Mechanism of formation in the selling price of urban industrial land in China based on the multi-attribute auction theory

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Abstract

There is the fierce competition for investment introduction among local governments in China. Thus, the auction relationship about urban industrial land belongs to a kind of reverse auction between local government and investment enterprise. To explore the mechanism of formation in the selling price of urban industrial land, we build a multi-attribute first-score sealed-bid auction model. Our studies reveal that the selling price of urban industrial land is the decreasing function of local government's expected comprehensive earnings from the investment introduction, the intensity of competition for investment introduction among local governments or its cost factors of providing some attributes. However, it is the increasing function of enterprise's weights for different attributes. They appropriately explain why the selling price of urban industrial land has been at the low level for a long time in China. Yet, the comprehensive earnings and the realization of land asset value are not a pair of irreconcilable conflicts. Local governments should prioritize the attributes, which the investment enterprises care about, then reduce the cost of providing these attributes. In the end, it will resolve the interest conflicts in the process of industrial land operation.

Keywords: industrial park, industrial land, selling price, multi-attribute auction

1 Introduction

The urban land is owned by the local governments in China. The ownership of the urban land is forbidden to merchandise. However, it is the land use rights for a certain period that are traded in the land market. According to the Chinese law, the maximum selling period of the urban industrial land is 50 years. Local governments have to sell the use rights of their land based on this law. In this sense, the selling price of the land is equivalent to the selling price of the land use rights. Based on the average selling price levels of the urban lands mainly monitored in China from 2001 to 2011, the selling price of commercial land rose by 2.4 times; residential land by 3.68 times. However, the selling price of urban industrial lands only rose by 0.44 times. When compared with the absolute values of the average selling price levels in 2011, the urban industrial land was only 11.5% of the commercial land and 14.4% of the residential land. Even though the selling price of industrial land in Shanghai was far higher than the national average level, it was only 45% of that in Shanghai in 2011. From 2001 to 2011, the industrial land price level rose by 0.63 times in Shanghai, which was also far higher than the national average.

Therefore, the changes in selling price of urban industrial land are significantly different from those of the commercial land and the residential land. The formation of selling price of the urban industrial land in China has its unique mechanism, which is possibly associated with the competition for investment introduction among local governments and the land-related properties besides the price.

To understand the mechanism of formation in the selling price of urban industrial land in China, Wu analysed the relationship between the low selling price and the earnings from the investment introduction by building a game model [1]. Zhang studied the mechanism from the view of the competition among local governments in China [2]. Xu explored the forming process and mechanism of industrial land selling price based on the game model and cost-benefit analysis method [3]. Yang analysed why the low selling price of industrial land was caused by the failure of local governments' roles in China [4]. Wang explored the factors affecting the selling prices of urban industrial land, such as industrial agglomeration and government intervention based on a panel data of 35 Chinese cities from 2000 to 2010 [5]. Liu investigated the city-level impact of the economic fundamentals on the selling prices in China by using the panel data model [6].

Now we focus on the mechanism of formation in selling price of urban industrial land by using the multi-attribute auction theory in the context of fierce competition for investment introduction among local governments in China.

2 The multi-attribute auction theory

Multi-attribute auction is an auction mode that the auctioneer and bidder have multiple negotiations on price and other attributes [7]. For example, in a procurement process, the buyer (auctioneer) announces the desired characteristics of a particular item, which may include the

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price, quality, delivery deadline, and warranty period. A fixed number of n sellers (bidder) who decide to send bids have to specify the full configuration. Finally, the buyer decides which bid it prefers, and the agent who suggests this bid, is called the winner agent and committed to providing it. Multi-attribute auction is an evolution of traditional auction, mainly suitable for the reverse auction centred on the buyer. It fully satisfies a variety of individual demands of the auctioneer, and is more in line with the real economic activity.

Che put forward a two-dimensional multi-attribute auction model, and studied several deformation auction protocols under sealed auction mechanism [8]. On the basis of Che's research, Brallco studied further the influence of the related costs for the bidders on the auction results [9]. Parkes and Kalagnanam analysed the multi-attribute auction of multi-rounds with the linear programming method [10]. David studied systematically multi-attribute auction [11-13]. In addition to the above theoretical researches, Bichler and Chen-Ritzo compared single-attribute auction with multi-attribute auction by the method of experimental economics, and found out that multi-attribute auction can improve both the buyer's and the seller's utilities. Chinese scholars gave priority to theoretical research, mainly focusing on the optimal mechanism design of multi-attribute auction, such as the optimal bidding strategy for bidders and the system design about online multi-attribute auction, etc.

