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Rare Earth Elements**

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# A Political Economy of China's Export Restrictions on Rare Earth Elements

Frank Pothen\*<sup>†</sup>      Kilian Fink<sup>‡</sup>

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## Abstract

We investigate why governments restrict exports of exotic raw materials taking rare earth elements as a case study. Trade restrictions on exotic materials do not have immediate macroeconomic effects. Relocating rare earth intensive industries is found to be the main reason behind China's export barriers. They are part of a more extensive strategy aiming at creating comparative advantages in these sectors and at overcoming path dependencies. Moreover, export barriers serve as a second-best instrument to reduce pollution and to slow down the depletion of exhaustible resources. Growing domestic rare earth consumption renders those increasingly ineffective. Rising reliance on mine-site regulation indicates that this fact is taken into account. Rare earth extraction is dominated by a few large companies; the demand side is dispersed. That speaks against successful lobbying for export restrictions. It appears as if the export barriers are set up to compensate mining firms.

JEL Classifications: Q37,Q38,D78, P26

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# 1 Introduction

Under the impression of boosting raw material prices, many nations supplying natural resources started to (further) restrict commodity exports from 2003 onwards. Metals were, by no means, an exception to that rule. Kim (2010) reports that 28 WTO members had export restrictions on metals and minerals in force between 2003 and 2009. Among the metals affected are a number of exotic elements such as antimony, niobium, and rare earths (EU Commission, 2010). Many of those were subsequently classified as critical raw materials by the US or the EU.

Raw materials are categorised as critical if they are both of high economic importance for domestic industries and if their supply is dominated by one or a few (politically unstable) nations (U.S. Department of Energy, 2011; EU Commission, 2010). Rare earths are the most well known example of critical raw materials. They are used in a diverse number of applications including high performance permanent magnets, ceramic capacitors, and defense technology. From the early 2000s to 2012, China accounted for around 95 per cent of global rare earth supply. Even today, more than 85 per cent of rare earths are mined in China. The People's Republic has implemented strict export restrictions.

Economic literature on export barriers is mostly concerned with food and other agricultural products as well as fossil fuels. The motivation for governments to restrict exports of exotic metals is likely to differ from those for crude oil or rice. They are only used as an intermediate input in downstream industries and their production is small, both in monetary and quantity terms. Thus, neither distributive effects nor major direct influences on macroeconomic variables are likely if their exports are hindered.

We investigate reasons why nations restrict exports of "exotic" raw materials, taking rare earth elements as a case study. We inspect five main motivations: Influencing the terms-of-trade, attracting foreign industries, limiting pollution due to mining activities, generating government revenues, and serving special interest groups. The latter explicitly acknowledges policy makers' self-interested behaviour. Comparing these motivations with stylised facts of rare earth markets and Chinese policies allows us to evaluate how influential the five motivations are in practice.

Despite considerable political and public interest in rare earths, only a few authors assess the rationale behind China's export barriers systematically. Hurst (2010) inves-

tigates how China achieved its dominance on rare earth markets and the challenges it currently faces as well as implications for the West. Hayes-Labruto et al. (2013) contrast perspectives on rare earth policies in the West and within China where environmental and social aspects gain importance. Wübbecke (2013) focuses on policy narratives within China highlighting the interaction between policy goals. We are, to our knowledge, the first authors using a political economy framework to investigate the export restrictions on rare earths.

Our analysis demonstrates that relocating industries is the most important driver behind China's export barriers for rare earths. The trade restrictions are part of a long-term strategy to turn China into a stronghold of rare earth based industries and to realise economies of agglomeration. Export restrictions are also second-best instruments to cope with the considerable environmental damages caused by rare earth mining as long as costs of enforcing regulation on the mine level are prohibitive. But as China's domestic rare earth consumption grows steadily, export restrictions become less and less effective. The combination of a concentrated supply side and scattered demand for the metals indicates that the former have a higher propensity for successful lobbying activities. It appears as if policy makers use rents from quantitative restrictions as a bargaining chip with special interest groups. Generation of government revenues and influence on the terms-of-trade are of limited importance.

The paper proceeds as follows. Section 2 provides an overview on rare earths' properties as well as on their markets and Chinese export restrictions. Section 3 assesses the relevance of the theoretical arguments for China's intervention in rare earth markets. Some recent developments on rare earth markets are discussed in the light of our results in section 4. Section 5 concludes.

## **2 Rare Earths: An Overview**

### **2.1 Basic Properties**

The terms rare earths or rare earth elements denote a group of 17 metals. They include the lanthanides, the elements with atomic numbers from 57 (lanthanum) to 71 (lutetium) as well as scandium (21) and yttrium (39). Rare earths are usually subdivided into light rare earth elements (LREE) and heavy rare earths elements (HREE). The light ones are

located on the left side of the periodic table, whereas heavy rare earths are found on the right. Yttrium is included in the latter due to its greater chemical similarity to them. A detailed overview on rare earths' physical and chemical properties is provided by Gupta and Krishnamurthy (2005).

Due to the lanthanide contraction, a unique structure of electrons within their atoms, all rare earths except scandium have similar ionic radii and thereby similar chemical properties. Because of their chemical similarity, rare earths usually occur together in their deposits. It also makes separating them from each other technically challenging and economically costly.

Rare earths are not rare in a geological sense. The most abundant rare earth, cerium, is roughly as abundant in the Earth's crust as copper. Even the rarest stable rare earth, lutetium, is more abundant than gold or platinum. They attain their rarity from the fact that they are rarely found in concentrations making their extraction profitable.

## **2.2 Supply**

China almost monopolistically supplies rare earths to the world market. About 133,000 metric tons of rare earth oxides (REO) were mined in 2011, 97 per cent thereof in the People's Republic (U.S. Geological Survey, 2012b). Figure 1 shows that this has not always been the case. From the mid-1960s to mid-1980s, the Mountain Pass mine in California was the most important supplier of rare earths worldwide. China started to expand its production massively in the late 1970s and 1980s. Its growing exports drove down rare earth prices in the 1990s forcing competitors to exit the market (Hurst, 2010). The Mountain Pass mine reopened in 2012 putting the US back on the map of rare earth producing nations.

