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ITJ

ISSN 1812-5638

# INFORMATION TECHNOLOGY JOURNAL

**ANSI***net*

Asian Network for Scientific Information  
308 Lasani Town, Sargodha Road, Faisalabad - Pakistan

## A Simulation Analysis of Barriers to Entry in China Refined Oil Market

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**Abstract:** The oil and gas industry is a high investment, high risk, high reward and high-tech industry with a need for highly qualified labour. China's oil and gas market has attracted more and more investors to join. However, due to oil and gas industry in all aspects of specificity, there are some Chinese oil and gas markets have barriers to entry. In this study, the Chinese oil and gas industry for effective market entry barriers based on the analysis, the use of StarLogo simulation tools, modeling, simulation of China's refined oil market. By analyzing simulation results, we want to help the investors effective investment and to promote China's oil and gas industry to create more opportunities for development.

**Key words:** Multi-agent simulation, refined oil market, starlogo, entry barriers, complex adaptive system

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### INTRODUCTION

The oil and gas production and processing volume of the three major group companies, China National Petroleum Corporation (CNPC), China Petroleum & Chemical Corporation (Sinopec) and China National Offshore Oil Corporation (CNOOC), account for 98.62% and 94.17% of the national total which shows high monopoly in oil and gas production and processing field (Yuan and Feng, 2007). Meanwhile, based on market demand and current production capacity of the refineries operating in China, the number of enterprises is controlled. In consideration of lack of vitality and low economic efficiency in oil and gas market, liberalizing barriers to entry moderately is necessary. A more competitive circumstance and higher economic efficiency will appear in the market with new enterprises making its entrance into.

In the economic market, market entry barriers are always the major factor of price structure which play a significant role in research of economic market. With the deepening of reform and openness, the economic market is also growing and it is much more important to research market entry barriers in China.

From three ways such as definition, kinds and influencing factors, Hou compare the representative concepts of barriers to entry theory in industrial organization (Hou and Mu, 2007). Barriers to entry can be divided into structural entry barriers and strategic entry barriers in accordance with formation and they can be

divided into economic entry barriers and Administrative entry barriers in accordance with type-difference in market (Deng, 1996).

**Policy barriers to entry:** Currently, due to the scarcity of oil resources and its prominent strategic position, governments around the world have attached great importance to monitoring and management of oil and gas resources and market. Franchising in oil industry is common in many countries which prohibits enterprises without franchising to enter the industry.

In China, national policy limits many aspects of the oil and gas industry, in particular the exploration and development rights to oil and gas resources. It is a large barrier to entry for the enterprises wish to enter the Chinese oil and gas market.

**Financial barriers to entry:** Investors can get high returns in oil and gas industry, however, the premise of high returns is high input. If an enterprise wishes to enter oil and gas market in China, a massive injection of funds are needed to invest for initial preparation and a series of production which may beyond the enterprise's affordability. Therefore, large investment brings financial barriers to most of enterprises.

**Technical barriers to entry:** In oil and gas industry, it is strict in technical level requirement, because the advanced technology the enterprise has; the higher yields of oil and gas will realize. At the same time, it is significant to apply

high technology to petroleum industry. Technical barriers to entry are produced by high level technical requirements.

**Strategic barriers to entry:** In business, strategic entry barrier refers to any action taken by an existing business who uses its own advantages to take actions initiatives in a particular market that discourages potential entrants from entering into competition in that market. CNPC, Sinopec and CNOOC, as known the three major group companies have a state monopoly on crude oil mining and oil refining, but not on oil & gas storage and transportation, or engineering and technical service, or retail. In these fields, due to ownership and management are not completely separating, they have certain administrative powers which make them have the ability to manipulate the market and formulate monopoly price. Market-competitive behavior is eliminated or limited by the administrative powers they have and the technical barriers are established to prevent other market entity from entering into the market.