3 The characteristics of the urban industrial land auction in China

As a developing country, there is the fierce competition of investment introduction among local governments in China. This kind of competition is beneficial to the investors when they are in the game with local governments. As is well known, when an enterprise chooses its investment place, it considers not only the industrial land selling price, but also such factors as location, industry development, tax level and social management. If having several invitations from local governments, an enterprise will have the right to choose investment place. It can select the most suitable region to set up a company according to its own revenue function. Under such circumstances, the negotiations about investment place between investment enterprise and multiple local governments are a multi-attribute first-score sealed-bid auction. Investment enterprise, as auctioneer, has its own scoring function; while local governments, as bidders, bid on the land-related attributes including the selling price. In the end, the investment enterprise decides which place it prefers, and the local government that suggested this bid, is committed to offer it and wins the enterprise to invest in the local area, as illustrated in Figure 1.

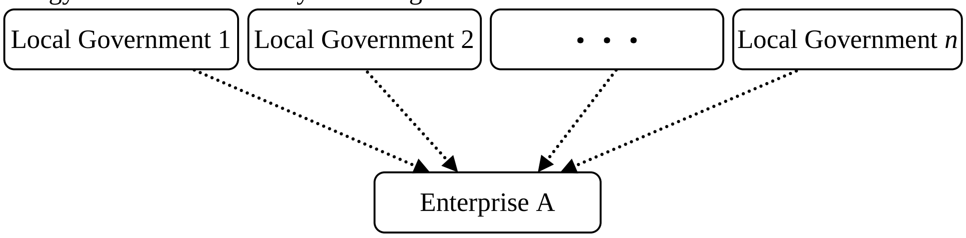

FIGURE 1 The auction relationship between enterprise and local governments

4 The multi-attribute auction model about the urban industrial land in China

In the multi-attribute auction model about the urban industrial land in China, the buyer of land (investment enterprise) is the sponsor of the auction, the seller of land (local government) is the bidder. Local governments carry on bidding competition on the multiple attributes that investment enterprise requires. In the study of multi-attribute auction, though each model is not identical, they all consist of five functions associated with the buyer or the seller:

1) the bidder's cost function;
2) the bidder's utility function;
3) the auctioneer's utility function;
4) the auctioneer's scoring function;
5) the auctioneer's announced bid's value function.

Based on the characteristics of industrial land multi-attribute auction, the modelling assumption and the corresponding functions are provided in the following sub-sections.

4.1 MODELING ASSUMPTIONS

Both local government and enterprise are risk neutral and the multiple attributes related to the industrial land are utility independent. Given this assumption, we can use the additive weighting utility function to combine the different attributes into a decision rule.

Both local government and enterprise are rational, and the game between local governments is non-cooperative. This hypothesis suggests that local government and enterprise will try to maximize their utility and will not take any action that brings them negative utility. Moreover, the local governments are rivals with each other, so there is no cooperation or conspiracy among them.

Local government's cost parameter θ_i is an independently and identically distributed function $F(\theta_i)$ over $[\underline{\theta},\bar{\theta}]$ $(0 \le \underline{\theta}_i \le \theta_i \le \infty)$, $F(\underline{\theta}_i)=0$, $F(\bar{\theta}_i)=1$, for which a positive, continuously differentiable density function $f(\theta_i)$ exists. This is the common knowledge for local governments and investment enterprise. Such assumption is similar to the retention value assumptions in the traditional single price auction mechanism. Because of complete symmetry among local governments, the subscript i will be omitted in the rest of the paper.

The industrial land is of independent private values for local governments. The local government can clearly know its earnings from investment introduction according to the exact value of cost parameters, but cannot know how many earnings other local governments will get.

Transaction cost is considered as zero here. In the competition of investment introduction, information cost, participation cost and opportunity cost do exist. In order to simplify the complexity of model, this paper does not however take into account of the transaction cost.

4.2 THE DESCRIPTION OF THE PROTOCOL AND THE UTILITY FUNCTIONS

Multi-attribute auction focuses mainly on the relationship between price and other attributes. When analysing a case of multi-attribute auction, there are an arbitrary number of attributes (m + 1). We can divide all these attributes into two categories: One is the price P, the other are the attributes besides price. Given the assumptions mentioned above, if the interest features of local government and enterprise are taken into account, the two sides' utility functions can be expressed as follows:

1) Local government's utility function (U_s):

$$U_s = P + R_s - \theta\sum_{i=1}^{m}\alpha_i q_i^{k_i} . \quad (1)$$

R_s represents the comprehensive earnings of local government from investment introduction, including tax, employment, etc. There are fixed coefficients for each of the attributes, namely, α_i is the cost coefficient of the attribute q_i. k_i is the index of the attribute q_i, and $k_i > 1$, this means that as q_i increases, local government's cost and marginal cost of providing the attribute q_i both increase.

