



Vertical vs. horizontal integration: Game analysis for the rare earth industrial integration in China



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ABSTRACT

Rare earths are important strategic mineral resources and have been widely used for economic development and national security. The Chinese government has carried out some policies to promote the process of rare earth industrial integration. Our study constructed a two-stage game-theoretic model to analyze the industrial integration tendency of rare earth firms. Three integration scenarios have been established, including no integration, horizontal integration between upstream firms and vertical integration between upstream and downstream firms. The results show that firms and the Chinese government prefer different modes of rare earth industry integration. For rare earths firms, they would like to carry out horizontal integration to maximize their profits, while the Chinese government would encourage the vertical integration between upstream and downstream firms to realize the maximization of social welfare. Finally, the Chinese government would like to make out some policies to guide the rare earth firms to implement vertical rather than horizontal integration.

1. Introduction

Rare earths are important strategic mineral resources that are widely used in various areas of national economic development. They are also indispensable elements in modern industry, with uses in new materials, energy conservation, environmental protection and aerospace and electronic information industries because of their unique physical and chemical properties (McLellan et al., 2013). Rare earths are mainly distributed in just a few countries. For example, China, Brazil and Australia occupy the major reserves of rare earths throughout the world, among which, China has the largest reserve with the share of 31% in 2015 (see Fig. 1).

China's rare earth distribution presents a "light north, heavy south" pattern (State Council, 2010). Light rare earths are mainly located in Baotou city of the Inner Mongolia Autonomous Region, accounting for half of the global supply (Wübbecke, 2015), while ion-absorbed-type middle and heavy rare earths are mainly found in South China, accounting for more than 80% of the world's total medium and heavy rare earths (Su, 2009). Besides, medium and heavy rare earths have more applications and are generally more expensive than those of light rare earths, due to their lower abundance (Müller et al., 2012; Yang et al., 2013). For example, the price of La (one of the light rare earths) was \$6.50 per Kg, while that of Tb (one of heavy rare earths) was \$580

per Kg in April 2010 (Walters and Lusty, 2010).

With the development of the rare earth industry in China, a complete industry chain has formed: upstream, midstream and downstream (see Fig. 2). The mining and refining is the rare earth upstream sector, producing rare earth raw material products, including rare earth minerals and concentrates; the smelting and processing of rare earths is the rare earth midstream sector, producing rare earth smelting and processing products, including rare earth compounds, oxides, alloys and metals; the applications of rare earths is the rare earth downstream sector, producing rare earth new materials and applications, such as permanent magnets, phosphors, high-quality polishing, catalytic converters, hydrogen storage hard drives, motors and generators (Su, 2009; Wübbecke, 2015).

As the world's largest producer of rare earths, China supplied 85% of global rare earth production with the 31% rare earth reserves in 2015 (USGS, 2016) (see Table 1). In China, rare earth exploration has brought about increasingly significant problems regarding the resource and environment. Specifically, rare earth industrial development is facing some problems, such as excess capacity, low utilization rate, serious environmental damage and the lack of pricing power (Zhang, 2013; Ye and Wu, 2014). Therefore, China has taken comprehensive measures in the links of exploitation, production and exporting of rare earths and strengthened efforts for resource and environmental

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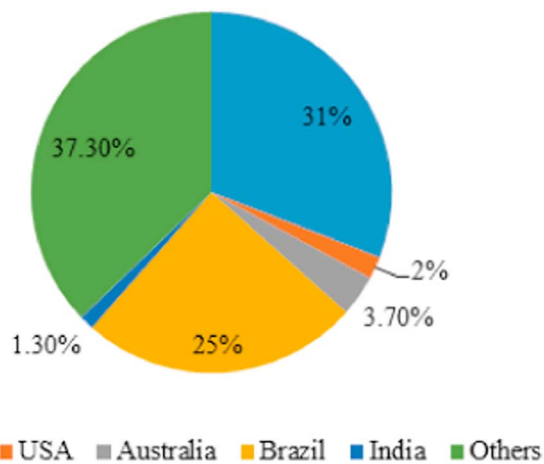


Fig. 1. Reserves of rare earths throughout the world in 2015. Data source: U.S. Geological Survey (2016).

“Suggestions on the promotion of sustainable and healthy development of rare earths industry” and clearly put forward that firms should promote industrial integration, eliminate backward production capacity and protect rare earth resources through merger and acquisition. At the end of 2015, six rare earth groups had been organized successfully in north and south China, distributing in Baotou of the Inner Mongolia Autonomous Region, Ganzhou of Jiangxi province, Guangdong province and Fujian province. This paper is formed against this background, providing a theoretical basis for China’s rare earth industrial integration in the next stage.

