of the investment transfer coefficient k and the performance penalty coefficient σ . These two variables have a strong influence on the choice of local government land strategies.

By sorting out the industrial park development report of some coastal cities in China, it is found that the cost of acquisition of 1 mu³ of industrial land and transfer subsidies is about 150,000 RMB, the tax per mu is about 600,000 RMB, and the enterprises can provide tax revenue for government in 20 subsequent years, so $T = 12$ million RMB and $m = T/C = 80$. Assuming a capital transfer coefficient of $k = 1.2$ and the industrial land supply increase $q = 2$, one can conclude that both adopt extensive strategies if $\alpha \leq 0.156$, $\sigma \leq 0.39$ (situation 1); both adopt intensive strategies if $\alpha \geq 0.185$, $\sigma \geq 0.46$ (situation 2); and both adopt mixed strategies if $0.156 \leq \alpha \leq 0.185$, $0.39 < \sigma < 0.46$. In situation 3, let x be the probability of A taking an extensive strategy, and $1-x$ is the probability of adopting an intensive strategy, y is the probability of B taking an extensive strategy, and $1-y$ is the probability of an intensive strategy. A's expected earning is:

$$E(x) = [(akm - am + 1 - k)y + km - k\alpha - q - m + 1]x + (m - 1)(3 - k - y)$$

B's expected earning is:

$$E(y) = [(akm - am + 1 - k)x + km - k\alpha - q - m + 1]y + (m - 1)(3 - k - x)$$

The critical value of the two formulas is:

$$x = y = \frac{-km + k\alpha + q + m - 1}{akm - am + 1 - k}$$

Substitute the values of k and m into the above formula. By setting different performance penalty coefficients σ and their corresponding α values, we can obtain the probability distribution of A & B's choosing extensive strategy (See Table 2).

Obviously, the higher the performance penalty coefficient, the lower the probability that local governments will choose an extensive strategy. For example, when the performance penalty coefficient is 0.39, no matter which strategy that B chooses, A will adopt an extensive strategy. When the coefficient rises to 0.42, if the government of B is 45% likely to choose extensive strategy, A will adopt extensive strategy. Once the coefficient further rises to 0.45, only when the probability of B choosing an extensive strategy exceeds 85%, A will adopt the extensive strategy. If the coefficient of performance penalty reaches 0.46, then A will choose the intensive strategy without regard to B's choice.

5. Discussion

5.1. The limitation of governance structure with unclosed loop

Despite a highly centralized administration, there has been a striking move away from a uniform approach to local authorities where now differentiation between regions has been actively encouraged (Caulfield, 2006; Zhang et al., 2021). A region's development is closely related to local competitiveness and potential. Local governments have strong incentives to supply more industrial land at a very

³ Chinese land measure. 1 mu = 666.67 m²

Table 2
Probability distribution of A & B choosing extensive strategy.

Performance penalty coefficient σ	A: extensive strategy $x = 1 y$	A: extensive strategy $y = 1 x$
0.38	[0,1]	[0,1]
0.39	[0,1]	[0,1]
0.4	(0.15,1]	(0.15,1]
0.41	(0.31,1]	(0.31]
0.42	(0.45,1]	(0.45,1]
0.43	(0.59,1]	(0.59,1]
0.44	(0.72,1]	(0.72,1]
0.45	(0.85,1]	(0.85,1]
0.46	NA	NA
0.47	NA	NA

low prices partly because of the importance that the manufacturing sector shows in generating local GDP as well as increasing local job opportunities (Cao et al., 2008). Besides, in the present tax-sharing system, an extensive strategy is able to ensure local competitiveness while providing budgetary revenue through production and operation income tax (Luo et al., 2018). Given that the promotion of intensive use of industrial land requires local governments to invest a lot of funds for land redevelopment, land supervision, and land consolidation. Therefore, from the perspective of fiscal stability, local governments will not actively advocate the intensive use of industrial land ideologically. The fundamental reason behind the local government's pursuit of financial stability is to improve its own political performance, which is closely related to evaluation results of political performance.