Three regions mainly account for China's rare earth production. The majority takes place in the Inner Mongolia Autonomous Region. It accounts for approximately 50 to 60 per cent of Chinese output. Rare earths from Inner Mongolia are mostly mined at the Bayan Obo mine as a by-product of iron ore extraction. Accounting for 40 to 50 per cent of worldwide production, Bayan Obo is the world's largest rare earth mine. 24 to 30 per cent of China's rare earths stem from the Sichuan province. The rest is mined in the southern deposits, in the Provinces of Fujian, Guangdong and Jiangxi (Tse, 2011; U.S. Geological Survey, 2010). Rare earths from Sichuan or the southern deposits are often

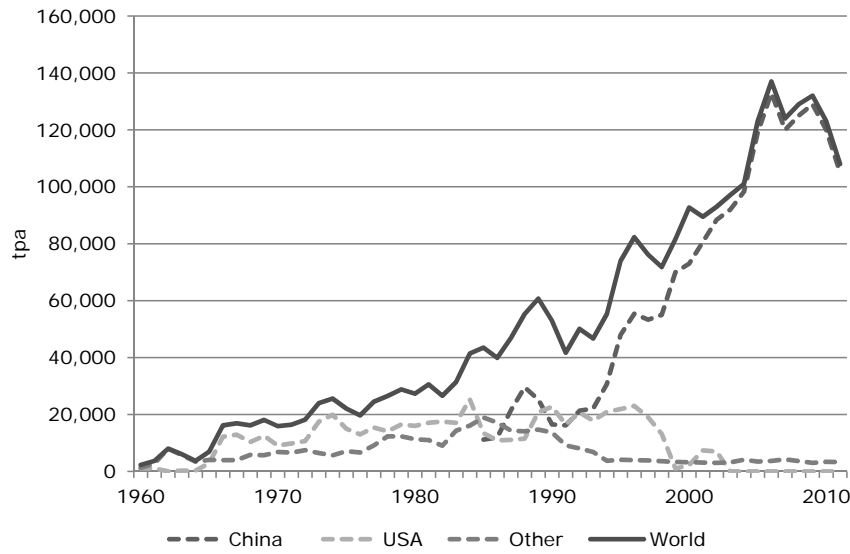


Figure 1: Global rare earth production by region in t  
Source: U.S. Geological Survey (2012a, 2015)

produced by small scale mines. Illegal extraction plays an important role, in particular for the southern deposits where remote and inaccessible locations simplify the operation of illegal mines (SCIO, 2012).

Reserves of rare earths are dispersed much more widely than production. According to U.S. Geological Survey (2012b), China holds approximately 50 per cent of the worldwide reserves of 114 million tons. Other important deposits are found in the Commonwealth of Independent States<sup>1</sup>, the United States, India, and Australia. The Chinese government estimates its own share of worldwide reserves to be much smaller, at approximately 23 per cent (SCIO, 2012).

A large number of junior mining companies attempt to enter the rare earth market. By the end of July 2013, 52 projects outside China estimated their resources by international standards (Hatch, 2013b). More than 400 mining projects aim at setting up a rare earth mine (Hatch, 2012a). That indicates a potentially more diverse mining sector in the future. The entry of non-Chinese suppliers could deteriorate China's market power (Pothen, 2013, 2014).

<sup>1</sup>The Commonwealth of Independent States is an organisation of former Soviet republics. As of 2015, it consists of Armenia, Azerbaijan, Belarus, Kazakhstan, Kyrgyzstan, Moldova, Russia, Tajikistan, and Uzbekistan.

Up until now, rare earths have been recycled only in negligible quantities (Du and Graedel, 2011; Schüler et al., 2011). There is some re-melting of new scrap from permanent magnet production but the metals are not retrieved from discarded products.

### 2.3 Demand

Rare earths serve as an input for a multiplicity of different products. U.S. Geological Survey (2011) identifies eight main applications. Table 1 provides an overview. To make them more tangible, exemplary products are listed. The last two columns show the amount of rare earth oxides (REO) used per application in tonnes per year (tpa) in 2008 and the share of heavy rare earths needed in the application, respectively. The latter reflects the great diversity of rare earths used in each application.

Application	Exemplary Products	tpa REO	% HREO
Glass industry	Polishing powders, coloured or decolourised glass	28,444	3
Catalysts	Catalysts for fluid cracking, automotive catalysts	27,380	0
Magnets	Permanent magnets in hard discs, wind turbines	26,228	7
Battery alloys	Nickel-metal-hydride (NiMH) batteries	12,098	0
Metallurgy	Steel and aluminium alloys	11,503	0
Phosphors	TV sets, monitors, fluorescent lamps	9,002	81
Ceramics	Superconductors, Ceramic capacitors	7,000	53
Other	Paints and pigments, waste water treatment	7,520	21

Table 1: Most important applications of rare earths  
Source: Schüler et al. (2011); U.S. Geological Survey (2011)

China also plays an important role in demand for rare earth elements. In 2012, 68 per cent of worldwide consumption of the metals took place in the People’s Republic (Kingsnorth, 2012).

Demand for rare earths is expected to grow strongly. Table 2 displays the projections by Kingsnorth (2012). He forecasts the overall demand for rare earths to grow from 105,000 tpa in 2011 to 160,000 tpa in 2016. Annual growth rates differ notably by application, ranging from 2-4 per cent for catalysts to 8-12 per cent for magnets. Alonso et al. (2012) estimate future demand for rare earths applied in wind turbines and electric vehicles, most notably neodymium (Nd) and dysprosium (Dy) used in permanent magnets. They expect demand to grow by between 700 and 2,600 per cent over the next 25 years.



Application	Demand 2011 tpa	Projection 2016 tpa
Catalysts	20,000	25,000
Glass	8,000	10,000
Polishing	14,000	18,000
Metal alloys	21,000	30,000
Magnets	21,000	36,000
Phosphors	8,000	12,000
Ceramics	7,000	10,000
Other	6,000	19,000
Total	105,000	160,000

Table 2: Demand projections  
Source: Kingsnorth (2012)