## SIMULATION MODEL DESIGNING

**Simulation hypothesis:** An agent-based approach is a promising technique to study human behaviors (Yang and Niu, 2013). Wang develop the petroleum market simulation model to analyze China refined oil market (Wang *et al.*, 2007). In this study, we also use an agent-based approach to deal with business complexity in China refined oil market.

According to statistics, the number of gas stations which belong to CNPC and Sinopec reached to 19362, accounting for about 54% of the total number of stations. In addition, according to the latest statistics from the Ministry of Commerce, coupled with the eight companies which are approved recently, there are 2512 refined oil wholesale enterprises in the market in China (Yang, 2001). The number of refined oil wholesale enterprises which CNPC and Sinopec wholly-owned or holding is 1654, accounted for 65.8% of the total enterprises. The remaining 858 enterprises are other state-owned enterprises or private enterprises which account for 34.2%. Because of distribution network and supporting facilities construction and some other aspects, there is no doubt that a large number of existing depots and gas stations will become the entry barriers to the foreign companies.

In this simulation, we set two types of agents, one represents the oil and gas enterprises which already exit

in the market, also named incumbents, on behalf of the oil companies belong to China Petroleum and China Petroleum and Chemical; another represents the oil and gas enterprises which attempted to enter the Chinese market, also named potential entrants, on behalf of the private oil enterprises or foreign oil companies.

While in this oil and gas market, the size of market capacity is not changed, so we assume the total market demand is 190,000,000 ton referring to the reports released by CNPC and Sinopec. In this simulation model, we construct a two-dimensional space with 50\*50 lattices and distribute the demand randomly. In StarLogo, we use green lattices to on behalf of demanding and set parameters for each lattices which named market demand and the sum of total is 190,000,000.

**Agents' attributes:** In this simulation, we assume that the number of incumbents is 17. In the StarLogo modeling, blue turtles represent incumbents and the parameters are volume of production, volume of sales, price, income, profit.

**Price:** Then we select 0 # diesel oil as the delegate of refined oil and the price is affected by the current market price fluctuations in crude oil. According to the "Crude oil cost" settled by National Development and Reform Commission for current refined oil pricing, we calculate the average crude oil price of Brent, Dubai and Minas and use the average as the benchmark, pulsing refining costs, appropriate profit margins and domestic tariffs, refined oil circulation fees, the sum is the final retail price. According to the 2007 annual report of Sinopec, the formula which used to calculate the price of refined oil based on crude oil price is as follows:

$$Y = ((X \times 6.09(\text{exchange rate}) \times 7.33 + 3446) \times (1 + 5\%))$$

- **Sales volume:** The sales volume is decided by the demand of the market supplied by incumbents (blue turtles in the Simulation model), unit: ton. The ability of meeting the market demand is decided by the capital strength at present
- **Income:** The formula of income is:

$$\text{Income} = \text{price} \times (\text{volume of sales}), (\text{unit: Yuan})$$

- **Profit:** The formula of profit is:

$$\text{Profit} = \text{Income} - 1240 \times (\text{sales volume}), (\text{unit: Yuan})$$

1240 is the cost price factor

Then we assume the number of potential entrants is 30, represented by red turtles in the simulation model which is same as above, the parameters are as follows.

- **Price:** The price of potential entrants is the same as incumbents' price. Unit: Yuan ton<sup>-1</sup>
- **Sales volume:** The sales volume is decided by the demand of the market supplied by potential entrants (red turtles in the Simulation model). The ability of meeting the market demand is decided by the capital strength at present (unit: Ton)
- **Income:** The formula of income is:

$$\text{Income} = \text{Price} \times (\text{sales volume}), (\text{unit: Yuan})$$

- **Profit:** The formula of profit is:

$$\text{Profit} = \text{Income} - 1240 \times (\text{sales volume}) - 60,000,000$$

(unit: Yuan)

1240 is the cost price factor and 60,000,000 is the upfront investment costs

**Designing agents' behavior:** In the simulated oil market, potential entrants tried to enter the oil and gas market. Before they entering in, it is assumed that they have been in the current market and calcite the profit based on the market conditions, such as the initial price of crude oil, refined oil market demand and so on. Only in the hypothetical case of profit is greater than zero, they will choose to enter.