In summary, between promoting the intensive use of industrial land or maximizing regional economic benefits, local governments prefer the latter. They expect to realize the prosperity and development of the regional economy by supplying industrial land. Due to the absence of “market feedback” in unclosed governance structure, the governments’ extensive land use strategy has not been severely punished. The disorderly spread of industrial construction occupies a large amount of high-quality cultivated land. The conversion of cultivated land to construction land is not reversible. Once high-quality cultivated land is occupied, it is relatively difficult to return it to the previous state. Although China’s agricultural production may have achieved a balance between supply and demand, food security is still essential to China’s economic and social stability, especially in view of the excessive use of chemical fertilizers and pesticides, fertility decline and arable land pollution. Promoting intensive use of industrial land is to transform the focus of industrial land from quantity to quality, from extensive to intensive, and help slow down the expansion of urban land use as well as realize the protection of cultivated land.

5.2. The applicability of governance structure with close loop

When improved performance appraisal system is introduced into the governance structure to show the “market feedback” and make the loop close, the game equilibrium solution suggests that improved systems can guide local governments’ decision-making behavior in industrial land use. The central government can set a higher performance penalty coefficient for market feedback, and thus, control the level of industrial land intensiveness of local governments. Whereas, the loss of political achievements may reduce the enthusiasm of local governments in attracting investment and even potentially hamper regional economic development, it would be for the overall good of society. In real society, factors like different stages of economic and social development, different players, multiple game subjects can at least partially change the value of the capital transfer coefficient. When k floats between 1 and 2, the participant's land strategy changes accordingly, and the critical value of the performance penalty coefficient corresponding to the game equilibrium varies as well. That is to say, government intervention should pay more attention to promote a more market-oriented environment with strict supervision during the land transformation process (Tu et al., 2014). For the sake of effectively promoting the intensive use of industrial land, it is necessary to scientifically and reasonably estimate the capital transfer coefficient and formulate an appropriate coefficient of performance punishment for a market feedback, which can not only facilitate the enthusiasm of local government for economic development, but also result in the intensive use of industrial land.

With an appropriate coefficient of performance punishment, local governments’ approach would be to randomly select a strategy from the possible extensive and intensive strategies. At present, which strategy A (or B) will choose depends on which strategy he thinks B (or A) will choose. For example, according to the modelling results, when the performance punishment coefficient falls into the mixed equilibrium area, although the strategies can be adopted randomly by players, the action consequence and benefits of the strategy profile are quite dissimilar. The benefits to both players choosing the same strategy are better than choosing different strategies. So, under these conditions, how to achieve [intensive strategy, intensive strategy] rather than [extensive strategy, extensive strategy]? The decisive factor is the judgment of A on B’s selection. If the industrial land pattern in region B is always extensive, then A has reason to believe that B will continue to choose the extensive strategy, so A’s choice is extensive strategy. To change A’s judgment on B, exogenous forces must intervene. The central government should assume the responsibility of transforming the local governments’ belief. In this example, it means to change the belief of A to B, or A corrects the probability distribution of the choice of B’s strategy selection and vice versa. That is to say, in the face of the current contradiction between land supply and demand and the need for cultivated land protection in China, the central government is urged to strengthen the management of industrial land and raise local governments’ consciousness of the potential to be gained by intensive land use.

5.3. Policy implications

Market feedback plays a fundamental role in intensive use of industrial land, but the present industrial land market is quite immature, and it is necessary to encourage government to play a supporting role. On the one hand, the central government need to improve the performance appraisal system and taxation system for local governments, incorporate the intensive use of industrial land into the performance assessment, and control the spread of extensive land use activities. On the other hand, as can be seen from the results of equilibrium strategy application, the determination of the performance penalty coefficient needs to be extremely cautious. The appropriate penalty coefficient should be the one that can promote the intensive use of industrial land without affecting the local governments' enthusiasm for economic growth.

We do not argue that the level of punishment should be same for all regions. Conversely, the most critical mission of market feedback is to help the central government to establish differentiated industrial land supply management policies. To understand this, it must be emphasized that there is an important constraint condition in the presently formulated game analysis, namely A and B have the same investment environment. If so, it can be concluded that performance punishment is able to achieve Pareto optimality at a certain probability. In generalizing the argument, regional disparities should be taken into consideration. The differences in the degree of the intensive use of industrial land among regions is probably evidence of uneven development. One significant cause behind this phenomenon is the absence of regionally differentiated land supply policies. A uniform threshold value of economic benefit or performance penalty coefficient per unit of industrial land alone is not able to effectively promote the intensive use of industrial land. It is necessary to set up a set of relevant standards to guide local government's industrial land supply behavior.

