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Structural Change in Mass-Procurement Systems:

China's Iron and Steel Industry and the Global Iron Ore Market

Akira Tanaka and Xiaochun Huang

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Graduate School of Economics
Kyoto University
Yoshida-Hommachi, Sakyo-ku
Kyoto City, 606-8501, Japan

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Structural Change in Mass-Procurement Systems:
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Akira Tanaka[1] and Xiaochun Huang[2]

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ABSTRACT

This study aims to describe historical trends in the "mass-procurement system" for iron ore, which for many years has been the largest non-fuel natural resource in terms of trade value. We focus on China because it reflects global trends most comprehensively.

Through modern history, all large steel producers have established their own iron ore mass-procurement systems. We can classify these systems into three major modes: "captive mine", "long-term contract (LTC)", and "spot trading."

We found that in China, traditional state-owned steel companies such as Anshan Iron and Steel (Ansteel) adopted the captive-mine mode from the prewar period, like the Americans. On the other hand, the newly established leading company Baoshan Iron and Steel (Baosteel) introduced the LTC mode, following the innovation of this mode by Japanese companies in the 1980s. Then, in the early twenty-first century, China's mass-procurement system for iron ore further diversified which established the spot-trading mode as the third mass-procurement system. As a result, many steel companies tended to create a portfolio of sourcing modes.

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[1] Kyoto University, Japan. ✉a.tanaka@econ.kyoto-u.ac.jp

[2] Hirosaki University, Japan.

1. Introduction

Mass production needs mass procurement of raw materials, and every giant steel company needs a large amount of iron ore at a low cost for long-term stability. This principle is especially true for capital-intensive industries such as the iron and steel industry.

Chandler (1977) concluded that the advantage of vertical integration as a general tendency of modern economic societies is that it encourages high-throughput production under administrative coordination over a series of value chains. He particularly described that the US iron and steel industry is integrated upstream to iron ore and coking coal, and is the ideal model of mass-procurement according to many scholars, business, and policy makers.

On the other hand, postwar Japan, with no rich domestic resources and a lack of prewar colonies, found no way of procuring natural resources other than purchasing both foreign ores and oil by long-term contract. Japanese companies sometimes lent to and/or invested in large foreign mining projects in order to secure the supply of this natural resource to Japan. This strategy was called the "*kaihatsu yunyu*" or the "develop-and-import scheme". Vernon (1983) examined iron and steel, aluminum, and petroleum industries, and insisted that Japan's procurement strategy became more efficient after the oil crisis than that of the US, in every case.

The dialogue between Chandler and Vernon suggests that the historical choices in procurement systems characterize the industrial value chain and may determine the competitiveness of iron and steel producers.

Our viewpoints from which we analyze the iron and steel industry in China are as follows:

First, we shall apply the comparative institutional framework of procurement systems in **Table 1**. The horizontal axis represents the nature of iron ore transactions

and is one of the basic insights provided by organizational economics.[3]

We take the geographic range of value chains as the vertical axis because when the supply chain expands across the border, it would be affected by political factors.

Table 1. The typology of procurement systems

		The mode of transaction		
		I. Vertical integration (Captive mine)	II. Hybrid (Long-term contract)	III. Market transaction (Spot trading)
Location	Domestic	US		
	International	(US)	Japan, South Korea	

Source: Modified from table 1 of Tanaka (2013).

Secondly, we will consider that the entities choosing a procurement system are not states nor countries, but rather firms or networks of firms. International economists and international political economists are traditionally, and even now typically interested in state- or country-based research. For example, Kojima (1978) focused on Japan's "dominant buyer relations with major suppliers" to obtain several metals. Japan's relationships with suppliers could explain its bargaining power in the Asia-Pacific iron ore market well. However, its bargaining power was the result of Japanese steel companies consolidating in purchasing to become quasi-single buyers, until the beginning of twenty-first century. We believe Kojima's argument should be examined using firm-level analysis.

[3] Williamson (1985) defined three types of efficient governance, which are determined by both investment characteristics and frequency of transactions. The three types of efficient governance are market governance, bilateral governance, and trilateral governance.