In this process, entrants will face all aspects of market barriers to entry. Due to policy barriers cannot be controlled nor quantified, we focus on financial barriers, technical barriers and strategic barriers mainly which show as upfront investment before entering and price-cutting strategy carried out by incumbents. The behavior strategies of two main agents are as follows:

- **Distribution:** Incumbents distribute uniformly in the two-dimensional plane and entrants distribute outside the scope of the incumbent radiation space
- **Sale process:** Each incumbent itself as the center radiates outward, the points that under the cover whose demand represents the incumbent's sales volume and the color of the points is white. We set the initial entrants coverage radius is 5 and if the profit is greater than the profit of the previous period, the coverage radius will be increased to 6.

Each entrant itself as the center radiates outward, the points that under the cover whose demand represents the entrant's sales volume and

the color of the points is black. We set the initial entrants coverage radius is 3 and if the profit is greater than the profit of the previous period, the coverage radius will be increased to 4

If an area is covered by both of entrant and incumbent, the one whose price is lower will dominate the market and if they have the same price, the market will be assigned randomly

- **Price-reduction strategies:** For incumbent, calculate the market share at first, the formula is the sales volume/total market share, if the result is less than 65%, then incumbent chooses the price and the number is 700 yuan ton<sup>-1</sup>

For entrant, if incumbent's price is lower than entrant's, entrant will reduce the price to consistent with incumbent. Meanwhile, taking into account its own costs, if the profit greater than zero, entrant survival, or die

- **Running rules:** The general rules of model running are as follows: sales process, reduction strategy, sales process, reduction strategy...which is a continuous cycle process. If all entrants die, then the simulation ends

## SIMULATION RESULT

Under the simulation environment, the number of incumbents is 17 and the number of potential entrants is 30. While the simulation interface is follow (Fig. 1):

- If the price of crude oil is 34 U.S. dollars per barrel, the price of refined oil is 5212 yuan per ton. The experimental simulation results are as follows in Fig. 2-4
- If the price of crude oil is 80 U.S. dollars per barrel, the price of refined oil is 7368 yuan per ton. The experimental simulation results are as follows in Fig 5-7
- If the price of crude oil is 140 U.S. dollars per barrel, the price of refined oil is 10180 yuan per ton. The results of simulation are as follows in Fig. 8-10

We can see from the results of the simulation, the specialty stores' strategy is the optimal when the amount of consumers of the brand-preferred businesses is larger than the price-preferred businesses, on account of the assume that the specialty stores attract consumers mainly by brand. The specialty stores put the most investment in advertisement, so the larger consumers of price-preferred businesses the specialty stores have an obvious advantage in sales volume, the specialty stores' sales are far more than the other types of businesses as a result of