## 2.4 Prices

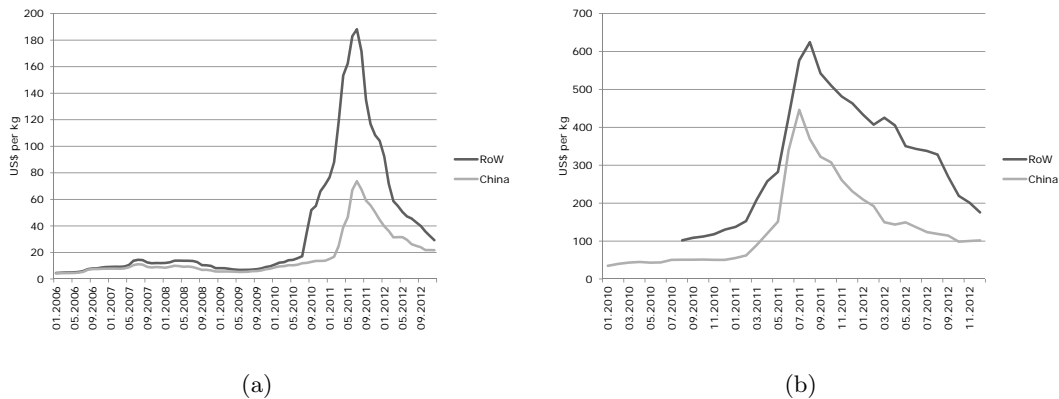


Figure 2: Prices of LREO and HREO in US\$ per kg  
Source: asianmetal.com, own calculations

Figure 2 shows the prices of light rare earth oxides (LREO, left hand side) and heavy rare earth oxides (HREO, right hand side) in US\$ per kg, both in China and in the rest of the world (RoW). A first large increase of prices was visible in 2008. The second and more severe spike took place in 2011. After that extreme phase, prices of rare earths exhibited a falling trend. Prices in the rest of the world exceed the Chinese notably, mostly due to the export barriers.

## 2.5 China's Export Restrictions and Related Policies

Already in 1990, the Chinese government declared rare earths to be a strategic raw material. Foreign firms were banned from all mining, smelting, and separating activities unless they form a joint venture with a Chinese company. Extraction quotas are set by the central government but have proved to be ineffective (Tse, 2011). Several further measures restricting exports of rare earths were implemented. They can be grouped into 1) tariffs and taxes and 2) quantitative export restrictions.

Exporters of rare earths pay ad-valorem export taxes. They range from 15 per cent to 25 per cent and are levied on ores, intermediate products, pure metals, but also alloys containing rare earths (Tse, 2011). In 2007, the Chinese government abolished the 16 per cent value added tax refund on exports of unprocessed rare earths (Korinek and Kim, 2010) which was introduced in the mid-1990s to encourage exports (Tse, 2011).

Quotas limit exported quantities. These quotas have been tightened gradually over the last years from 65,600 tpa in 2005 to 31,000 tpa in 2012. Starting in 2012, the Chinese government has set separate export quotas for light and heavy rare earths. The export quotas remained virtually unchanged in 2013 (Hatch, 2013a).

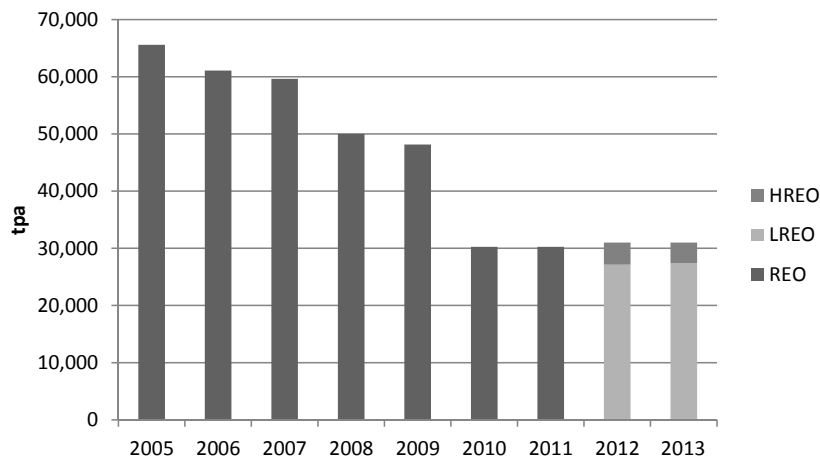


Figure 3: Chinese export quotas 2005 to 2013

Source: Tse (2011); Hatch (2012b,c, 2013a)

Export licenses are allocated directly by the Ministry of Commerce (MOFCOM). Firms applying for them have to fulfil a number of conditions to be eligible. These include compliance to environmental and social security standards, minimum firm size and that all rare earths must originate from licensed mining operations. Since 2012, MOFCOM grants

licenses only to firms passing inspection by the Ministry of Environmental Protection (Liu and Maughan, 2012).

According to the United States' delegation at the World Trade Organization, China relies on further, less transparent measures to restrict rare earth exports. Firms subject to export licenses are, for example, bound to minimum export prices (WTO, 2012).

Significant shares of rare earths are smuggled out of China, circumventing the export restrictions. Hurst (2010) states that approximately one third of all rare earth exports in 2008 were shipped abroad illegally. Illegal exports appear to have declined, however. While the Chinese export statistics were between 20,000 and 30,000 tons per year lower than foreign import data from 2006 to 2008, this number fell to 3,000 tons in 2011 (Wübbecke, 2013).

The Chinese government aims at creating a more concentrated rare earth industry, allowing for greater control of domestic extraction (SCIO, 2012). It divided the country into three large mining districts displayed in figure 4: The northern district encompassing Inner Mongolia and Shandong, the western district being Sichuan, the southern consisting of Jiangxi, Guangdong, Fujian, Hunan and Guangxi (Hurst, 2010).

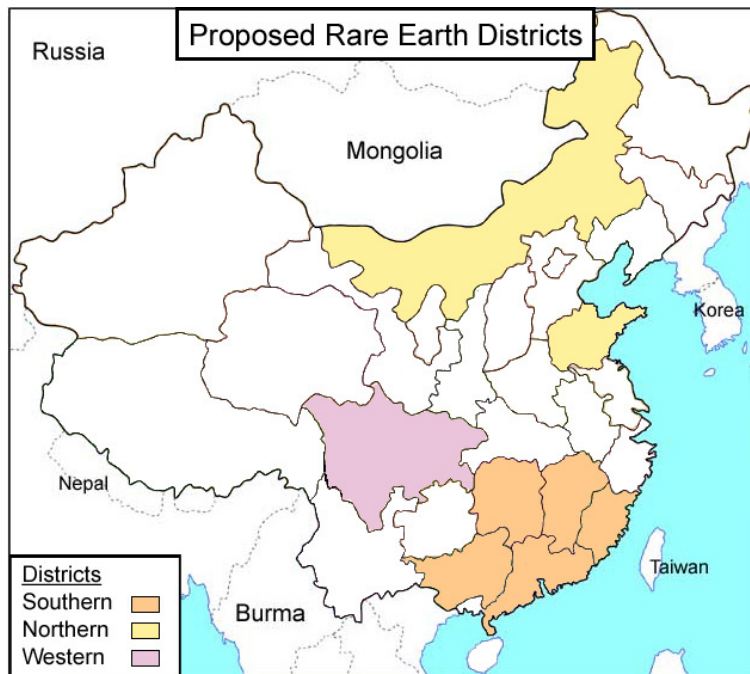


Figure 4: Proposed rare earth districts  
Source: Hurst (2010)