In some areas with a poor investment environment, even if local governments are willing to increase the supply of land, enterprises may be reluctant to locate there. The transactions between local government and enterprises on industrial land may not take place, which suggests that land resource is unused. Intensive use facilitates the effective use of resources rather than letting resources lie idle. To achieve coordinated development of the regions, the central government should implement regional differentiated land supply policies based on market signals, and implement the intensive use of industrial land in accordance with local conditions. In areas where industrial land use is relatively extensive, the newly-added land use quota should be strictly controlled; and in areas where land should be further developed, the supply of the land use quota can be slightly increased. To give a simple example, assume that for a certain enterprise, the locational attractions of area A are slightly inferior to those of area B. If the supply of industrial land between regions is indistinguishable or if no obvious differences exist, the region which provides the most benefits to the investor can win in this investment attraction competition. Preferential policies are important contributory factors for enterprises in the early stage of site selection, especially the preferential policies from special economic zones and developed coastal cities in China (Shen & Lin, 2020). In most cases, local governments from flourishing regions are able to provide attractive preferential policies. A is a developed city, so it can provide better land use preferential policies (like reducing enterprises' tax burden) while B is not and is unable to provide comparable policies. This enterprise will ignore the small location differences and chooses A over B. But if there is a clear difference in the inter-regional industrial land supply policies, suggesting that the advantages in A are not as strong as previously, then the locating firm may think more about existing locational advantages, and choose B. This change in locational choice is of benefit to promote intensive land use in developed areas as well as to balance regional development.

6. Conclusions

The main contribution of this paper is that by linking tax system and performance appraisal system in a conceptual framework, we elaboration the governance structure in industrial land in China, and reveal the limitation of "unclosed" governance structure and the applicability of "closed" governance structure. The governance structure is an organizational structure composed of the central government, local government and the market, and these three participants hold interdependent relationships. In unclosed loop, the central and local government form a top-to-bottom relationship chain based on their performance, and local government and the market form a top-to-bottom relationship chain based on the tax structure. In closed loop, there is another bottom-up relationship chain from the market.

What is clear from this study is the need for establishing market feedback to form a complete closed loop for the governance structure. The self-interest of local government and the resulting strategy choices are closely related to current performance appraisal system and tax-sharing system. Without market feedback, the local governments always adopt extensive strategy in the hope of obtaining financial revenue and promoting economic development by attracting investment while improving its own political performance as well. The central government can send a signal by setting a higher performance penalty coefficient for the market, and then control the level of intensiveness for the use of industrial land by local governments. The results of the model, combined with the findings of a case study, show that the performance penalty coefficient is able to send a market signal and promote the realization of a cooperative equilibrium. Of course, how to determine the performance penalty coefficient appropriately is very important. An excessively large coefficient will inhibit local economic development, while an excessively low coefficient cannot play a role in promoting the intensive use of industrial land.

A limitation of this study is that it only considers complete information-based static and repeated games, although in Section 4, limited consideration was given a game equilibrium in an incomplete information situation. However, no mathematical reasoning was used to prove the argument. Follow-up studies will pay more attention to the games in incomplete information situations. Furthermore, the parameter setting in empirical research is inevitably subjective. A more scientific method for estimating the coefficient should be adopted in future studies. Despite the methodological constraints and theoretical approach used in the study, this research has suggested

a solution to promote intensive use of industrial land, and this solution would provide benefits to the ecological civilization construction and urban sustainable development of China.

Author contributions

J.L. and Y.W. proposed the initial idea of the paper. J.L. drafted the manuscript. J.L., Y.W. and X. Z. revised the manuscript. C.C reviewed and edited the manuscript.

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Declaration of competing interest

We declare that we have no financial and personal relationships with other people or organizations that can inappropriately influence our work, there is no professional or other personal interest of any nature or kind in any product, service and/or company that could be construed as influencing the position presented in, or the review of, the manuscript entitled, “A Study on Promoting the Intensive Use of Industrial Land in China through Governance: A Game Theoretical Approach”.

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