DOI: 10.7763/IPEDR. 2012. V49. 17

A Game Theory Analysis in Trade Security of Iron Ore

He Wei-da and Yu Yi

Department of Economics and Foreign Trade, University of Science and Technology Beijing, Beijing, China
e-mail: hewd@manage.ustb.edu.cn, yubenz@yeah.net

Abstract—The structure of bilateral oligopoly in iron ore international trade makes the monopoly profit, and the means to divide the monopoly profit is the pricing of iron ore. From the game analysis on pricing in iron ore international trade , this article find that the pricing right can bring the price-maker first-mover advantage, thus, both in the buyers and sellers, oligarchs have incentive to obtain the pricing right, and the relatively intensity of the competition determines their bargaining strength. In the pricing right competition of iron ore international trade, there is effect of "advantage of the weak", but the effect is limited. So, for releasing the pressure from the durative increase of iron ore price, the steel enterprises of China should take both the pricing right competition and increase of bargaining strength into account, and to design strategy on the aim of changing the relatively intensity of pricing right competition between buyer and seller.

Keywords-Iron Ore International Trade, Pricing Right, Bargaining Strength, Game Analysis

1. Introduction

In recent years, the international trade prices of iron ore had risen sharply. 2004-2007, the annual price increases were18.6% and 71.5%, 19% and 9.5%. The price boosting has brought great pressure to the Chinese iron and steel enterprises on the cost and has a negative impact on downstream industries. On the whole, notwithstanding the mounting up market demand was the reason iron ore prices continue to rise sharply in international market, the relatively weak bargaining power of the seller and buyer is another essential explanation. Because of the lacking of discourse power, China as the largest iron ore international buyers, cannot achieve an "ideal price". In this way, how to obtain international pricing power and enhance the bargaining power of iron ore has become an urgent and realistic issue for China's iron and steel industry. At present, there are several explanations for China's lacking pricing power and bargaining power in iron ore trade, such as the interference of foreign enterprises, the domestic betrayer, the low industrial concentration and the view of Prisoner's Dilemma, etc. The views above explain the multiple factors that leading the up-roaring of iron ore price respectively; it also reflects the complex situations that China's iron and steel enterprises are up against. As a result, not only an analysis of direct affecting factors but also a more comprehensive analysis inside the buyers and sellers and the structure of the competition. So this article holds that, under current international pricing mechanism of iron ore, buyers and sellers both have their pricing power competition separately. While the competition between buyers and sellers are scramble for bargaining power. The bargaining power of the buyer and seller are determined by the relative intensity of their rivalship.

2. How competition in iron ore international pricing power impact the bargaining power

Today's international iron ore trade market is a typical example of bilateral oligopoly market, while the buyers and sellers are both oligarch. The three major oligarch in buyer's market are Brazil's CVRD, Australia's Rio Tinto and BHP Billiton, while the buyers are represented by Japan (represented by Nippon Steel), Europe (Albania Sailor, Thyssen·Krupp etc.), South Korea (POSCO) and China (represented by Baosteel), both the buyers and sellers are in oligopoly markets. At the beginning of each year, Under the current international long-term iron ore contract pricing mechanism, the major buyers and sellers are to catch on a number of rounds of negotiations to determine the transaction price of that year. All negotiates will

Foundation item: National Social Science Foundation Monumental Projects of China Grant No.10ZD&029; Fundamental Research Funds for the Central Universities Grant No. FRF-BR-09-011A

suspend talks and take the price When the first pair come to an agreement. Obviously, the pair come to a conclusion first win the trading pricing power of iron ore, that is to say the competition of pricing power is Time-bound.