The Baotou Steel Rare-Earth (Group) Hi-Tech, a subsidiary of Bao Steel and owner of the Bayan Obo Mine, is planned to become the sole producer of rare earths in Inner

Mongolia. It was reported that it integrated 12 rare earth producers in 2012 (China Daily, 2012). Similar developments are taking place in the southern province of Jiangxi where major amounts of heavy rare earths are produced. The state-owned Ganzhou Rare Earth Group Co was founded by merging a number of local rare earths producers (Xinhua, 2013). The Chinese government states that it aims at developing "large-scale, highly-efficient, and clean production enterprises" (SCIO, 2012).

In March 2012, the US, the EU, and Japan filed a complaint at the World Trade Organization (WTO) about Chinese trade restrictions for rare earths, tungsten and molybdenum. The three parties accused the Chinese authorities of violating the GATT and parts of China's Protocol of Accession to the WTO <sup>2</sup>. This development is discussed in subsection 4.1.

### 3 Motivations for Export Restrictions

#### 3.1 Influencing Terms-of-Trade

The terms-of-trade effect is the textbook example of mechanisms raising domestic welfare through trade barriers (Johnson, 1953). China possesses power on rare earth markets. If the People's Republic restricts its exports, it drives a wedge between (reduced) domestic and (increased) international prices. Higher revenues from rare earth exports allow the households in China to consume more imported goods. They enjoy a welfare gain at the expense of the rest of the world.

The idea behind the terms-of-trade effect is straightforward, its practical implementation is not. Finding an optimal level of trade restrictions is challenging, both theoretically (Helpman and Krugman, 1989; Deardorff and Rajaraman, 2009; De Santis, 2000) and empirically (Piermartini, 2004). Empirical evidence that the terms-of-trade effect is relevant for actual trade policy exists, though (Broda et al., 2008).

When applying for export licenses, firms need a minimum size or export volume and they have to prove compliance with environmental and social standards (Liu and Maughan, 2012). This excludes small firms from selling rare earths abroad. Such regulation can be interpreted as an application of Rodrik (1989). He analyses how to optimally

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<sup>2</sup>For a detailed summary of the dispute, see [http://www.wto.org/english/tratop\\_e/dispu\\_e/cases\\_e/ds432\\_e.htm](http://www.wto.org/english/tratop_e/dispu_e/cases_e/ds432_e.htm)

exploit the terms-of-trade effect in the presence of non-atomistic firms of heterogeneous size. He shows that tariffs should decrease with firm size because large firms can internalise their market power by themselves.

The terms-of-trade effect's relevance is confined by the small share of rare earths in China's exports. Figure 5 shows the share of rare earths in China's exports. The People's Republic officially exported 2.7 billion US\$ worth of rare earths in 2011. In the same year, its exports totalled 1.9 trillion US\$. Rare earths accounted for only .14 per cent of those. As figure 5 shows, this number is even smaller in most years.

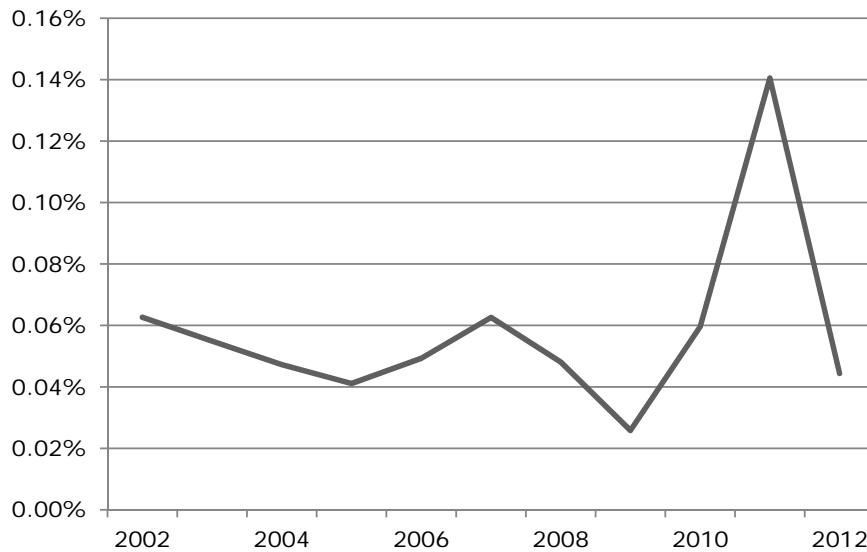


Figure 5: Share of rare earths in China's total exports in per cent  
Source: UN comtrade, own calculations.

### 3.2 Attracting Foreign Industries

The relocation of firms is another channel through which export barriers can raise domestic welfare (Ossa, 2011). Restricting rare earth exports lowers their prices inside and raises them outside China. Downstream industries in the People's Republic face reduced production costs and expand their output while foreign competitors have to exit the market. Domestic consumers enjoy welfare gains from increased factor income as well as more and cheaper domestic varieties. Welfare grows on the expenses of others, however.

Fostering growth of domestic industries is declared to be a goal by Chinese sources. Developing specific industries is listed as a purpose why exports of goods might be restricted in the Chinese Foreign Trade Law (Liu and Maughan, 2012) and is sometimes

admitted to be a target quite frankly by Chinese officials (Xinhua, 2009).

The terms-of-trade and the production relocation argument share their static nature. If China's power on rare earth markets vanishes, its ability to manipulate prices strategically declines. Raising world market prices, Chinese policy creates incentives for foreign suppliers to enter the market and to undermine China's market power.<sup>3</sup> The Chinese government can anticipate potential market entry. Thus, either she discounts future welfare strongly and accepts the risk of losing market power to exploit market power in the short run. Or she expects that export restrictions help to overcome market failures or path dependencies limiting industrial growth and allow for sustained effects.