One of the authors of this paper, Tanaka (2008, 2012, 2013, 2014, and 2015) told the story of the world's iron ore procurement systems. At the beginning of the twentieth century, modern US enterprises established a captive-mine system and became first movers not only in the mass production of iron and steel but also in the mass procurement of iron ore. Several US and European steel companies have acquired foreign captive mines mainly in Latin America. However, they lost almost all of them under the resource nationalism movement in 1970s. Meanwhile, the Japanese iron and steel industry, with special assistance from general trading companies, formed the LTC method in the 1960s to replace the captive-mine method. About a decade later, South Korean iron and steel companies systematically adopted Japan's mass-production technology and mass-procurement system. Several Asian and European companies followed suit, and the LTC method became the world's *de facto* mass-procurement system in the last quarter of twentieth century. Spot trading of iron ore has not been a major procurement system for any country for a long time, and there have been no futures markets for iron ore prior to 2010.

In this study, we aim to explore the case of the Chinese iron and steel industry and show that China is becoming the epicenter of the revolution in two aspects: the structure of global iron ore trade and the change in mass-procurement systems.

In the next section, we will survey trends in the world's production and trade of iron ore. Then, we describe the general tendencies in the structure of demand and supply in China both on a country and firm level. In section 3, we inquire into the trends in procurement systems in China, examining two companies in particular: Anshan Iron and Steel (Ansteel) and Baoshan Iron and Steel (Baosteel), which are typical firms from different time periods. In section 4, we explore the new trends in the twenty-first century and examine a third company, Qian'an Iron and Steel Co. (Qian'an Co.). We provide a conclusion in the final section.

2. The Structural Change in the Worlds' Iron Ore Market

In recent years, the global iron and steel industry had been expanding rapidly. In 2015, global crude steel production reached 1.62 billion tons, of which China produced 804 million tons, making up 49.6% of the world total. China's contribution to global crude steel production was only 5.2% in 1980 (WSA, *World Steel in Figures 2016*). China's crude steel production has grown more than twenty times that of 35 years ago, and this increase of 767 million tons equals 85% of the world's total increase during the same period. Furthermore, the proportion of Chinese electric steelmaking plants, which use little iron ore, is much fewer than the world's average, so China is a much larger iron ore consumer than steel producer in the world. Therefore, the question of how to procure large amounts of iron ore to meet growing demand is much more pressing for China than any other steelmaking country. We have to look into how the structure of supply and demand of iron ore has changed over the long run.

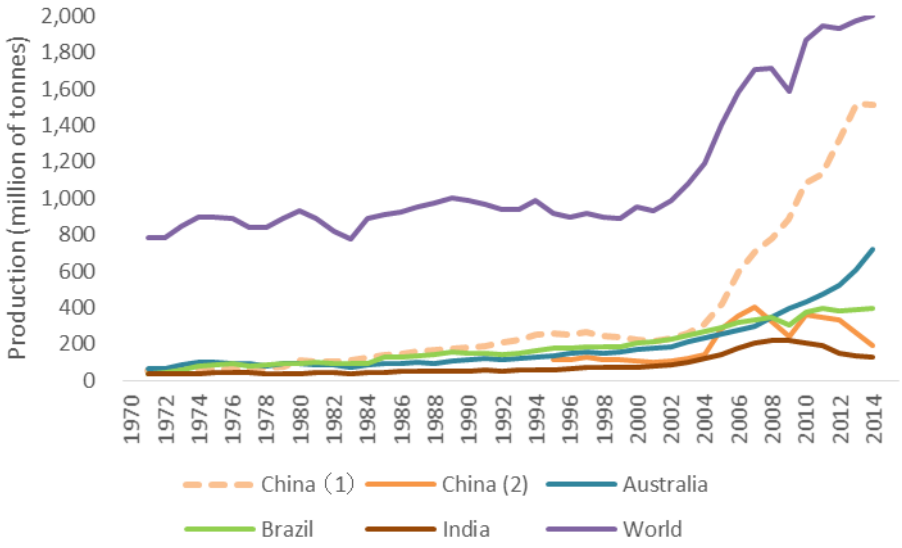

Figure 1. Trends in iron ore production by country

Source: Compiled from WSA, *Steel Statistical Yearbook*, various issues.

Note: China (1) is total production including ore with low Fe content. China (2) is

converted to correspond with world average Fe content (Source: UNCTAD). World total includes China (1), 1970-1994; and China (2), 1995-2014.