2) Local government's cost function (C_s):

In the multi-attribute auction theory, cost function is opposite to price, so the Equation (1) can be reformed as the Equation (2):

$$U_s = P - \left(\theta\sum_{i=1}^{m}\alpha_i q_i^{k_i} - R_s\right). \quad (2)$$

Thus, local government's cost function can be expressed as follows:

$$C_s = \theta\sum_{i=1}^{m}\alpha_i q_i^{k_i} - R_s . \quad (3)$$

This equation indicates that for local government, the comprehensive earnings it can obtain mean a reduction to the cost of providing all attributes.

3) Enterprise's utility function (U_b):

$$U_b = \sum_{i=1}^{m}\beta_i q_i - P . \quad (4)$$

Enterprise's utility is the quasi-linear function of the attribute q_i, β_i is the weights associated with q_i, which indicates enterprise's preference for different attributes.

Given enterprise's utility function, it will announce a scoring function, which is used for choosing among bids. If the number of bidders is large enough, the auctioneer can announce its true preferences [13]. Under the circumstance of the fierce investment introduction, the scoring function of enterprise is considered as the same with its real utility function in the multi-attribute first-score sealed-bid auction. That is:

$$S_b = \sum_{i=1}^{m}\beta_i q_i - P . \quad (5)$$

From the scoring function, we can infer that the announced value of industrial land for the enterprise is:

$$V_b = \sum_{i=1}^{m}\beta_i q_i . \quad (6)$$

4.3 THE OPTIMAL ATTRIBUTE VALUES OF INDUSTRIAL LAND FOR LOCAL GOVERNMENT

In the case of multi-attribute auction, the local government faces the challenge of how to bid to maximize its expected utility. If the seller is rational, in order to determine the optimal non-price attribute values maximizing the seller's utility, we need to introduce the following important lemma:

Lemma 1: In a multi-attribute auction protocol, given the scoring rule and the seller's utility function, the optimal non-price attributes q_i that maximize the seller's utility can be chosen at $q_i^*(\theta)$ for all $\theta \in \left[\underline{\theta}, \overline{\theta}\right]$, where,

$$q_i^*(\theta) = \arg\max_{q_i}\left\{V_b(q_1,\cdots,q_m) - C_s(q_1,\cdots,q_m,\theta)\right\}. \quad (7)$$

The optimal attribute values are calculated independently of the price and the seller's beliefs about the other participants. This proof can be found in David's thesis [12]. Lemma 1 is critical for solving the bidder's optimal bidding strategy of multi-attribute auction. Because the choices of the optimal non-price attributes are independent of the price, the multi-attribute auction will be turned into traditionally single price attribute auction by solving the optimal non-price attribute values first.

According to the lemma 1, the differences between enterprise's announced bid's value V_b and local government's cost function C_s can be shown in Equation (8).

$$y = V_b - C_s = R_s + \sum_{i=1}^{m} \beta_i q_i - \theta \sum_{i=1}^{m} \alpha_i q_i^{k_i} \quad (8)$$

The optional attribute values $q_i^*(\theta)$ of industrial land which maximize *y*, should satisfy Equation (9):

$$\frac{\partial y}{\partial q_i}\Big|_{q_i^*} = \beta_i - \theta \alpha_i s_i q_i^{(k_i-1)} = 0 \quad (9)$$

Through solving Equation (9), the optimal attribute values of industrial land are shown as Equation (10):

$$q_i^*(\theta) = \left[\frac{\beta_i}{\theta \alpha_i k_i}\right]^{\frac{1}{k_i-1}}, \quad (10)$$

where, $i = 1, 2, ..., m$; $k_i > 1$.

4.4 THE OPTIMAL SELLING PRICE OF INDUSTRIAL LAND FOR LOCAL GOVERNMENT

After calculating each optimal attribute value, what local government needs to do is to determine the selling price of industrial land. Thus, the multi-attribute auction of industrial land is turned into a typical single price attribute auction. Under the first-score sealed-bid mechanism, the optional selling price of industrial land for a local government can be calculated by using Che's method [8], as follows:

$$P^*(\theta) = C_s\left(q_1^*(\theta), ..., q_n^*(\theta), \theta\right) + \int_{\theta}^{\bar{\theta}} C_{s\theta}\left(q_1^*(t), ..., q_n^*(t), \theta\right)\left[\frac{1-F(t)}{1-F(\theta)}\right]^{n-1} dt,$$