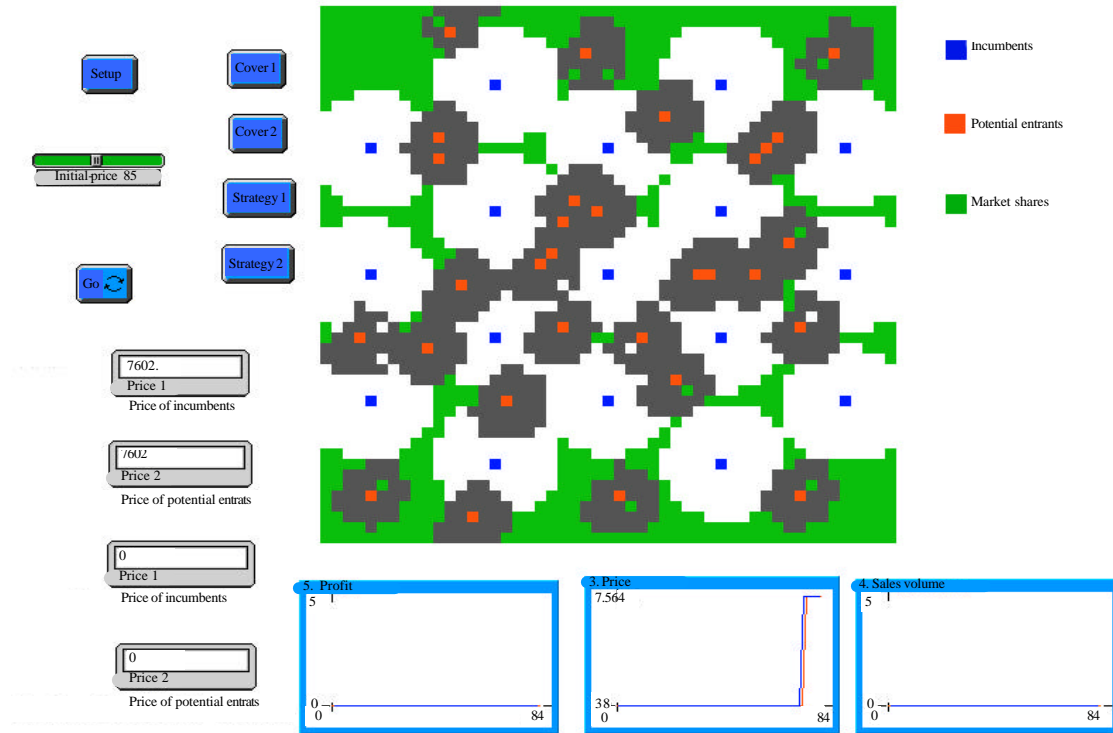


Fig. 1: Initial interface of system

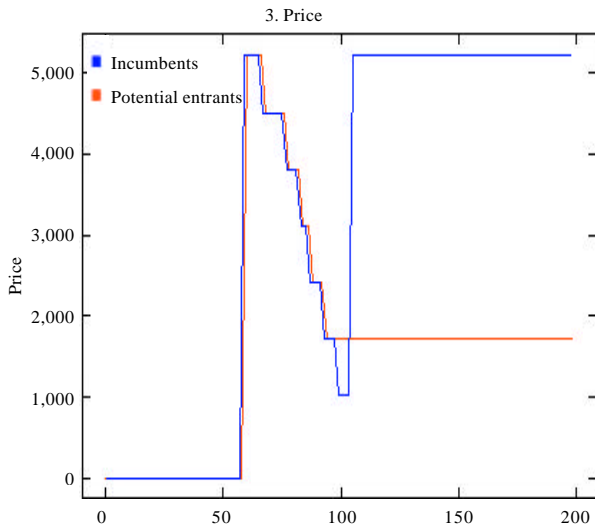


Fig. 2: Change of price-1

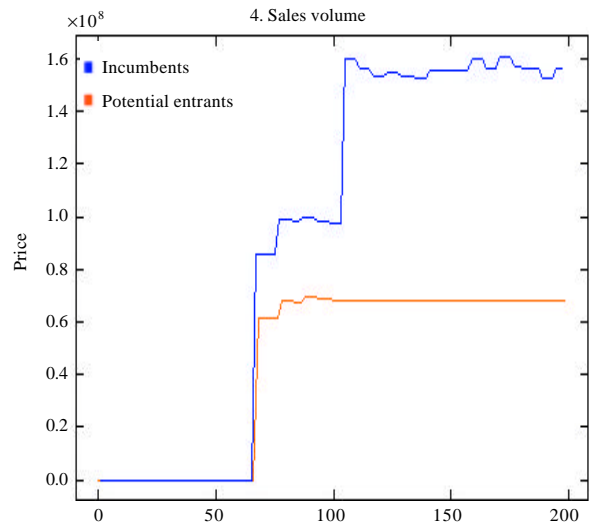


Fig. 3: Change of sales volume-1

its selling price is also higher than the other two types of businesses. Under this condition the specialty stores' profits are obvious higher than the other types of businesses, many flagship shops businesses drop out the platform of tmall.com because of the negative of margin.