Because of their wide use, rare earths are playing an important role in modern industry, and thus, more and more studies focus on rare earths. Baldi et al. (2014) showed that there was a negative relationship between neodymium price changes and the stock market performance of the European clean energy index during 2009–2011 by using a multifactor market model for the period of 2006–2012. Besides, aimed at enhancing the supply of rare earths, Binnemans et al. (2013), Rademaker et al. (2013), Sprecher et al. (2014) and Mueller et al.

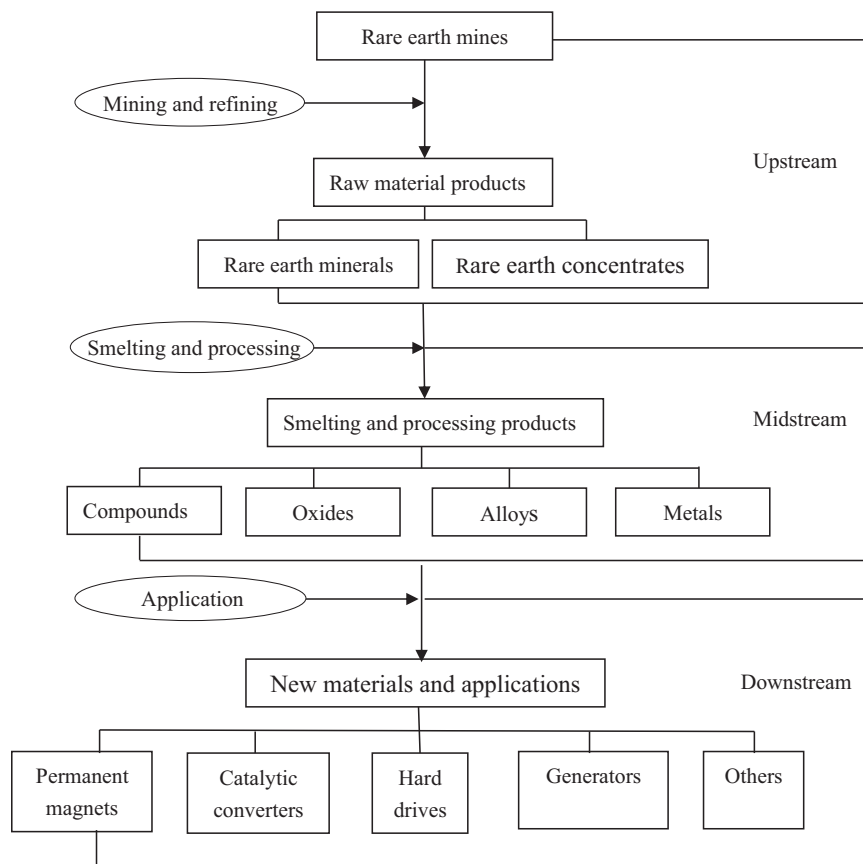


Fig. 2. Industry chain of rare earth in China.

protection in recent years (He et al., 2014). After losing the rare earth case that the European Union, Japan and the United States teamed up to put before the WTO over China’s measures on rare earths export in 2014 (WTO, 2014), the Chinese government might prioritize domestic exploitation, production and industrial integration in the future, endeavoring to ensure a sustainable and healthy development of the rare earth industry (Han et al., 2015).

As one of the most important policy options, industrial integration has been adopted to promote the development of the rare earth industry by the Chinese government. It focuses on the mining and smelting separation. In recent decades, some specific policies have been introduced to guide the progress of rare earth industrial integration. For example, in May 2011, the State Council promulgated the

(2015) analyzed the recycling of rare earths from the perspective of the world rare earth supply. As the largest producer and exporter in the world, China’s rare earths and policies have attracted substantial attention in recent years. Wübbeke (2013) indicated that the domestic concerns for rare earth resources and environmental protection are the two major driving motives of China’s rare earth policies. Golev et al. (2014) and Christmann (2014) introduced the existing and emerging rare earth supply chains outside China and concluded that China’s rare earth monopoly would be shaken by the diversified supply of the USA, Australia, Russia and India in the near future. Meanwhile, based on the generalized Weng model, Wang et al. (2015b) showed that China’s production of mixed rare earths, bastnasite and ion-absorbed rare earths would account for 45%, 28% and 64%, respectively, by 2050.

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