The most well-known example of a market failure limiting growth of industries are learning externalities which underlie the infant industry argument. Let us assume that Chinese firms want to enter the market for a high-tech good but lack experience in its production and thus suffer from higher costs than their foreign competitors. The comparative disadvantage vanishes as Chinese firms produce and gain experience themselves. If learning effects are external to the firm, because workers are hired by competitors for instance, an incentive to free-ride arises. This justifies government intervention. Melitz (2005) shows that trade restrictions can serve as a second-best instrument to counteract the learning externalities if subsidies on production are not feasible.

The infant industry argument is of limited relevance for Chinese rare earth-based industries. Take the production of Neodymium Iron Boron (NdFeB) permanent magnets as an example. Figure 6 shows the production of NdFeB magnets by region. Already in 2005, the majority of NdFeB magnets were manufactured in the People's Republic. On an aggregate level, China accounted for more than 20 per cent of worldwide consumption of rare earths in 2000 already. The industry outgrew its infant stage.

An explanation why the relocation of industries might be permanent can be derived from Amiti (2005). Imagine a firm deciding upon where to locate its production. It faces two, potentially opposing, incentives. It can either produce in a region abundant in the production factors it needs and exploit comparative advantages a la Heckscher-Ohlin. Or it can set up production close to customers and suppliers and save trade costs.

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<sup>3</sup>Under optimistic assumptions, Pothén (2014) finds that non-Chinese mines might supply 137,000 tons per year or about half of the world consumption by 2020. Section 4 indicates that this development is likely to remain absent.

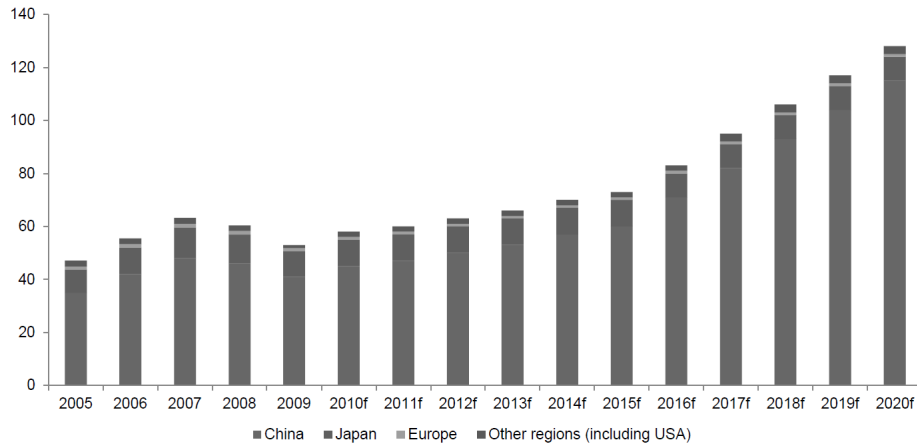


Figure 6: NdFeB permanent magnet production by region in kt  
Source: Shaw and Constantinides (2012).

Economies of agglomeration arise if firms locate close to each other because they provide cheap intermediate inputs to each other.

Sectors can sustain in a region with comparative disadvantages because the economies of agglomeration overcompensate for higher factor costs. It is inefficient for an individual firm to move to the other region and the firms cannot coordinate to relocate collectively. Firms only relocate if the comparative advantage is strong enough to make it beneficial for them individually.

China's export restrictions on rare earths can be interpreted in the light of this theory. China was rich in rare earths and consequently possessed a comparative advantage in rare earth intensive goods already in the 1980s. Its market size was small, however, and it lacked other factors important for the production of high-tech goods such as qualified labour, capital, or institutional quality. Consequently, industries employing rare earths emerged in the US, Japan or Europe.

Over the last decades, China implemented a broad strategy to create a comparative advantage in rare earth-based industries. Since the 1980s, the People's Republic has undertaken considerable efforts to educate qualified labour and to establish a comprehensive research infrastructure focusing on rare earths. Three scientific institutes conduct research solely on rare earth elements. The Baotou Research Institute of Rare Earths in Inner Mongolia is the world's largest, with a staff of about 700. The other ones are the State Key Laboratory of Rare Earth Materials Chemistry and Applications, affiliated to Peking University, and the State Key Laboratory of Rare Earth Resource Utilization in

Changchun in the northeastern province of Jilin. The latter is affiliated to the Chinese Academy of Sciences. Additionally, the General Research Institute for Nonferrous Metals conducts research on rare earths (Hurst, 2010). Motohashi and Yun (2007) confirm the close link between public research and the mining sector in China. They find that the mining industry is among those cooperating most intensively with third party researchers. Note that while China achieved a strong position in research on rare earth elements, gaps to cutting-edge technology still persist (Wübbecke, 2013).

Export restrictions contribute to the comparative advantage. They reduce costs for downstream firms and make relocation of production more favourable. It is, however, important to interpret the trade barriers as part of a broader strategy. Empirical studies indicate that the availability of cheap raw materials alone has only a limited effect. Luo et al. (2008) analyse factors determining foreign direct investment (FDI) flows into China's hinterland. They do not find a statistically significant impact of wealth in fossil fuels. Agglomerations and the availability of qualified labour, however, have significant positive effects on FDI inflows. Luo et al. (2008) do not control for specific sectors and the importance of natural resources is probably underestimated for resource intensive industries. Amiti and Javorcik (2008) also find access to customers and upstream firms to be of importance, in particular on a regional scale.

Recall that policy makers have to take opportunity costs into account when they decide upon export restrictions. Export barriers subsidise downstream industries but also disturb input prices. Relative prices of rare earths fall and induce a more rare earth-intensive production. Four reasons explain why export restrictions, nevertheless, might be favourable compared to less disturbing policy instruments.

Firstly, even if China's long-term strategy for rare earths is motivated by overcoming path dependencies rather than simple beggar-thy-neighbour policies, they are still complementary in the short-run. Secondly, a diverse number of sectors benefit from the implicit subsidies. Spreading the subsidies avoids choosing specific industries to be subsidised, avoiding the problem of "picking losers" (e.g. Baldwin and Robert-Nicoud, 2007). Thirdly, the WTO decided that export restrictions are not considered subsidies for downstream products and countervailing tariff measures are not allowed under WTO regulation (WTO, 2001). Fourthly, if the People's Republic is able to induce sufficient relocation of downstream industries in the time frame in which it possesses market power, declining



margin on international prices is acceptable. It might even be useful because firms can anticipate that the subsidies have a “date of expiry” on them.