First we establish a bilateral bargaining negotiate model including a single buyer and seller, in order to analyses the impact international pricing power made on Bargaining Power of iron ore. We assume there is only one buyer "M" and one seller "S" in the international iron ore market, thus it is a duopoly model. If the buyer purchase iron ore with a price of "P" and a amount of "Q", the profit of the buyer and seller is as follow:

$$\pi_S(p,q) = R(q) - pq \tag{1.1}$$

$$\pi_M(p,q) = pq - C(q) \tag{1.2}$$

R(q)stand for the total revenue of the buyer form turning the "Q" amount iron ore into steel and sold out in the market. C(q) stand for the total cost. Suppose that R(0)=0, R'(q)＞0, R''(q)＜0, C(0)=0, C'(q) ＞0, C''(q) ＞0, and R'(0) ＞C'(0)

Participants take turns bidding procedures under the bargain, a bid is a pair (p,q) and p≥0,q≥0.Seller and the buyer at time t△ to an agreement of (p,q), the participants pay for the, which paid for the participants I is $\pi_i(p,q)\exp(-r_i t\Delta)$, ri is the discount rate of the future. If the seller and the buyer cannot reach an agreement for a long time, their pay are 0.

Pareto equilibrium of the pricing game results (p*,q*) should satisfy the following twoconditions:

- Total pay $\pi(p^*,q^*)=\pi_S(p^*,q^*)+\pi_M(p^*,q^*)=R(q^e)-C(q^e)$;
- If $\delta_i = \exp(-r_i t\Delta)$, $V_i^* = \pi_i(p_i^*, q_i^*)$, according to Rubinstein bargaining model, $V_i^* = \pi - \delta_j V_j^*$, $i \neq j$, $i, j = S, M$, that is：

$$V_S^* = \pi - \delta_M V_M^* \tag{1.4}$$

$$V_M^* = \pi - \delta_S V_S^* \tag{1.5}$$

from(1.4)and(1.5), we have：

$$V_S^* = \frac{\pi(1-\delta_M)}{1-\delta_S\delta_M} \tag{1.6}$$

$$V_M^* = \frac{\pi(1-\delta_S)}{1-\delta_S\delta_M} \tag{1.7}$$

from(1.1)，(1.2)，(1.3)，(1.4)，(1.5), we can say：

$$p_S^* = \frac{\delta_M(1-\delta_S)}{1-\delta_S\delta_M}\left(\frac{R(q^e)}{q^e}\right) + \frac{1-\delta_M}{1-\delta_S\delta_M}\left(\frac{C(q^e)}{q^e}\right) \tag{1.8}$$

$$p_M^* = \frac{1-\delta_S}{1-\delta_S\delta_M}\left(\frac{R(q^e)}{q^e}\right) + \frac{\delta_S(1-\delta_M)}{1-\delta_S\delta_M}\left(\frac{C(q^e)}{q^e}\right) \tag{1.9}$$

when $\Delta \to 0$， p_S^* and p_M^* Will tend to the same price p^*， plus

$$p^* = \frac{r_S}{r_S + r_M}\left(\frac{R(q^e)}{q^e}\right) + \frac{r_M}{r_S + r_M}\left(\frac{C(q^e)}{q^e}\right) \tag{1.10}$$

The number is set to R(q)-C(q),and sellers in the first transaction to maximize the level of benefit and use price as a tool for allocation of the remaining output. Equilibrium price level depends on rs and rm, the discount factor and the comparison, if the ratio is close to 0 (that is, buyers more patient than sellers), the average cost is close to the balance of the seller, which means that the seller's profit is close to 0, to buy Who get most of the remaining output; the other hand, if rm/rs close to 0, the average income is close to equilibrium of the buyer, which means that the buyer and the seller profits get close to 0 most of the remaining output.

In the Rubinstein model, the discount factor ri is defined as the patience of the participants level of international trade in iron ore price negotiations, due to the pricing power of buyers and sellers with the effectiveness of competition ,ri can be defined as both parties compete internal pricing strength, which will convert a bilateral monopoly pricing analysis of bilateral oligopoly pricing. So come, buyers and sellers in international trade of iron ore pricing competition within the relative strength of bargaining power to

determine its size, the greater rm/rs, the instructions in the relative bargaining power within the seller when the buyer within the more intense pricing competition, the bargaining power of buyers lower. In recent years the iron ore price in international trade practice, the buyer who frequent changes starting price, indicating the presence of the buyer within the intense pricing competition, and thus weaken the bargaining power of buyers can not stop the ongoing iron ore price rose sharply.