Figure 1 shows that total world production of iron ore has been stable at 0.8 to 1.0 billion tons for the last three decades of the twentieth century, and increased rapidly in the twenty-first century. China has been one of the biggest iron ore producers. In particular, China's crude iron ore production (China (1) in the figure) remarkably grew by 41.4% per year since 2000. However, because of depletion, China's domestic iron ore contains low levels of elemental iron (Fe); therefore, measures of Fe by the World Steel Association (WSA) are adjusted so that Fe content is similar to world average since 1995. According to the adjusted statistics, iron ore production of China (2) looks to have peaked in 2007 and has stagnated since then to fall below the production levels of both Australia and Brazil.

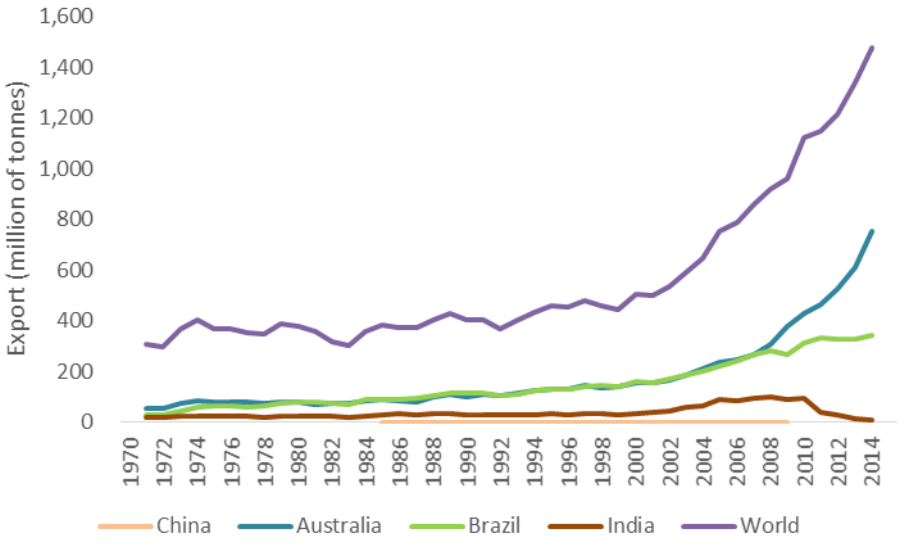

Figure 2. Trends in iron ore exports by country

Source: Compiled from WSA, *Steel Statistical Yearbook*, various issues.

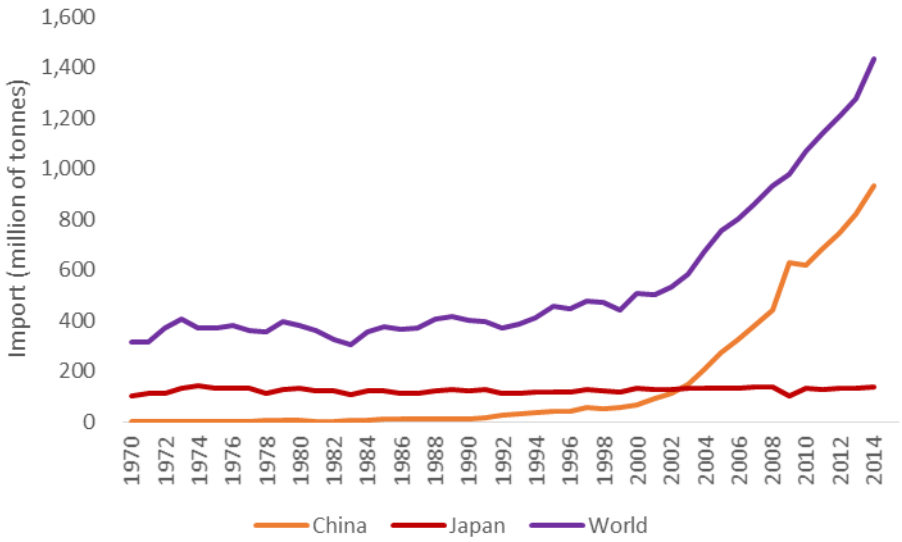

Figure 3. Trends in iron ore imports by country

Source: Compiled from WSA, *Steel Statistical Yearbook*, various issues.

Total world iron ore exports (**Figure 2**) shows a similar trend as production. However, China does not appear because of its huge demand for iron ore. China's import of iron ore also began to accelerate around 2000 to overtake that of Japan, which has been the dominant importer for decades, in 2003 (**Figure 3**). In 2014, China's imports reached 65% of total world imports.

