State-owned Enterprises' Scale Orientation, Government Subsidies, and Overcapacity: An Analysis from the Perspective of Game Theory

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Abstract: This study explores the root causes of overcapacity in China, focusing on the roles of government subsidies and the scale-oriented behavior of state-owned enterprises (SOEs) in markets where SOEs and private firms coexist. Using game theory models, it finds that while subsidies may trigger short-term overcapacity, they do not cause long-term imbalance. In contrast, the persistent scale-oriented expansion of SOEs is the key driver of sustained overcapacity, as it both boosts SOE output and squeezes private firms' capacity. The study warns that without policy correction, SOEs may eventually dominate the market entirely, exacerbating overcapacity over time.

***Keywords*:** overcapacity, scale orientation, game theory, market strategy, government intervention

1. Introduction

Overcapacity is a major issue in China's economy, leading to inefficiency, innovation stagnation, and market imbalances. While early explanations like the "tidal surge" theory emphasized investment booms, persistent overcapacity suggests deeper structural causes. This study focuses on two key drivers: government subsidies and the scale-oriented behavior of state-owned enterprises (SOEs). It finds that overcapacity is especially severe in industries where SOEs and private firms coexist, largely due to SOEs' pursuit of scale over profit. Using game theory models, the research examines how subsidies and SOE behavior interact to cause long-term overcapacity and proposes policy measures to curb it through structural reform and better incentive systems.

2. Model assumptions and decision model construction

This study builds a theoretical framework to examine how the scale-oriented behavior of state-owned enterprises (SOEs), influenced by political goals, strategic positioning, and government policies, contributes to overcapacity. It assumes rational actors, distinct objectives between SOEs and private firms, and cost differences driven by policy. The research is divided into two parts: one analyzes how SOEs' scale orientation affects capacity through a series of game theory models, and the other examines how cost differences—particularly from subsidies—impact capacity. These models reveal the mechanisms behind both short-term and long-term overcapacity in mixed-ownership markets[1].

3. Will the particularity of state-owned enterprises lead to overcapacity: Introduce the game model of state-owned enterprises

This section introduces three Cournot oligopoly models to assess the impact of scale-oriented behavior on overcapacity. The first models a normal market with profit-driven private firms as a baseline. The second examines competition between scale-oriented state-owned enterprises (SOEs), and the third explores mixed competition between scale-oriented SOEs and profit-oriented private firms. These models help reveal how industrial policy-driven scale orientation affects overall market capacity and the competitive dynamics between different enterprise types.

Model 1.1: The Kunot oligarchic competition model between private and private enterprises

First, we establish the reference frame established in this study, and regard the game equilibrium capacity when an industry is a pure private enterprise as the capacity of the normal market. We assume that there are two private enterprises, A and B, which produce homogeneous products. The production technology function of the enterprise is: $C_i\left(q_i\right)=c_i q_i, i=1,2$

Two enterprises determine their output separately, and the market price is a function of the total output q. The respective cost is a function of production, and both companies pursue profit maximization, assuming the same cost[2].

participant: {A, B}

The strategy of the participants: $q_i, q_i \in \left[0,+\infty\right)$ (i=1, 2)

Participant gains: $\mu_i(q_1,q_2)=q_iP(q_1+q_2)-c_i(q_i)$ (i=1, 2)

Assume that, $P=\alpha-q_1-q_2$, $C_i(q_i)=cq_i$, i=1,2

Solving for the equilibrium of the game:

For A, $\mu_1(q_1,q_2)=q_1(\alpha-q_1-q_2)-cq_1$, At equilibrium, given q2, solve the value of q1 that maximizes the utility function

$$\frac{d\mu_1}{dq_1}=\alpha-2q_1-q_2-c=0 \tag{1}$$

For B, $\mu_2(q_1,q_2)=q_2(\alpha-q_1-q_2)-cq_2$. In equilibrium, given q_1, solve for the value of q_2 that maximizes the utility function

$$\frac{d\mu_2}{dq_2}=\alpha-2q_2-q_1-c=0 \tag{2}$$

Joint stand (1), (2) solution

$$\begin{cases} q_1=\dfrac{a-c}{3} \\ q_2=\dfrac{a-c}{3} \end{cases}$$

At equilibrium, both firms produce the same amount $\frac{a-c}{3}$, Total output is $\frac{2(a-c)}{3}$, The profit of the manufacturer is all of $\left(\frac{a-c}{3}\right)^2$.