By the results (Table 1), we can find out when the crude oil price is higher, the smaller entrants barriers to entry. If the market price of crude oil is low initially, entrants will die under long-term strategic barriers. In contrast, if the price of crude oil is

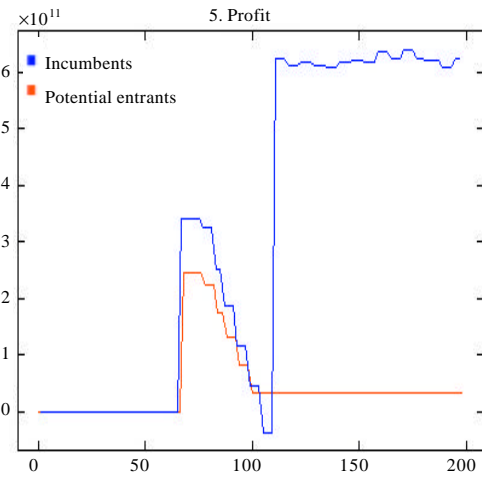


Fig. 4: Change of profits-1

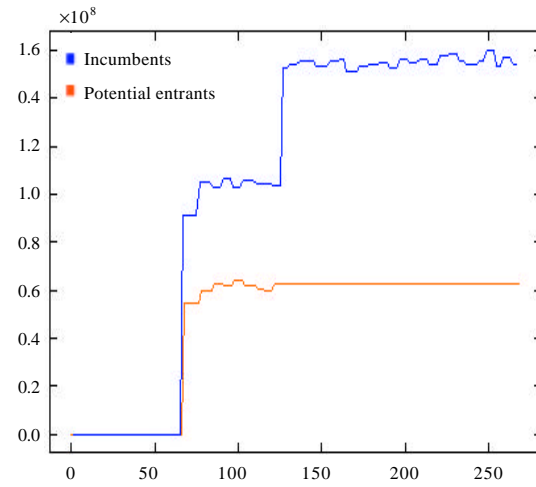


Fig. 7: Change of profits-2

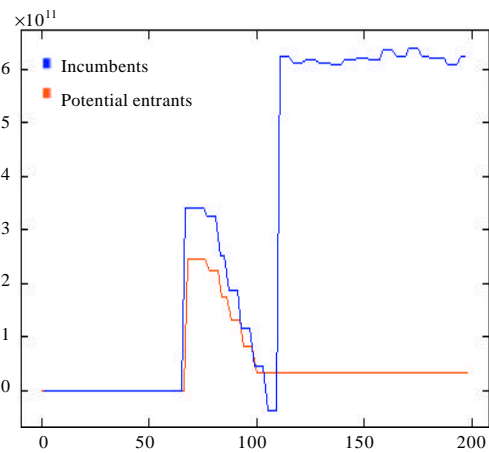


Fig. 5: Change of price-2

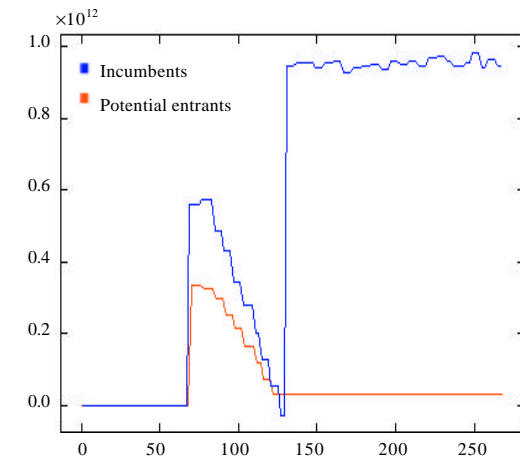


Fig. 8: Change of price-3

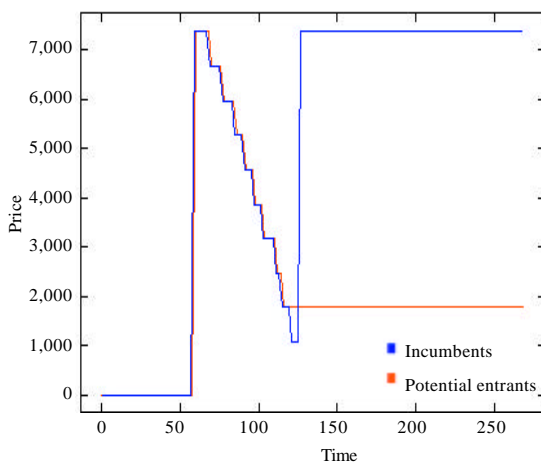


Fig. 6: Change of sales volume-2

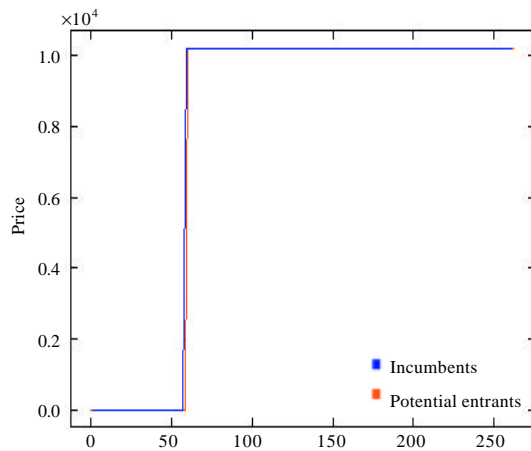


Fig. 9: Change of sales volume-3

Table 1: Simulation results

Price of crude oil (U.S. dollars per barrel)	Price of refined oil (yuan ton <sup>-1</sup> )	Results
34	5212	Under the strategic barriers to entry, entrants die soon
80	7368	Under the long-term strategic barriers to entry, entrants die
140	10180	Under the long-term strategic barriers to entry, entrants operate normally and occupy a certain market share

