



A system analysis of the development strategy of iron ore in China



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ABSTRACT

This paper aims to present a full picture of the current status and future trends of China's iron ore development using system analysis on the iron supply chain. First, we map China's iron flow to present the physical patterns of iron ore supply and demand in China. Next, the historical and future trends of iron ore development in China are discussed from four aspects including demand, resource availability, technology improvement, and strategy and policy. Based on these aspects, we conclude how to sustainably obtain overseas iron ore resources at a reasonable price as the key issue, and this issue is further analyzed from perspectives of market structure, the pricing mechanism, and Chinese steel companies' behavior. In conclusion, we determined China must enhance cooperation with the main global suppliers, expand overseas investments effectively, and enhance domestic coordination to secure the import of resources and reduce price fluctuations.

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1. Introduction

In recent years, massive infrastructure buildings and consumption upgrading have provided a rapidly growing demand for iron ore in China. To meet this growth, China's iron ore import increased rapidly and China became the largest importer in the world. With a high and fluctuating international trading price of iron ore, how to develop the supply and utilization of iron ore has become an important strategic issue for the sustainable development of China.

Many studies have been published to propose strategic suggestions for the development of iron ore in China from different aspects, including demand and supply (Wang et al., 2007; Yellishetty et al., 2010; Gao and Wang, 2010; Cullen et al., 2012; Ma et al., 2013; Yin and Chen, 2013), technology improvement (Schenk, 2011; L.W. Ma et al., 2012; Tao et al., 2013), scrap recycling (Pauliuk et al., 2012), and international price (Alexander et al., 2013; Ma, 2013; Wilson, 2012; Li et al., 2011). However, few studies can integrate these various aspects together to form a more complete picture of iron ore development, which is urgently required for making strategic decisions during a rapidly and dynamically developing process for the sustainable development of China.

This paper aims to use the approach of system analysis based on the perspective of a supply chain to present a complete picture

of iron ore development and to propose comprehensive strategic suggestions. The following content is organized as follows: a brief introduction of the system analysis method in Section 2; a review of the current status of iron ore supply and demand by mapping China's iron flow in Section 3; a discussion of historical and future trends in iron ore development from four key aspects including demand, resource availability, technology improvement, and strategy and policy in Section 4; additional analysis of key issues in Section 5; and conclusions and suggestions in Section 6.

2. Methodology

The framework of the system analysis approach used in this paper is illustrated in Fig. 1, which refers to a previous study (S.H. Ma et al., 2012) on oil development but is carefully modified to make it fit in this work. The physical flow of iron, located in the center of the system, is the key part of the analysis. It includes all stages of the iron ore supply chain from mining and processing of mineral resources, iron making, steel making, manufacturing, end-use, to recycling. To understand the dynamic development of the physical flow of iron, we identify three direct factors and one indirect factor influencing its development as follows:

- (1) **Iron ore demand (direct factor):** Iron ore is mainly used to produce crude steel and its downstream products, which are the fundamental materials for building, infrastructure, transportation, machinery, and other uses. The demand for iron ore has a close relationship with the economic development in

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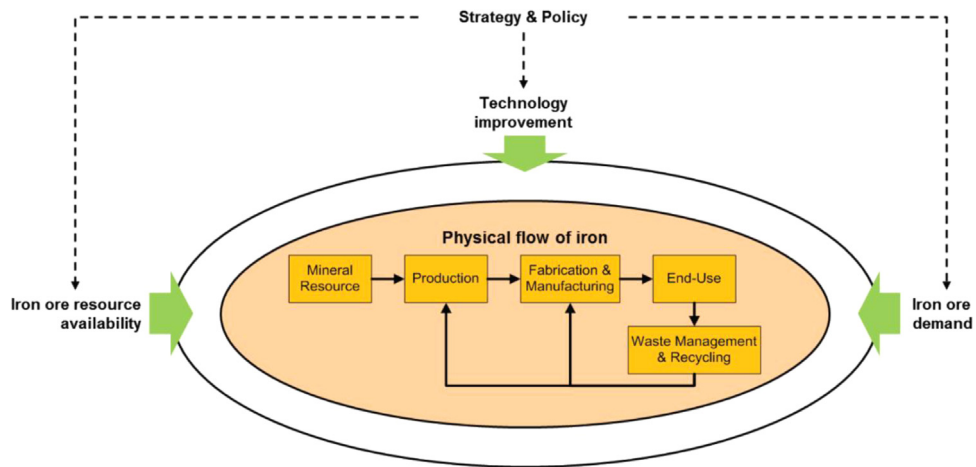


Fig. 1. The framework of system analysis from the perspective of a supply chain.