### 3.3 Conserving Exhaustible Resources

Chinese defense in the WTO dispute settlement on rare earths is primarily based on two arguments: Firstly, that export barriers are used to bring rare earths back on a sustainable extraction path. Secondly, that they are used to prevent environmental damages from mining rare earths.

In 2011, China provided around 97 per cent of world supply of rare earths, whereas Chinese resources just accounted for 50 per cent of world resources (U.S. Geological Survey, 2012b). The high share of supply is perceived as unsustainable by Chinese authorities (SCIO, 2012). It might indeed be a symptom of inefficiently fast extraction.

Insecure property rights can accelerate extraction sub-optimally. The mergers of rare earth suppliers in Inner Mongolia, which were ordered by the central government, show that mining firms face a risk of being expropriated. Private suppliers have to consider such insecurities with respect to property rights and, consequently, decide upon their extraction path under higher discount rates. Large-scale, capital-intensive mines face smaller incentives to extract inefficiently quick. While weak property rights encourage fast depletion, they also reduce the incentive to invest in capacities (Bohn and Deacon, 2000). Labour intensive illegal mining operations do not require large investments and extract faster. Being illegal induces additional risks for miners and leads to further an acceleration of depletion. Note that the insecure property rights are partially policy-induced themselves.

Inter-generational welfare considerations can also justify policy intervention. How rents from extracting exhaustible resources are used determines whether an extraction path is welfare optimal. If the decline in stocks of rare earths is offset by investing in produced capital, Chinese authorities might be indifferent between extracting today and extracting tomorrow (Hartwick’s rule). Investment in produced capital might be lower than the decline in stocks of rare earths. Hence, there can be an incentive for Chinese policy makers to slow down extraction.

The most efficient way to slow down the extraction of rare earths is to regulate the quantity being extracted. In 2009, authorities did a first step on their way to gain control

over the extraction path of rare earth resources by implementing production quotas. In 2012, the restructuring of the market followed. These measures are signs for the Chinese efforts to control the domestic market and slow down extraction.

Considerable illegal mining, especially in remote and mountainous southern regions of China, indicate that existing mine-site regulation is ineffective. Recent reports support the interpretation that institutional reasons impede implementing mine-site regulation (Wübbeke, 2013). Local and provincial policy makers benefit from extraction and lack incentives to enforce regulations in the area for which they are responsible (Want China Times, 2013, for a recent example). In practice, enforcing mine-site regulation might be prohibitively costly for the national government.

We argue that regulating the extraction path is part of the Chinese government's long-term strategy. Rare earths will remain a resource with a high value for the Chinese economy, even in the presence of agglomeration effects. China's government wants to provide its economy with a secure supply of domestically mined rare earths in the future. Therefore, authorities use export policy, in combination with the policy measures implemented since 2009, as second-best policy to regulate the extraction path for its rare earth resources and smoothen national consumption over time. If export barriers actually slow down extraction, they create welfare gains for Chinese governments from a more efficient extraction schedule. But the increasingly high share of Chinese domestic rare earth consumption makes export policy less and less effective as a second-best policy instrument.

### **3.4 Reducing Pollution**

Environmental damages caused by the mining and separation of rare earths are well documented by various sources. The Chinese White Paper (SCIO, 2012) lists contamination by radioactive elements and severe pollution of surface and ground water as well as reduced food crop output. These statements are backed by a report published by the U.S. Environmental Protection Agency (EPA, 2012). Hong Kong based think tank Civic Exchange accuses the techniques used in the illegal mining of rare earths and the lack of official supervision as one of the main reasons for environmental problems in the Dongjiang river system (Guangdong Province), the main source of water supply for the Hong Kong agglomeration (Liu, 2012).

Since the 1980s, comparatively low environmental standards have contributed to China's power on rare earth markets. The closure of the Mountain Pass Mine in California, for example, was at least partially caused by its inability to satisfy environmental standards. China specialised in the pollution-intensive production of rare earths, creating a pollution haven.

The growth of income since the 1980s has plausibly increased the Chinese valuation for a clean environment, relative to the valuation of consumption, entailing bids for stricter regulation directed towards the authorities. Policy follows their citizens' preferences, putting more emphasis on environmental policies.

First-best policy actions internalise the negative externalities directly where they occur. In our case, the most suitable way to deal with these problems is implementing measures tackling externalities at the mine sites. Apparently, Chinese authorities are aware of that. In order to efficiently counteract the negative consequences of rare earth production for the environment, they implemented various measures in the market in recent years. Table 3 provides a list of these measures.<sup>4</sup> Due to limited data, the impact of these interventions on production decisions is not clear. But especially the resource tax seems to be an ambitious step towards the reduction of domestic supply, since the tax accounts for 20 per cent of the firms' production costs. Also, the environmental standards implemented in 2011 could lead to a rise in production costs of 70 per cent for the mining companies (Wübbecke, 2013).

Export restrictions attain justification for reasons touched already in the discussion on the conservation of exhaustible resources. The costs of monitoring or enforcing regulations on the mining sector might be prohibitively high. Either because rare earths can be extracted using very simple technologies in remote areas, predominantly in the southern regions, or because local authorities benefit from extraction activities and do not enforce regulations sufficiently. Again, the growing share of Chinese rare earth consumption limits the effectiveness of export restrictions as a means to reduce pollution.

Let us assume that China possesses a comparative advantage in rare earth dependent industries. If the export barriers contribute to overcoming path dependencies, they make these industries relocate into the People's Republic. That will expand production beyond

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<sup>4</sup>For more detailed information on the implemented measures see Wübbecke (2013).

	Year	Measure
Pigouvian Tax	2011	Resource tax of 60 RMB per ton LREE minerals and 30 RMB per ton HREE minerals extracted → rise of approx. 2.000% (LRE) and 7.500% (HREE) compared to the tax before 2011
Pollution rights	2011	Emission standards of pollutants from the rare earth industry
	2012	Measures for the environmental protection Inspection of rare earth enterprises
Regulation of respective industries	2009	Control indices of 2009-2011
	2012	Restructuring of the market

Table 3: Policies implemented by the Chinese government

levels achieved without the export restrictions. Export barriers are likely to be subject to rebound effects if not accompanied by mine site regulation.

Export restrictions can reduce pollution from rare earth extraction, and thus rise domestic welfare. They are justified as second-best instruments if mine-site regulation cannot be enforced. However, their effectiveness falls as the share of domestic rare earth consumption grows. Furthermore, they are subject to rebound effects. Thus, we conclude that the strength of this channel to justify export barriers is continuously declining.