where, $C_{s\theta}(\cdot) = \frac{\partial C_s}{\partial \theta}$. Here, local government's cost parameter θ is considered to subject to independent, identical and uniform distribution over $\left[\underline{\theta}, \bar{\theta}\right]$. Substitute $F(\theta) = \frac{\theta - \underline{\theta}}{\bar{\theta} - \underline{\theta}}$ and $q_i^*(\theta) = \left[\frac{\beta_i}{\theta \alpha_i k_i}\right]^{\frac{1}{k_i-1}}$ into the equation above, then the optional selling price of industrial land for local government is:

$$P^*(\theta) = \theta \sum_{i=1}^{m} \alpha_i \left[\frac{\beta_i}{\theta \alpha_i k_i}\right]^{\frac{k_i}{k_i-1}} - R_s + \sum_{i=1}^{m} \alpha_i \left[\frac{\beta_i}{\alpha_i k_i}\right]^{\frac{k_i}{k_i-1}} \frac{1}{\left(\bar{\theta}-\theta\right)^{n-1}} \int_{\theta}^{\bar{\theta}} \frac{\left(\bar{\theta}-t\right)^{n-1}}{(t)^{\frac{k_i}{k_i-1}}} dt = \sum_{i=1}^{m} \alpha_i \left[\frac{\beta_i}{\alpha_i k_i}\right]^{\frac{k_i}{k_i-1}} \left[\frac{1}{\theta^{\frac{1}{k_i-1}}} + \frac{1}{\left(\bar{\theta}-\theta\right)^{n-1}} \int_{\theta}^{\bar{\theta}} \frac{\left(\bar{\theta}-t\right)^{n-1}}{(t)^{\frac{k_i}{k_i-1}}} dt\right] - R_s. \quad (11)$$

From the Equation (11), we know that the optional selling price of industrial land for a given local government is affected by its cost parameters, the estimation of cost parameters for other local governments, as well as the scoring function announced by the enterprise. Thus, there are the following properties regarding the optional selling price for a given local government.

1) The optional selling price of industrial land for a given local government is the decreasing function of its expected comprehensive earnings from the investment introduction. The more the expected comprehensive earnings are, the lower demand for the selling price will be.

2) Where $\frac{1}{\left(\bar{\theta}-\theta\right)^{n-1}} \int_{\theta}^{\bar{\theta}} \frac{\left(\bar{\theta}-t\right)^{n-1}}{(t)^{\frac{k_i}{k_i-1}}} dt = \int_{\theta}^{\bar{\theta}} \left(\frac{\bar{\theta}-t}{\bar{\theta}-\theta}\right)^{n-1} \frac{1}{(t)^{\frac{k_i}{k_i-1}}} dt$ and $\frac{\bar{\theta}-t}{\bar{\theta}-\theta} < 1$, so $P^*(\theta)$ is the decreasing function of *n*. This indicates that the competitive intensity for investment introduction among local governments significantly influences the selling price of industrial land. The fiercer the competition among local governments is, the lower the demand for the selling price will be.

3) $P^*(\theta)$ is the increasing function of β_i. This means: if some land-related attributes q_i is valued by investment enterprise, local governments will provide more such attributes q_i to cater to enterprise's demand. Obviously, this will lead to cost addition for a local government. The local government has to improve the selling price of industrial land to get some earnings.

4) To transform the Equation (11) into the Equation (12):

$$P^*(\theta) = \sum_{i=1}^{m} \frac{1}{\alpha_i^{\frac{1}{k_i-1}}} \left(\frac{\beta_i}{k_i}\right)^{\frac{k_i}{k_i-1}} \left[\frac{1}{\theta^{\frac{1}{k_i-1}}} + \frac{1}{\left(\bar{\theta}-\theta\right)^{n-1}} \int_{\theta}^{\bar{\theta}} \frac{\left(\bar{\theta}-t\right)^{n-1}}{(t)^{\frac{k_i}{k_i-1}}} dt\right] - R_s. \quad (12)$$

Given $k_i > 1$, then $\frac{1}{k_i - 1} > 0$, so we know that $P^*(\theta)$ is the decreasing function of α_i. According to $\frac{\partial P^*(\theta)}{\partial \theta} < 0$, it can be inferred that $P^*(\theta)$ is also the decreasing function of θ, which was already proven in Zheng's thesis [14].

Cost factors (α_i and θ) for a local government both negatively impact on the selling price of industrial land. When its cost factors of providing some land-related attributes are bigger, it will provide fewer amounts of such attributes. The local government has to lower the selling price of industrial land to increase its desired probability of investment introduction.