In twenty-first century China, with iron production continuously growing, the demand for iron ore had also been expanding quickly. However, the domestic ore is of a lower grade, high cost. Thus, China's domestic supply of ore cannot meet the needs of its current iron and steel production. China is increasingly dependent on imported ore. In 2001, imported ore accounted for 39.7% of total demand. In 2014, China imported 933 million tons making up 83% of the total demand, and establishing a new historical high (*World Steel in Figures 2016*). Currently, China is the world's largest iron ore importer and consumer with each year's import of ore accounting for 60% of the world's iron ore production while remaining one of the world's major producers.

Thus, the world's international trade structure of iron ore has changed dramatically (**Table 2** and **3**). In short, China's imports increased remarkably, and Australia ("Oceania" in the tables) and Brazil ("Other America" and "Latin America" in the tables) supplied the increasing demand. In this sense, China became the new "dominant buyer" of iron ore in Asia Pacific in place of Japan.

Table 2. World iron ore trade by area, 2015

million of tonnes actual weight

Exporting region / Destination	EU28	Other Europe	CIS	NAFTA	Other America	Africa and ME	Asia	Oceania	Total imports	ex-reg imports
EU28	37.0	4.0	27.1	17.7	54.0	13.2	0.0	-	153.1	116.0
Other Europe	1.3	0.1	4.8	0.7	5.0	0.3	0.5	-	12.5	12.4
CIS	0.0	0.0	11.1	-	-	0.0	0.0	-	11.1	0.0
NAFTA	0.2	0.0	-	8.9	2.9	0.1	0.0	-	12.1	3.2
Other America	0.0	-	-	1.4	13.7	-	0.0	0.0	15.2	1.5
Africa and Middle East	5.2	0.0	-	0.2	24.8	0.0	0.6	-	30.8	30.8
China	0.2	0.2	30.1	8.1	**207.6**	72.8	26.8	**607.6**	**953.4**	926.6
Japan	0.0	0.0	1.9	4.4	**37.7**	6.9	0.1	**80.0**	**131.1**	131.0
Other Asia	0.0	0.1	0.4	3.8	51.6	6.0	1.7	122.9	186.4	184.7
Oceania	0.0	-	-	-	0.1	0.0	1.6	1.1	2.8	1.7
Total exports	44.1	4.3	75.2	45.2	**397.4**	99.3	31.2	**811.6**	1,508.2	1,407.8
extra-regional exports	7.0	4.2	64.1	36.3	383.7	99.3	2.7	810.5	1,407.8	
Net exports	-109.0	-8.2	64.1	33.1	382.2	68.6	-1,239.6	808.9		

Source: World Steel Association, *World Steel in Figures 2016.*

Table 3. World iron ore trade by area, 1980

million of tonnes actual weight

Exporting region / Destination	EEC	Other WE	USSR and EE	North America	Latin America	Africa	Asia	Oceania	Total imports	ex-reg imports
EEC	8.7	21.7	0.5	16.7	36.6	28.5	0.1	10.9	123.7	115.0
Other Western Europe	-	2.5	1.8	0.9	4.2	2.5	0.5	0.5	12.9	10.4
USSR and Eastern Europe	-	1.8	37.5	-	10.9	2.0	6.4	-	58.6	21.1
North America	-	0.2	-	23.6	5.4	2.2	-	-	31.4	7.8
Latin America	-	-	-	-	2.0	-	-	-	2.0	-
Middle East	-	0.3	-	-	0.2	0.3	-	-	0.8	0.5
China	-	-	-	-	**0.5**	-	-	**5.3**	**5.8**	5.8
Japan	-	-	0.2	3.4	**38.3**	8.2	20.6	**63.0**	**133.7**	113.1
Other Asia	-	0.2	-	0.2	7.2	-	2.0	5.6	15.2	13.2
Total exports	8.7	26.7	40.0	44.8	**105.3**	43.7	29.6	**85.3**	384.1	730.7
extra-regional exports	0.0	24.2	2.5	21.2	103.3	43.4	7.0	85.3	286.9	
Net exports	-115.0	13.8	-18.6	13.4	103.3	42.9	-125.1	85.3		