When the enterprise of an industry appears scale-oriented, what will its capacity change compared to the pure private enterprise? Next, we establish a Kunot oligopoly competition model with scale-oriented competition among soes. We assume that two soEs A and B produce homogeneous products, the two enterprises determine their output respectively, and the market price is a function of total output q[3]. The respective cost is a function of the yield. Both enterprises have scale orientation, that is, the utility function of the enterprise is a function of profit and scale, the enterprise pursues scale, we assume two parts, one part is the utility brought by profit, multiplied by a coefficient W, W is the utility brought by unit profit; part is the utility is the function of sales volume, assuming scale multiplied by a coefficient β, β is the utility brought by unit scale, understanding is the benefit except profit from scale. Similarly, the cost of the two enterprises is the same, the asset weight is the same and the same utility function.

Model 1.2: Kunot oligopoly competition model between enterprises and Es

participant: {A, B}

Strategy of the participants: q_i, $q_i\in[0,+\infty)$ (i=1, 2)

Participant gains: $\mu_i(q_1,q_2)=w_i\left[q_iP(q_1+q_2)-c_i(q_i)\right]+g_i(Pq_i)$ (i=1, 2)

Assume that, $P=\alpha-q_1-q_2$, $C_i(q_i)=cq_i$, $g_i(Pq_i)=\beta Pq_i$, $w_i=w$, (i=1, 2)

Solve the equilibrium of the game:

For A, $\mu_1(q_1,q_2)=w\left[q_1(\alpha-q_1-q_2)-cq_1\right]+\beta(\alpha-q_1-q_2)q_1$, At equilibrium, given q_2, solve the value of q_1 that maximizes the utility function

$$\frac{d\mu_1}{dq_1}=w\alpha-2wq_1-wq_2-cw+\beta\alpha-2\beta q_1-\beta q_2=0 \tag{3}$$

For B, $\mu_2(q_1,q_2)=w\left[q_2(\alpha-q_1-q_2)-cq_2\right]+\beta(\alpha-q_1-q_2)q_2$, At equilibrium, given q_1, solve the residual value of

q_2 that maximizes the utility function

$$\frac{d\mu_2}{dq_2} = w\alpha - 2wq_2 - wq_1 - cw + \beta\alpha - 2\beta q_2 - \beta q_1 = 0 \tag{4}$$

Joint stand (3), (4) solution

$$\begin{cases} q_1 = \frac{a-c}{3} + \frac{\beta c}{3(w+\beta)} \\ q_2 = \frac{a-c}{3} + \frac{\beta c}{3(w+\beta)} \end{cases}$$

At equilibrium, the output of both manufacturers is $\frac{a-c}{3} + \frac{\beta c}{3(w+\beta)}$,Total output (production capacity) is $\frac{2(a-c)}{3} + \frac{2\beta c}{3(w+\beta)}$, The profit of both manufacturers is $(\frac{a-c}{3})^2 - \left[\frac{\beta c}{3(w+\beta)}\right]^2 - \frac{\beta c}{3(w+\beta)}\left[\frac{a-c}{3} + \frac{\beta c}{3(w+\beta)}\right]$

In the competition between soes, scale-oriented enterprises will lead to the emergence of excess capacity, Excess capacity $D = \frac{2\beta c}{3(w+\beta)}$, When $\beta \neq 0$, When a company can derive benefits from scale beyond profit, the greater the benefit per unit of scale, the more severe the overcapacity becomes. For state-owned enterprises, the smaller the utility w derived from unit profits, the more severe the overcapacity. Currently, there is an argument that increasing the profit remittance ratio for state-owned enterprises helps control overcapacity. However, according to model results, the smaller w is, the more severe the overcapacity may be. Therefore, the proposal to control overcapacity by raising the profit remittance ratio is open to debate. When β = 0, regardless of the value of W, there is no excess capacity[4]. That is, under the condition of β = 0, the impact of the decision-maker's profit share w on the equilibrium output of state-owned enterprises differs from that of private enterprises. Thus, eliminating scale orientation is an effective means to curb overcapacity. The larger β is, the greater the excess capacity; the smaller w is, the less excess capacity. In other words, the more benefits a company gains from each unit of scale, the more likely it is to experience overcapacity; the fewer benefits a company gains from each unit of profit, the more likely it is to experience overcapacity.

Corollary 1: The scale orientation of soes leads to expand to build more capacity.