5 Example

To illustrate the real situation of urban industrial parks in China, we now assume that a foreign enterprise (b) is trying to select a city to set up a factory. There are three local governments (s_1, s_2, s_3) competing for the settlement of such a factory in their respective cities. The foreign enterprise may conduct a reverse auction against the three local governments. Consequently, the foreign enterprise becomes the auctioneer, and the three local governments are the bidders. Here, we assume that the attributes which the enterprise considers are the industrial agglomeration level q_1, the infrastructure condition q_2, and the management environment q_3 in their industrial parks. At the same time, we assume the utility functions of the participants are as follow:

$$U_b(p, q_1, q_2, q_3) = -P + 2\cdot q_1 + 4\cdot q_2 + 6\cdot q_3,$$

$$U_{s_1}(q_1, q_2, q_3) = P_{s_1} + R_{s_1} - 0.2\cdot\left(1\cdot q_1^2 + 2\cdot q_2^2 + 3\cdot q_3^2\right),$$

$$U_{s_2}(q_1, q_2, q_3) = P_{s_2} + R_{s_2} - 0.2\cdot\left(1\cdot q_1^2 + 3\cdot q_2^2 + 5\cdot q_3^2\right),$$

$$U_{s_3}(q_1, q_2, q_3) = P_{s_3} + R_{s_3} - 0.2\cdot\left(1\cdot q_1^2 + 4\cdot q_2^2 + 7\cdot q_3^2\right).$$

Since the three local governments decide about their bids based on the enterprise's scoring function, here, let the scoring function still be consistent with the enterprise's utility function:

$$S_b(p, q_1, q_2, q_3) = -P + 2\cdot q_1 + 4\cdot q_2 + 6\cdot q_3. \quad (13)$$

Given the information above, under the first-score sealed-bid auction protocol, we can calculate the optimal attribute values of industrial land, the selling prices of land, and the scoring values of three local governments respectively based on Equations (10), (11) and (13). List them separately as follows:

$$BID_1 = \left(P = 44.8 - R_{s_1}, q_1 = 5, q_2 = 5, q_3 = 5\right),$$

$$BID_2 = \left(P = 30.8 - R_{s_2}, q_1 = 5, q_2 = 3.3, q_3 = 3\right),$$

$$BID_3 = \left(P = 24.51 - R_{s_3}, q_1 = 5, q_2 = 2.5, q_3 = 2.14\right),$$

$$S_1 = 15.2 + R_{s_1}; S_2 = 10.4 + R_{s_2}; S_3 = 8.33 + R_{s_3}.$$

From the example above, we can learn that as the cost coefficient decreases, the local government may provide this type of attribute more. Thus it will require the higher selling price of industrial land. According to the calculated results, we can also learn that the selling price of industrial land is directly affected by the comprehensive earnings brought by the introduction of an enterprise. The higher the comprehensive earnings are, the lower the demand for the selling price is. Then the final bidding result will be affected accordingly. When $R_{s_1} = R_{s_2} = R_{s_3}$, that is, the three local governments can get the same comprehensive earnings from the investment introduction, the winner in this case will be the local government s_1 who obtains a score equal to S_1.

6 Conclusion

We explore the mechanism of formation in the selling price about urban industrial land in China based on the theory of multi-attribute first-score sealed-bid auction. Our results show that the competition for the investment introduction among local governments will significantly influence the selling process of industrial land. When faced with an alternative between the realization of land asset value and the comprehensive earnings from the investment introduction, local governments have to make efforts to win the competition for the investment introduction at the expense of land asset value in order to maximize the overall revenues. If there are more and more local governments to participate in the auction, and the enterprise possesses the strong negotiation ability, local governments will be forced to provide a number of preferential policies including land price. This will make each other fall into the predicament of "competition hitting new lows". Obviously, such results are in line with the basic characteristics of the transaction of urban industrial land in China. They explain why the selling price of urban industrial land has been at the low level for a long time.

Our results also indicate that the comprehensive earnings and the realization of land asset value are not a pair of irreconcilable conflicts. Local governments need to differentiate the attributes, which the investment enterprises more care about first, such as industrial agglomeration level, infrastructure construction level, management environment etc. They then reduce the cost of providing these attributes through scientific planning and strict management if possible, so as to improve the amount of these attributes and to obtain the higher selling price of industrial land. In this way, local government cannot only improve the successful rate of investment introduction, it also can better the market value of industrial land gradually. Thereby, local government can resolve the interest conflicts in the process of industrial land operation, and make land operation as well as industry operation develop in coordinate with each other.

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