Source: IISI, *World Steel in Figures 1982.*

Table 4. China's largest steel companies and iron ore companies, 2000

Place in steel	Place in ore	Name of Company	Location	Production (thousand tonnes) crude iron ore	fine iron ore	pig iron	crude steel
1	—	Baosteel Co.,Ltd. (Baosteel Group)	Shanghai	0	0	10,290	11,304
2	1	Ansteel Group	Liaoning	26,602	8,671	9,111	8,812
3	3	Shougang	Beijing	11,797	3,717	7,726	8,033
4	10	Wuhan Iron and Steel (WISCO)	Hubei	4,833	1,975	6,413	6,652
5	2	Benxi	Liaoning	13,735	5,452	4,968	4,223
6	5	Baotou	Inner Mongolia	7,806	1,808	3,921	3,925
7	6	Ma'anshan	Anhui	7,278	3,123	3,971	3,922
8	4	Panzhihua	Sizhuan	9,919	4,822	4,062	3,595
9	11	Tangshan	Hebei	3,049	948	3,356	3,196
10	—	Handan	Hebei			3,622	3,150
11	—	Jinan	Shandong	550	185	2,869	3,030
12	—	An'yang	Henan	598	n.a.	2,634	2,434
13	7	Taiyuan	Shanxi	6,354	2,741	2,243	2,429
14	—	Shanghai No.1 (Baosteel Group)	Shanghai			2,517	2,256
15	—	Laiwu	Shandong	1,708	338	1,708	2,140
16	8	Jiuzhuan	Gansu	4,763	1,227	1,872	1,926
17	—	Tianjin Tiantie	Tianjin			2,279	1,901
18	—	Kunming	Yunnan	552	251	2,044	1,853
19	—	Nanjing	Jiangsu	507	291	1,697	1,777
20	17	Chongqing	Chongqing	254	254	1,656	1,773
		Subtotal		100,303	35,803	78,957	78,330
—	9	Hainan Iron and Steel	Hainan	4,180	n.a.		
31	12	Shanghai Meishan (Baosteel Group)	Shanghai	2,693	1,004	2,517	1,251
—	13	Hanxing Metal Mine Bureau	Hebei	2,671	2,051		
—	14	Luzhong Metallurgical Mining	Shandong	1,379	822		
33	15	Xuanhua	Hebei	370	183	1,635	1,207
26	16	Shuicheng	Guizhou	275	276	1,332	1,472
		Total of 'Key Steel Companies' (n=77)		110,856	39,259	109,716	120,895
		Total of 'Key Iron Mine Companies' (n=17)		105,387	49,189		
		Total of China		222,562		131,015	128,500

Source: Compiled from *Zhongguo Gangtie Gongye Nianguan 2001* (*Yearbook of China's Steel Industry*).

However, China's status as a "dominant buyer" could be accurate only on the state or country level. If we examine the firm-level structure of demand and supply, we can see different trade patterns. The world's iron ore market has become concentrated and dominated by the 'Big Three' iron ore producers (Vale, Rio Tinto, and BHP Billiton) that hold 57% market share in 2009 seaborne trade. On the contrary, the steel industry remains much more competitive, despite a significant M&A activity. Especially in

China, the steelmaking companies are too many in number to collaborate in purchasing. In 2000, the four largest steel mills individually produced 5% to 9% of all crude steel, and the top 20 companies' total crude-steel production only amounted to 61% of China's overall production (**Table 4**). China's market trends are completely different from that of Japan, the previous, successful, dominant buyer. The implication of these differences is that steel companies face unknown situations in their industrial history, and therefore have to adapt their mass-procurement systems.

3. Transformation of the Mass-Procurement System for Iron Ore

Iron ore trading has evolved through many stages, beginning with spot trading, and thereafter long-term contract, and short-term contract as well as the current long-term contract with the fixed volume and non-fixed price, index pricing, spot trading and futures trading.

Prior to 2000, there were two dominant modes for iron ore procurement: captive mines and long-term contract. The US and Japan were the first movers of the captive-mine and long-term contract methods, as we mentioned in section 1. These two countries also respectively represented the most successful combinations of mass-production and procurement systems in the first and latter halves of twentieth century.

In China, which had one of the richest iron resources in the world, most of the major steel companies adopted the captive-mine method just like producers in the US. The tendency of the Chinese to adopt the captive-mine method can be seen data from 2000 in **Table 4**. Ansteel had been the leading company in the industry, followed by most other Chinese steel mills from the prewar period to the 1980s, including procurement system. In the late 1970s, Baosteel established itself through the systematic introduction of mass-production technology and mass-procurement systems from Japan, as one aspect of the 'reform and openness policy'.[4] In other words, Baosteel was a

[4] The Baosteel project was originally started by the local government of Shanghai;

follower in adopting the LTC method in the Asia-Pacific iron market, and a unique challenger in the Chinese iron and steel industry.