### 3.5 Special Interest Policies

Up until now, policy makers' decisions have been motivated by increasing their citizens' welfare, either because of the politicians' benevolence or because it serves their own interest. Now, we consider purely self-interested behaviour as a motivation. We analyse if contributions by special interest groups influence their decisions. Two conditions have to be fulfilled. Firstly, policy makers have to derive utility from special interest groups' contributions. Secondly, export restrictions need to increase the sum of contributions they receive from lobby groups.

Table 4 displays China's ranks in the Transparency International Corruption Perceptions Index (CPI) and in the World Bank's Worldwide Governance Indicators' (WGI)

Control of Corruption index. The People’s Republic achieves only mediocre results in both surveys. This indicates that serving special interest groups has some importance in policy decisions.

Year	CPI		WGI	
	Value	Rank	Value	Rank
2000	3.1	63	-0.24	95
2007	3.5	72	-0.59	138
2012	39*	80	-0.48	128

Table 4: China in international corruption surveys

Source: Transparency International (2012, 2007, 2000); World Bank (2013)

\* Due to methodological changes, the values from 2012 are not comparable to results for previous years.

The second condition requires trade restrictions to increase the sum of contributions. Mitra (1999) provides a theory of lobby formation based on the endogenous trade policy model by Grossman and Helpman (1994). He finds that inelastic demand, market concentration, small geographic dispersion, and large capital stocks raise the propensity of being organised and, thus, being able to influence policy decisions.

Rare earths are used in a number of diverse industries, many of which are unconcentrated. 130 firms produce NdFeB permanent magnets in China, for example (Wübbeke, 2013). Rare earths account for a small share of overall costs in many applications. Each individual firm can only reap a small share of its own investment in influencing policy decisions, creating a strong incentive to free-ride and making successful lobbying unlikely.

The rare earth mining sector exhibits characteristics more favourable for lobbying activities. Despite the substantial role small scale mining plays in China, the industry is dominated by a few large firms. The most outstanding one is Baotou Steel Rare Earth Hi-Tech (Group) Company, a subsidiary of Baotou Steel. State owned Baotou Steel is China’s second and the world’s fourth largest steel producer (World Steel Association, 2013). It accounts for about 50 per cent of Chinese rare earth production and is currently integrating further firms in Inner Mongolia to become the only producer in the northern region. Regional monopolists are to be created in other regions as well, further increasing the sector’s concentration.

Theoretical reasoning indicates that the mining sector can lobby more effectively in its own favour than rare earth consuming industries. That contradicts with the tight export barriers leading to burdens for the Chinese mining sector. Policy makers need some way to compensate firms possessing lobbying power.

Anecdotic evidence indicates that export quotas play a role for that. Binding export quotas create rents which can be shared between the government and firms. Take the creation of a monopolistic rare earth supplier in Inner Mongolia as an example. In late 2012, Baotou Steel Rare-Earth was reported to have concluded integration agreements with 12 other rare earth producers in Inner Mongolia (China Daily, 2012). Those firms agreed to transfer a 51 per cent stake to Baotou Steel. In return, Baotou Steel "will support the 12 parties in areas relating to production and export quotas" (Currie, 2013). It appears as if the rents are used to compensate the smaller firms.

Again, we have to check for opportunity costs. The most efficient way to redistribute wealth to lobbying groups is plausibly lump-sum transfers. There are, nevertheless, reasons why export restrictions might be preferable to policy makers. Export barriers on raw materials are not considered subsidies for downstream industries by the WTO (WTO, 2001), reducing the danger of countervailing measures by trading partners. Trade restrictions are easier to justify to the population than monetary transfers. They can be motivated by arguments such as that the nation is selling its natural wealth too cheaply or that the country should not be burdened with environmental damage without reaping the benefits (Jin, 2010; ?; MOFCOM, 2012). As mentioned before, rents from quantitative restrictions can be used to compensate losers of trade barriers.

### **3.6 Generating Government Revenues**

The last motive potentially explaining why the Chinese government restricts rare earth exports is generating government revenues. Export tariffs yield revenues, as do the abolished VAT deductions on rare earth exports. The export quotas can yield income to the government but that depends on how they are allocated.

The exact income from taxes and tariffs on rare earth exports is not published but a rough estimate is possible. Chinese rare earth exports add up to 2.7 billion US\$ in 2011 and 0.9 billion US\$ in 2012. If we assume that these numbers include export taxes of 15 per cent, which is the lower bound, and add the 16 per cent value added tax, the taxes

yield government revenues of 670 million US\$ and 230 million US\$, respectively. Overall tax revenues were 1.42 trillion US\$ in 2011 and 1.8 trillion US\$ in 2012. Taxes on rare earth exports are not a major part of China's government revenues.

Recall that many rare earth suppliers are state-owned. Taxes reducing their profits redistribute wealth within the public sector but do not generate net government income. On the other hand, if the export barriers foster growth in downstream industries, tax revenues might increase in the long run.

As long as a large fraction of rare earths is sold abroad, export taxes resemble an extraction tax. As in the case of environmental protection and resource conservation, export taxes can be justified as a second-best instrument. But, again, the growing domestic demand limits their effectiveness.

## 4 Recent Developments

Two recent developments in the markets for and the international policy on rare earths are discussed in the light of our results. Firstly, the WTO's dispute settlement on Chinese export restrictions. Secondly, the emergence of non-Chinese rare earth producers and their struggle to stay in the market.

### 4.1 WTO Dispute Settlement

In March 2012, the US, the EU, and Japan filed a complaint at the World Trade Organization about Chinese trade restrictions for rare earths, tungsten and molybdenum. In a public announcement, the Chinese Ministry of Commerce defends its export policy.

"China's rare earth measures, including imposing export quotas, are fair and legitimate, and are simply aimed at protecting its environment as well as its natural resources. They also conform to relevant WTO rule. [...] Therefore, it is crystal clear that Western countries are aiming at pressing China to continue providing irrationally cheap rare earth despite serious pollution problems."  
(MOFCOM, 2012)

The statement refers indirectly to the articles XX (b) and XX (g) of the GATT, conceding exceptions to the general prohibition of quantitative export restrictions codified

in Article XI if they aim either at the protection of human life and health (article XX (b)) or at the conservation of exhaustible resources (article XX (g)). However, the latter entails the need for a conjunct implementation of restrictions on domestic production or consumption.