3. Competition in international trade, the buyer of iron ore pricing in real terms

Buyer's pricing power over internal competition would weaken the bargaining power of buyers, resulting in iron ore prices in international trade, indicating that pricing competition has a negative effect on the price setters. Meanwhile, according to the dynamic game theory, pricing is not only the first to give pricing by bringing a "first mover advantage" It can be deduced, the buyer of iron ore pricing competition in international trade, the real reason is that the competitive allocation of iron ore trade volume rather than price, that is, through the first pricing, pricing are able to get more ore resources, and thus competition in the steel market To grab more market share.

To test this hypothesis, the need to establish the following pricing competition in international trade of iron ore buyers dynamic game model:

- assumption in international trade of iron ore only two steel companies S1, S2, and two iron ore companies M1, M2, four bilateral trade through negotiated iron ore prices and quantities.
- Suppose the supply of iron ore international trade market function is $P_M(Q_M) = b + Q_M = b + q_{M1} + q_{M2}$, the demand function for steel products is $P_S(Q_S) = a - Q_S = a - q_{S1} - q_{S2}$.
- as intermediate products, iron ore, the demand for entirely by the steel market demand, and that demand is equal to the steel market demand for iron ore market. In equilibrium, $Q_M = Q_S$, $q_{Mi} = q_{Si}$.

Accordance to existing international trade in iron ore pricing mechanism, the buyer and the buyer were to catch on the negotiations, any one of the successful negotiation of negotiators (reach an p_m and q_m agreement), and the other negotiators will follow the pricing according to the number remaining to complete the transaction. S1and M1 is assumed to reach the first(p_m, q_m), the equilibrium price if the price is, S2 , then residual trading volume $q_{M2} = Q_M - q_{M1}$.

Assume that iron and steel enterprises S1, S2 have the same marginal cost, $MC = c + p_M$, then the response function of S2 is $\pi_{S2} = q_{S2}(P_S - c - p_M)$.

To

$$\underset{q_{S2}\geq 0}{Max}\,\pi_{S2} = q_{S2}(P_S - c - p_M),$$

The first order optimality conditions is: $\partial\pi_{S2}/\partial q_{S2} = a - q_{S1} - 2q_{S2} - c - p_M - q_{S2}\partial p_M/\partial q_{S2} = 0$ that is

$$q_{S2} = \frac{1}{2 + \partial p_M/\partial q_{S2}}(a - q_{S1} - c - p_M) \tag{2.1}$$

According to the supply function, we have $\partial p_M/\partial q_{S2} = 1$, then

$$q_{S2} = \frac{1}{3}(a - q_{S1} - c - p_M). \tag{2.2}$$

Then the optimal choice for S1 is

$$\underset{q_{S1}\geq 0}{Max}\,\pi_{S1} = q_{S1}(P_S - c - p_M) \tag{2.3}$$

The first order optimality conditions is: $\partial\pi_{S1}/\partial q_{S1} = a - 2q_{S1} - q_{S2} - q_{S1}\partial q_{S2}/\partial q_{S1} - c - p_M - q_{S1}\partial p_M/\partial q_{S1} = 0$, so : $q_{S1} = \frac{3}{8}(a - q_{S2} - c - p_M)$,based on all the functions above,

$$q_{S1}^{*} = \frac{2}{7}(a - c - p_M) \tag{2.4}$$

$$q_{S2}^{*} = \frac{5}{21}(a - c - p_M) \tag{2.5}$$

From equation 2.4 and2.5, $q_{S1}^{*} > q_{S2}^{*}$ means due to an agreement prior to gain more market share in iron ore resources and to obtain first-mover advantage, proven to be inferred. Then the equilibrium price of iron ore is $p_M^{*} = \frac{21}{32}b + \frac{11}{32}(a-c)$.