The balance of the profit of the scale-oriented enterprises will be reduced,

$$(\frac{a-c}{3})^2 - \left[\frac{\beta c}{3(w+\beta)}\right]^2 - \frac{\beta c}{3(w+\beta)}\left[\frac{a-c}{3} + \frac{\beta c}{3(w+\beta)}\right] < (\frac{a-c}{3})^2$$

That is to say, enterprises will ignore the free capital risk to invest. The scale orientation of state-owned enterprises makes the enterprises ignore the risk of their own capital to invest.

Corollary 2: The scale-oriented characteristics of enterprises will lead to long-term overcapacity in the industry.

Model 1.4: Game analysis of state-owned enterprises and private enterprises

The previous text constructed three game models and solved the equilibrium decisions of corporate decision-makers when facing these three types of games. It is not hard to see that the existence of state-owned enterprises (SOEs) results in a higher total output equilibrium compared to non-SOE firms. This means that SOEs produce more than the equilibrium output of normal market conditions, especially when SOEs and private firms engage in competition[5]. The presence of SOEs causes private firms 'equilibrium output to fall below their normal market equilibrium value, leading to SOEs capturing a larger share of the private sector's market. As the competition between SOEs and private firms continues, will SOEs eventually completely dominate the private sector, leaving only SOEs as the dominant form of organization in the market? If the answer is yes, we can conclude that the overcapacity caused by the organizational structure of SOEs will become increasingly severe as the game evolves. To study this issue, we constructed an evolutionary game analysis model for SOEs and private firms.

Game participants: A;B

Game strategy: {state-owned enterprise, private enterprises}

Game proceeds: market share

Table 1. Payment Matrix of State-owned and Private Enterprises

	private enterprise	state-owned enterprise
Private enterprise	$\frac{1}{2}, \frac{1}{2}$	$\frac{1}{2}-\frac{3}{2}\times\frac{1}{\frac{2(a-c)(w+\beta)}{c\beta}+1}, \frac{1}{2}+\frac{3}{2}\times\frac{1}{\frac{2(a-c)(w+\beta)}{c\beta}+1}$
state-owned enterprise	$\frac{1}{2}+\frac{3}{2}\times\frac{1}{\frac{2a-cw+\beta}{c\beta}+1}, \frac{1}{2}-\frac{3}{2}\times\frac{1}{\frac{2(a-c)(w+\beta)}{c\beta}+1}$	$\frac{1}{2}, \frac{1}{2}$

Solving for the evolutionary stability strategy.

Suppose that for a small positive number x, 1-x proportion of enterprises use the strategy “state-owned enterprise”, and x proportion of enterprises use the strategy “private enterprise”

Expected benefits of the private sector in a random interaction:

$$\frac{1}{2}x+\left[\frac{1}{2}-\frac{3}{2}\times\frac{1}{\frac{2(a-c)(w+\beta)}{c\beta}+1}\right](1-x)=\frac{1}{2}-\frac{3}{2}\times\frac{1}{\frac{2(a-c)(w+\beta)}{c\beta}+1}+\frac{3}{2}\times\frac{1}{\frac{2(a-c)(w+\beta)}{c\beta}+1}x$$

Expected benefits of soes in a random interaction:

$$\left[\frac{1}{2}+\frac{3}{2}\times\frac{1}{\frac{2(a-c)(w+\beta)}{c\beta}+1}\right]x+\frac{1}{2}(1-x)=\frac{1}{2}+\frac{3}{2}\times\frac{1}{\frac{2(a-c)(w+\beta)}{c\beta}+1}x$$

No matter what value x is, the expected adaptability of state-owned enterprises is greater than that of private enterprises, so the strategy of “state-owned enterprises” is evolutionary and stable[6]. That is to words, with the game between state-owned enterprises and private enterprises, state-owned enterprises will eventually completely occupy the market share of private enterprises, so that there is only an organizational form of state-owned enterprises in the market, that is, the overcapacity caused by the organizational form of state-owned enterprises will become more and more serious with the evolution of the game.

4. Conclusions and revelation

This study, based on game theory models, finds that government subsidies cause only short-term overcapacity, while the scale-oriented behavior of state-owned enterprises (SOEs) is the key driver of long-term overcapacity. Unlike private firms, SOEs tend to expand capacity beyond profit motives, crowding out private enterprise and causing persistent market imbalances. High costs and inefficiency of SOEs may even buffer against overcapacity rather than exacerbate it. The study suggests that policy efforts should focus on reforming SOE assessment systems to curb excessive scale orientation and ensure fair competition. However, the findings are theoretical and lack empirical validation, and industry-specific differences warrant further research.

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