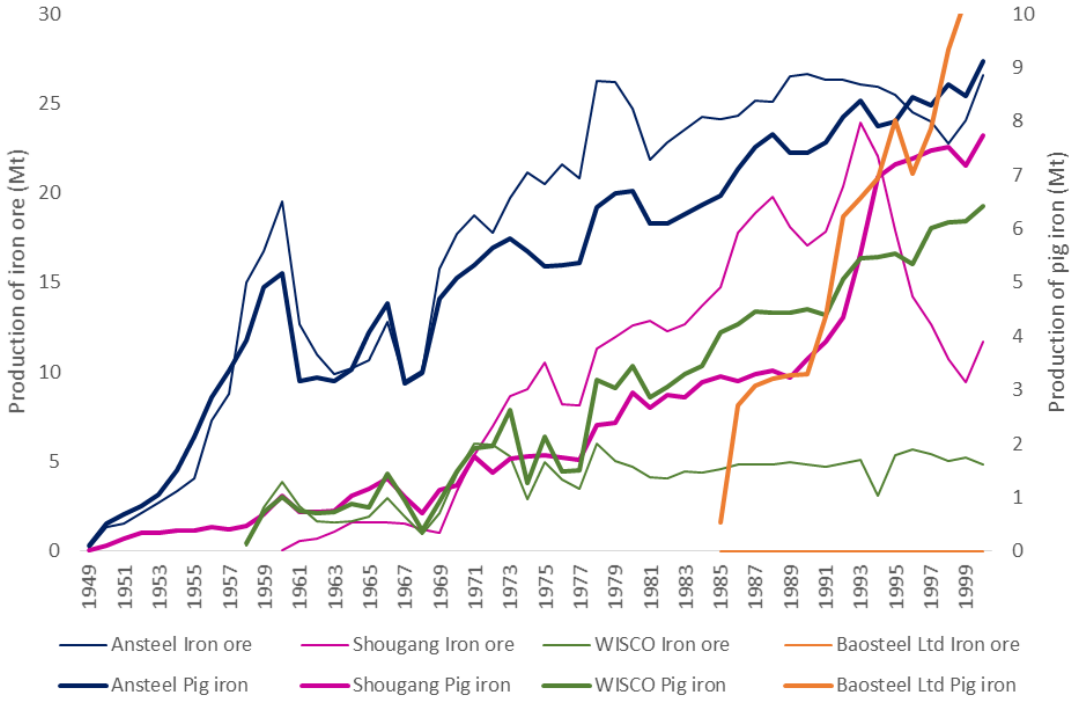

Figure 4. Trends in China's major steel companies' production of iron ore and pig iron

Source: Compiled from *Zhongguo Gangtie Gongye Wushi-Nian Shuzi Huibian* (*Fifty Years of China's Iron and Steel Industry in Figures*), 2003.

However, with increasing steel production and iron ore demand in the long run, more Chinese steel mills came to adopt the LTC method in addition to the captive-mine method. Please see **Figure 4**. Suppose that Chinese domestic iron ore has 33% iron ore content on average; therefore, one will need 3 tons of iron ore to make 1 tons of pig iron. A steel mill needs to produce triple the amount of iron ore over pig iron to justify using the captive-mine method. We can see that Wuhan Iron and Steel (WISCO) could not

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however, it was developed to be one of the most important national projects by the central government.

sustain itself in the 1980s, and Sougang and Ansteel were also likely to face a shortage of iron ore from captive-mine production in the 1990s.

Under a long-term contract mode, both the major steel mills and major mining companies agree on trade volume and annual price (FOB) through business negotiations. However, since April 2010, this negotiation mechanism has evolved from the annual long-term contracts to quarterly and monthly pricing based on an index price. The Platts index is a typical index used. The index pricing is expanded from medium grade fines to high grade fines and lump ore, and pellets.