China. The future economic development will greatly affect the end-use pattern and then the demand for iron ore through the whole supply chain.

- (2) **Iron ore resource availability (direct factor):** It affects the beginning stage of the whole supply chain – the amount of iron ore being supplied. The resource availability means not only the reserves and production capacity in China and the world but also the price of imported iron ore.
- (3) **Technology improvement (direct factor):** The technologies are the links between the resource supply and end-use demand along the whole supply chain. They convert the input iron ores into steel products to provide final services for the society. The efficiency of technologies and the scrap recycling ratio will affect the amount of required iron ores and final steel products. Therefore, the improvement of technologies is important for reducing iron ore consumption and also for improving environment protection.
- (4) **Strategy and policy (indirect factor):** The strategy and policy has complex influences on the physical iron flow by influencing the demand, resource availability and technology improvement. Generally, the strategy and policy can lead to the development of other factors. The aim of this paper is to propose a proper development strategy for iron ore in China from a comprehensive view of the whole supply chain.

In the following sections, this approach is used to generate strategic suggestions for the development of iron ore in China. By

mapping the physical flow of iron, we systematically present the current status of iron ore development. Then, by discussing the historical and future trends and analyzing the influencing factors above, we try to provide a deep understanding of the future dynamics of iron flow from various aspects, determine key issues for additional analysis, and propose strategic suggestions.

3. Current status of iron ore development in china

The diagrams of iron flow are made by the method of material flow analysis or are called the substance flow analysis (Yellishetty and Mudd, 2014). The earlier examples are published by the Center for Industrial Ecology at Yale University (Wang et al., 2007, 2008). In this paper, we construct one diagram from the perspective of the supply chain and another from the perspective of the iron cycle to reveal the complex patterns of China's iron ore supply and demand in 2011, as illustrated in Figs. 2 and 3. The key definitions and data input are listed in Table 1.

In both diagrams, the iron use in China is traced from left to right and allocated to each of the six stages as follows:

- (1) **Mining and processing**, where crude ore is extracted and converted to finished ore through processing, including the import, export, and stock of finished ore in main ports.
- (2) **Iron making**, where finished ore is converted to pig iron or direct reduced iron and also includes the import, export, and

China's iron flow in 2011
Unit: Million tonnes iron

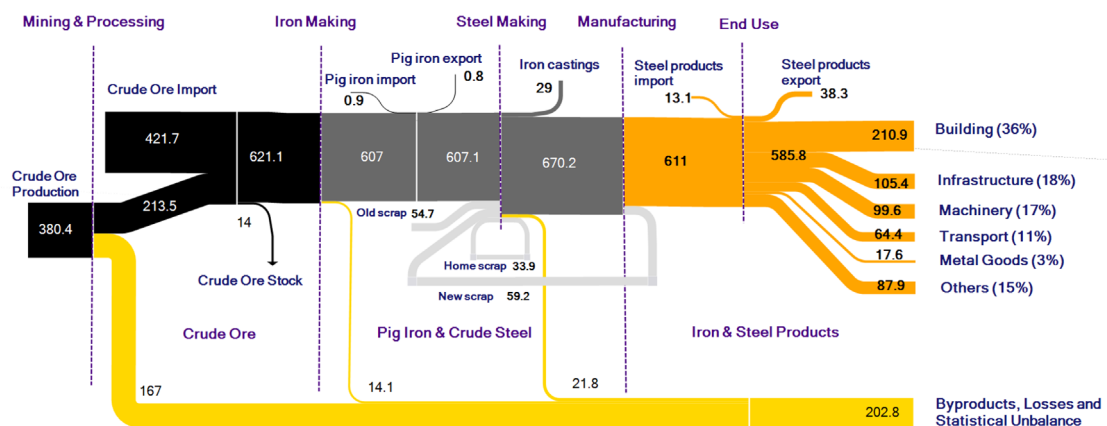


Fig. 2. China's iron flow in 2011 (Mt iron).

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