4. China's iron and steel enterprises in the iron ore pricing competition in the international trade position

International trade in iron ore pricing competition, China's steel companies and steel companies in Europe and Japan compared to the low efficiency is generally believed that competition in pricing in a weak, but the results of this analysis is not entirely the case.

We use the marginal cost of iron and steel enterprises to measure the level of business efficiency, the use of pricing above competitive game buyer model, assuming S1 and S2, iron and steel enterprises have different marginal costs $MC_1 = c_1 + p_M$， $MC_2 = c_2 + p_M$.

First, let the starting price assumed by the S1, the game's equilibrium trading volume are:

$$q_{S1}^{*} = \frac{2}{7}(a - p_M) - \frac{1}{7}(3c_1 - c_2) \tag{3.1}$$

$$q_{S2}^{*} = \frac{5}{21}(a - p_M) + \frac{1}{21}(3c_1 - 8c_2) \tag{3.2}$$

The equilibrium price is：

$$p_M^{*} = \frac{21}{32}b + \frac{11}{32}a - \frac{6}{32}c_1 - \frac{5}{32}c_2 \tag{3.3}$$

Accordingly, if the starting price assumed by the S2, the game's equilibrium trading volume are:

$$q_{S2}^{**} = \frac{2}{7}(a - p_M) - \frac{1}{7}(3c_2 - c_1) \tag{3.4}$$

$$q_{S1}^{**} = \frac{5}{21}(a - p_M) + \frac{1}{21}(3c_2 - 8c_1) \tag{3.5}$$

Then equilibrium price is：

$$p_M^{**} = \frac{21}{32}b + \frac{11}{32}a - \frac{6}{32}c_2 - \frac{5}{32}c_1 \tag{3.6}$$

from(3.1)and (3.5)，starting pricing can acquire more market share：

$$\Delta q_{S1} = q_{S1}^{*} - q_{S1}^{**} = \frac{1}{32}(a - b - c_1) \tag{3.7}$$

from(3.3) (3.6)，the changes in iron ore price range is:

$$\Delta p_M = p_M^{*} - p_M^{**} = -\frac{1}{32}(c_1 - c_2) \tag{3.8}$$

By (3.8) can we seen, if S1 is the low efficiency of enterprises, then, that starting from the S1 to reduce the iron ore pricing in international trade equilibrium price. Therefore, the low efficiency but to make iron and steel enterprises in China international trade in iron ore pricing competition has certain advantages, we can be called "weak advantage." However, the "weak dominant" role is limited. If, that is, S1 is highly efficient business, then, that is, starting from the high efficiency of enterprises in international trade of iron ore prices will raise the price, the buyer bad, but because of S1 steel increased market share, net income for the units set up steel products, at that time, S1 is still an active competition pricing. Therefore, "the weak advantage" with the increases. This is interpreted as with the improvement of the steel market rate of return, the buyer of iron ore to increase the value of international trade, pricing, pricing competition, increase in intensity, high efficiency, the cost of the buyer because of its greater tolerance and more easy to gain pricing right.

From the practice of recent years, 2003-2005 world steel demand increased by strong growth in steel market expected rate of return, resulting in 2004-2006 iron ore pricing in international trade is a strong business in Europe and Japan won. During this period, particularly in 2006, although the strong insistence of iron and steel enterprises, international trade is still unable to obtain iron ore pricing. Steel market in 2006 the decline in real yields, weakening the steel market competition among enterprises, to a certain extent, contributed to China's steel enterprises to obtain pricing for 2007.

5. International trade in iron ore pricing measures iron and steel enterprises in China

From the practice of recent years, 2003-2005 world steel demand increased by strong growth in steel market expected rate of return, resulting in 2004-2006 iron ore pricing in international trade is a strong business in Europe and Japan won. During this period, particularly in 2006, although the strong insistence of iron and steel enterprises, international trade is still unable to obtain iron ore pricing. Steel market in 2006 the decline in real yields, weakening the steel market competition among enterprises, to a certain extent, contributed to China's steel enterprises to obtain pricing for 2007.