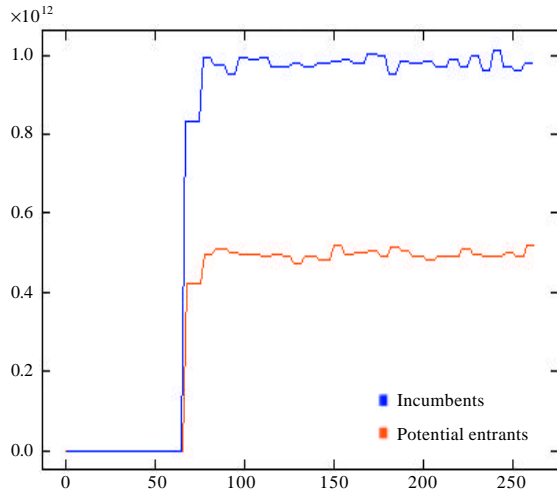


Fig. 10: Average price-3

high enough initially, entrants will operate normally under the long-term strategic barriers to entry.

To some extent, structural barriers to entry play a protective role for the incumbents.

**ACKNOWLEDGMENT**

This study was partially supported by a grant from the National Natural Science Foundation of China (No. 70671107).

**CONCLUSION**

The oil and gas market is an important part of the national economy in China and oil and gas companies in China's industrial development plays an extremely important role. Therefore, the research for market entry barriers in the oil and gas business is very necessary.

Based on the research of entry barriers of refined oil market, simulation model is built with utilizing StarLogo under the guidance of agent-based simulation thought and the results of simulation are analyzed. We want to provide reference for the development of refined oil market in China.

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