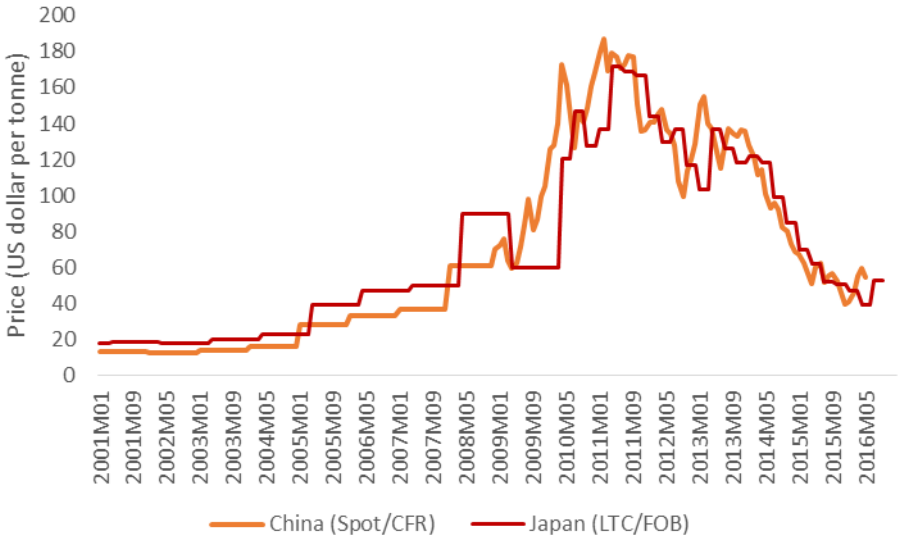

Figure 5. Trends in iron ore prices for China and Japan

Source: Compiled from *IMF Primary Commodity Prices* (for China), Tex Report, *Iron Ore Manual* and *Nikkei* (for Japan), various issues.

Note: (China) Fines 62% Fe spot (CFR Tianjin Port), (Japan) Pilbara Blend fines (FOB).

Regardless, there are many other pricing models, such as bidding, e-commerce platforms, base-spread pricing, and others. Although trading volume has been increasing on the two major trade platforms (GlobalOre and COREX) in recent years, it still has

not reached expected levels. In terms of types of products, there are cases where only one bidding price for a shipment was used to determine the index.

The iron ore market price has much volatility. Prices peaked in 2011, but since then the imported iron ore price fell from USD 170 per ton to USD 50 per ton. This volatility has strongly affected the production and operation of steel companies, whose iron ore cost is 60% of the pig iron cost, exposing them greatly to the market risks. At present, in the face of the slowdown of both the world and the domestic economy, there is a surplus in steel production capacity. With weak exports and domestic markets, the domestic steel mills make little profits or a loss.

4. A Case Study: Qian'an Co.

4-1. Iron ore imports and issues emanating from the original procurement mechanisms

Qian'an Iron and Steel Co. (Qian'an Co.) is a subsidiary of Shougang Co., Ltd, which in turn belongs to the Shougang Group. It has an annual production capacity of 7.8 million tons of iron, 8 million tons of crude steel, and 7.8 million tons of steel products.

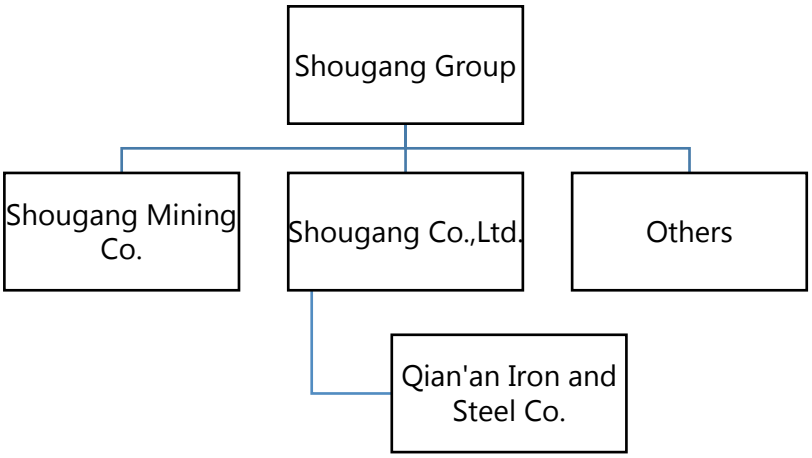

Figure 6. The structure of Shougang Group

Source: http://www.shougang.com.cn/shougang_cn_web/

Although Qian'an Co. has 4.5 million tons of concentrates from Shougang Mining Co., it has to procure 7-8 million tons of iron ore to meet its blast furnace production (its annual pig iron production is 7.8 million tons), accounting for 60% of the total raw materials needed for its steel production. Procurement is a key component of the company's operation. However, in the management of iron ore, the ore price is greater than the current month's Platts index. In 2014, there was a USD 12 gap between the price of the ore it used and the Platts index during the same period.