In the pricing competition, China's steel companies need to take a proactive competitive strategy, pricing for access to get first-mover advantage. Add especially considering China is the biggest buyer of ore trading volume has more ability to affect the supply and demand pattern, it needs to compete actively in international trade of iron ore pricing. Short-term competitive strategy can still play the "weak advantage" card, and to control the value of pricing power, weakening the competitiveness of enterprises in Europe Japan and South Korea motivation. Long-term competitive strategy must be to improve production efficiency as the core, through the control of new projects, eliminate backward production capacity, promote technological innovation, optimize product structure, not only helps to reduce the demand for iron ore, regulating market supply and demand balance, help to improve China's comprehensive competitiveness of the steel industry, strengthen the deterrent power in the pricing game, the buyer's pricing power to curb competition of other motives.

In terms of bargaining power is required to enhance the management of competitive pricing, constraints, pricing competition among different buyers, to promote the cooperation of the buyer in the pricing and improve the overall bargaining power of buyers. The main constraint competitive pricing strategy buyer has separated the steel market, iron ore joint procurement, the buyer to form strategic alliances. These strategies in recent years the practice has to some extent, have been used. Such as in the "Eleventh" Five-Year Plan proposed the development of the steel industry led by domestic demand policy, and in 2006 began to gradually reduce the export tax rebate rate of steel products, for some low value-added, and the introduction of primary steel products export tax, as well as some steel exports export license management. The purpose of the introduction of these policies is to transfer to other iron ore buyer does not encourage the expansion of China's exports of steel products, information, thereby reducing the intensity of competition in the international steel market. China has also tried to establish the Steel Association, the domestic steel industry led the joint procurement mechanism to strengthen the domestic steel industry iron ore procurement collaboration, and by encouraging mergers and acquisitions among iron and steel enterprises to improve industrial concentration among domestic steel companies to avoid disorderly competition. From the perspective of international cooperation in iron and steel enterprises, Japanese and Korean steel companies, steel companies in Europe presents a strategic alliance between the trend, which also helps to reduce the buyer's pricing competition, improve the buyer's bargaining power. Iron and steel enterprises in China should also actively seek alliances with foreign steel prices combined to international trade in iron ore pricing coordinated action to avoid each other "spoiler."

The seller can take to enhance the competitive pricing strategy to improve the international trade in iron ore buyer's bargaining power. Price negotiations can take in the distinctive incentives, that is the first supplier to reach an agreement with us to give some non-price incentives (such as investment support and long-term contracts, etc.), competitive pricing in order to stimulate the enthusiasm of the seller; positive open up new ore source, increasing the seller potential competitors, lower seller concentration, reducing our individual seller's excessive dependence on iron ore, but also help enhance the competitive pricing of the seller; the long run, China's steel enterprises should increase our overseas prospectors, mining investment, the implementation of backward integration, which not only conducive to China's steel enterprises to obtain a stable mineral resources, but also the flexibility to adjust the supply of ore to break the monopoly seller, improve our bargaining power.

In addition, the establishment of a sound domestic and international iron ore market spot and forward transactions, and fundamentally change the current international trade in iron ore pricing mechanism, information structure and pricing competition, is also worth further study.

6. References

[1] Rubinstein. A Perfect Equilibrium in a Bargaining Model[J]. Econometrica, 1982,50:97-110.

[2] Michael A. H, Xiaoming H. Firm strategies in a changing global competitive landscape. Business Horizons ,2008, 51:363—369.

[3] Mohammad N, Kemal T. Game theoretic approach in routing protocol for wireless ad hoc networks. Ad Hoc Networks, 2009),7:569–578

[4] Jung W K, Jeong Y L, Jae Y K, Hoe K L. Sources of productive efficiency: International comparison of iron and steel firms. Resources Policy, 2006,31:239–246.

[5] Leandro A and Federico W, The effect of corruptionon bidding behavior in first-price auctions, European Economic Review,2008,11:2001-2046.

[6] Esmaeili M., Mir-Bahador Aryanezhad Zeephongsekul P. A game theory approach in seller–buyer supply chain. European Journal of Operational Research ,2009,195: 442–448.