In March 2014, the WTO published a report largely following the complainants arguments (WTO, 2014). The panel argued that the export barriers are inconsistent with general WTO regulations and with the commitment to reduce or abolish export restrictions on raw materials which China made in its accession protocol.

The People's Republic abolished its export quotas on rare earths effective January 1st 2015. The export taxes are to be dropped at the 2nd May 2015 (Shen, 2015a). While formally complying to the WTO ruling, it is not clear whether China is giving up its influence on rare earth trade. The consolidation of Chinese rare earth producers into six firms is expected to be completed in 2015. The government plans to "establish a strong cooperation mechanism" (Shen, 2015b) between these companies. A system of export licenses is planned to be introduced, re-regulating rare earth sales abroad (Shen, 2015b). It is unclear if these measures will effectively restrict exports. Their intransparent nature will ease allocating rents, however, and satisfying special interest groups' claims.

## 4.2 New Non-Chinese Suppliers

Currently, two mines extract major quantities of rare earths outside China: The Mountain Pass mine owned by Molycorp and Lynas's Mount Weld mine in Australia. Both produce mostly light rare earths. Market experts state that lanthanum and cerium, the most common rare earths, are already oversupplied. Neodymium and praseodymium, two other important products of these mines, are less affected by falling prices. Figure 7 shows the prices for the four metals. While lanthanum and cerium prices are only twice as they were in 2007, neodymium and praseodymium cost more than 10 times as in 2007. Facing lower prices and higher costs than expected, both firms struggle to stay in the market (e.g. Lifton, 2015). In mid 2014, Molycorp barely avoided bankruptcy (Ecclestone, 2014).

The problems experienced by Molycorp and Lynas indicate that Chinese power on rare earth markets will plausibly continue. Optimistic scenarios as in Pothen (2013, 2014) appear less likely. If China is able to restrict exports using the licensing system, it can retain its influence on rare earth markets.



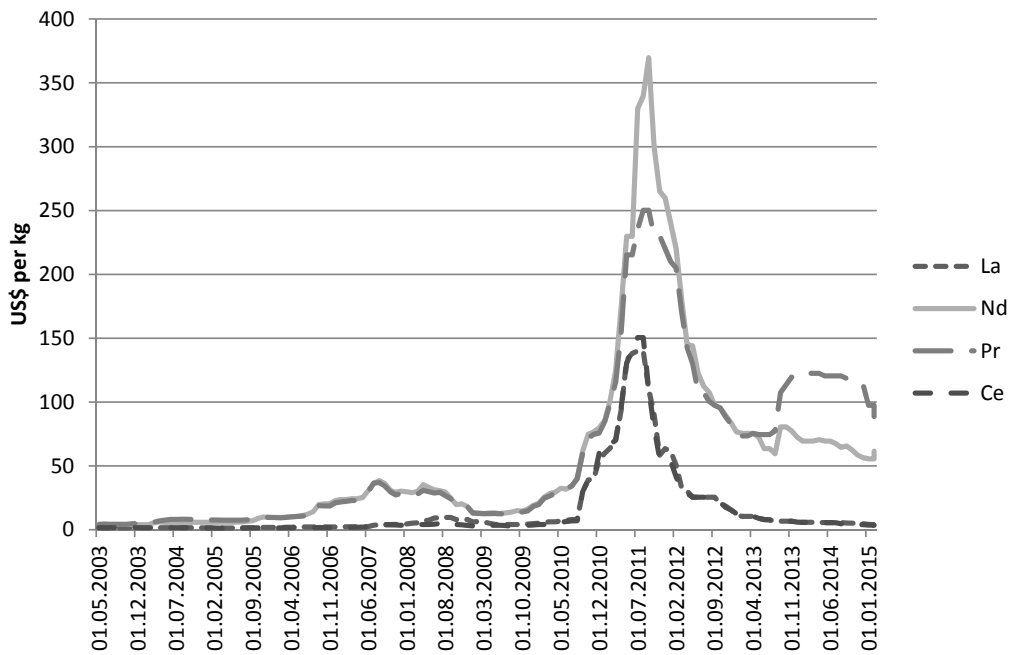


Figure 7: Prices of lanthanum (La), cerium (Ce), neodymium (Nd), and praseodymium (Pr) in US\$ per kg of oxides

Source: asianmetal.com

## 5 Conclusions

Export restrictions on metals have increased in number and severity since 2003. Even exotic materials were affected by trade barriers. They are not consumed by households directly. Thus, strong distributive effects due to intervention in their markets are unlikely. Immediate macroeconomic effects of such policies are improbable. We take rare earth elements as a case study to investigate why it is, nevertheless, appealing to limit trade flows of exotic raw materials.

Five main motivations for restricting exports are inspected: Influencing the terms-of-trade, attracting rare earth-based industries, reducing pollution from mining and separating rare earths, serving special interest groups, and generating government revenues.

Comparing the theoretical results with stylised facts from rare earth markets and actual Chinese policy yields a number of important insights. Attracting foreign firms is an important driver of export barriers. They are part of a long-term strategy to turn the People's Republic into a stronghold of rare earth-based industries which mostly relies on generating knowledge and the education of a specialised labour force. Exploiting market

power in the short-run is much less of a motivation, though the goals are complementary.

We find, in accordance with Hayes-Labruto et al. (2013) and Wübbecke (2013), that environmental protection and conservation of natural resources are important drivers of policy decisions. Export barriers can serve as a second-best instrument if regulating mines directly is not feasible. Growing domestic demand for the metals constrains their effectiveness. Environmental protection and resource conservation represent less and less of a justification for export barriers, in particular if the export restrictions contribute to raising domestic rare earth demand in the long run.

Theoretical considerations imply that firms supplying rare earths have a higher propensity of lobbying successfully than those demanding them. Export restrictions, which burden the mining sector, appear at odds with serving special interest groups as a motive. Evidence suggests that the specific set up of the restriction, in particular the quotas, creates leeway to satisfy demands from special interest groups.

It is likely that the main policy drivers identified for the case of China and the rare earth elements drive export restrictions in other nations and for other metals as well. Governments want to relocate downstream industries, and protect exhaustible resources as well as the environment, while taking into account the special interest groups.

Taking these motives into account helps designing policies to avoid trade barriers and the associated distortions. Helping countries to create efficient mine site regulations and to set up institutions able to enforce them reduces the need for export barriers as a second-best instrument. Supporting them in educating well-trained labour force and encouraging FDI allows for creating competitive downstream industries.

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