Long-term contracts in Qian'an accounted for approximately 95% of total annual imported iron ore. The procurement of these resources covered 5 routes and 9 ports, including the following: 1 Peruvian port with a shipping distance of 9,800 nautical miles and travel time of 40 days; 3 Brazilian ports, 120,000 nautical miles, 45 days; 3 Australian ports, 4,000 nautical miles, 15 days; 1 South African port, 8,500 nautical miles, 40 days; and 1 West African port, 12,100 nautical miles, 45 days. Long-term contract execution is a long process and includes planning the logistics of obtaining the resources, shipping arrangements, seaborne transportation, custom clearance at the port, unloading management, road transportation, receiving and warehousing, and obtaining production consumables.

The seaborne ports into which Qian'an Co. receives its iron ore are Qinhuangdao, Jingtang, Caofeidian, and Tianjin Beijing. Each of these have different geographic characteristics, port facilities, and road transportation conditions, with different costs.

Imported ore is stored at both the ports and the plant. Shougang Group is in charge of storage after the ore is unloaded and then transports the ore to the plant. Qian'an Co. takes care of the storage within the plant. Due to the separate management of the port and in-plant storage, the two companies are responsible for their storage management. The total inventories amount to over 1 million tons. In 2014, the total inventory at Qian'an was 1.19 million tons at its maximum, which could remain there for over 2 months. With high inventory, working capital is not used efficiently and the per unit cost

of the ore (including transportation and storage cost) is higher than the market price index. The steelmaking cost is thus higher than that of the rest of the industry. Furthermore, the company's slow reaction to changes in the market would reduce its competitiveness.

In daily operations, when the iron ore enters the production flow, many vehicles are used to transport the ore to be weighed, inspected, and cleaned. All these costs are raw material processing costs. If all these processes are poorly managed, the total costs of raw materials shall increase. In 2014, 1.13 million tons of ore were transported from the ports to the 82-meter stockpiling place, then from the stockpile to the steel mills, during which the ore was weighted again. The handling cost was about RMB 12.35 per ton, which meant the total cost of handling in the year was about RMB 13.96 million.

4-2. Strategy of securing iron ore suppliers and production practices

Qian'an decided to reduce its pre-production inventory from the volume for 15 days of production, then that for 7 days. During the process, the certain grades of iron ore could be less than 7 days, which makes it more challenging to guarantee stable supplies for production and increases the responsibility of the operations management.

The total inventories are being maintained at 300,000 tons, which includes in-plant inventory of 200,000 tons and 100,000 tons at the port. During different periods, different strategies are applied to reduce the market impact. During times of high market prices, the total inventory of non-mainstream ore should be increased. At times of low prices, an appropriate number of long-term contracts based on actual production requirements should be used to reduce inventories, and control of the total procurement volume improves the capital turnover rate. At times of high volatility, one should take the opportunity to buy at a low price and control the procurement volume of ore at high price levels to reduce the gap between the ore price and the current market index.

In iron ore operations, long-term contracts provide stable supply to production,

while spot-trade contracts contribute to cost reduction and improvements in efficiency through the management of inventory. During the planning of resource procurement, some procurement is set aside for spot-traded ore, which is about 10% of total monthly consumption.

Both spot purchases of supplies with flexible trading and pricing models and purchases of small quantities are Qian'an has increased the amount of ore procured by spot trading to about 10% of its total monthly consumption.

Spot supplies are among the most flexible trading and pricing models sources for purchases of small quantities, and efforts to effectively procure these supplies can help reduce the gap between the ore price and the current market index. As a result, the gap between the fines at storage area and the current market price has been reduced from USD 12 to less than USD 10.

5. Conclusions

China's remarkable growth in steel production changed the structure of the Asia-Pacific iron ore market. China came to dominate imports, which caused Australia and a few countries to increase production and exports. However, it is just a nominal 'dominant buyer' because China's steel industry is too highly fragmented to construct bargaining power against the Big Three iron ore producers. As a result, highly competitive industrial organization in China's steel industry affects the world market.

China also caused another structural change in procurement systems. Rapid expansions (and large contractions) in iron ore demand made it inefficient for captive-mine and LTC schemes to coordinate the amount of demand and supply and stabilize market prices. Consequently, China created a huge spot-trade market, the third mode of mass procurement, which had previously only played a small, local, temporary complementary role. Currently, the iron and steel companies in Asia Pacific typically develop a multi-sourcing policy which combines LTC, spot-trade, and captive-mine

systems (if possible) as a portfolio of mass-procurement systems.

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