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Effect of Trade Costs on Future Rare Earth Exports

Prabuddha Sanyal
Senior Member of Technical Staff
Resilience and Regulatory Effects Department, 06921

Outline

- Background
- Trade in Rare Earths – What China Is Doing and How the World Is Responding
- Model for Rare Earth Export Growth Decomposition
- Results
- Opportunities and Capability Development
- Implications

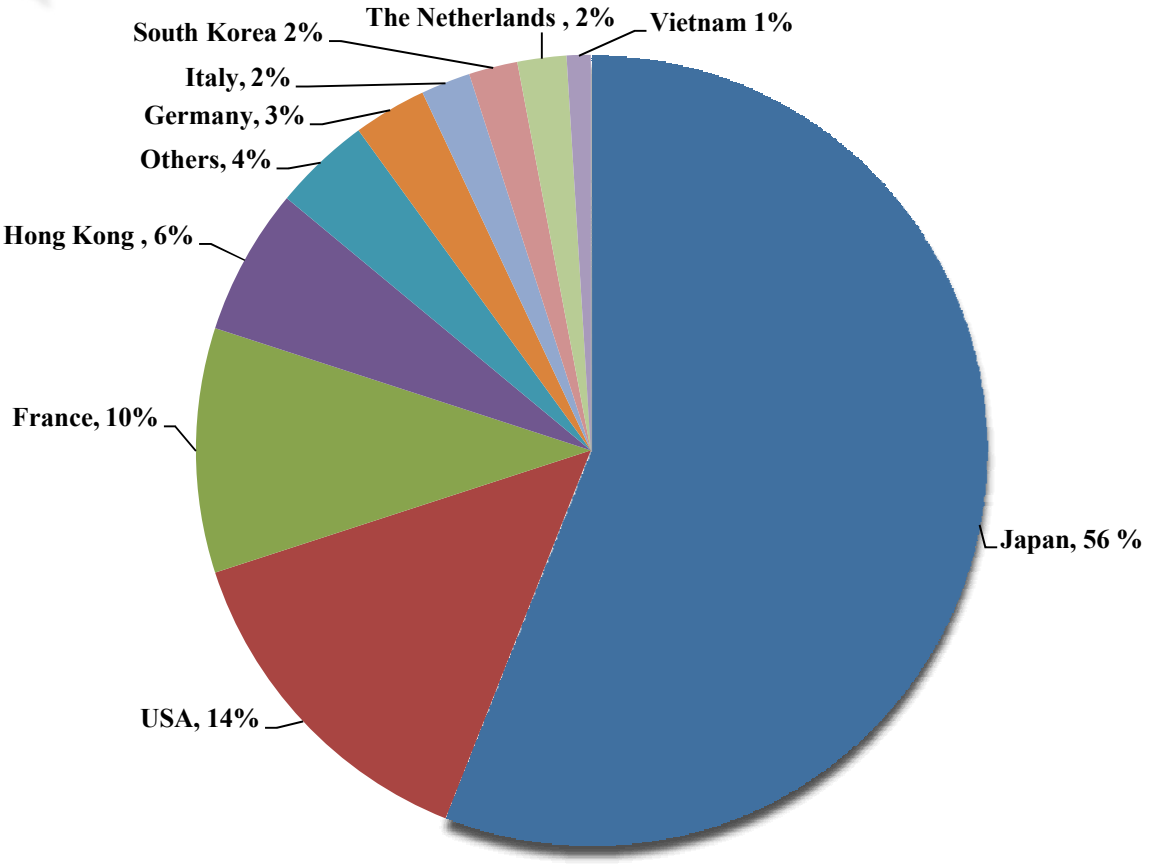
Background — Rare Earth Supply

- **China produces 95% of total rare earth supply**
- **Lower costs in China have collapsed the supply coming from other mines**
- **China has reduced the effective supply of rare earths through restrictive export policies, such as export taxes and quantitative restrictions**
  - Due to these restrictions, black market activities have spread, leading to further price spikes
  - With this rare earths supply crisis, the USA, the EU, and Japan filed simultaneous complaints against China at the World Trade Organization in 2012

Prominent Rare Earth Deposits by Mining Companies

(1) Lynas Corp, (2) Molycorp Minerals, (3) (4) Great Western Minerals, (5) Alkane Resources, (6) Vietnamese govt/Toyota Tsusho/Sojitz, (7) Arafura Resources, (8) Avalon Rare Metals, (9) Kazatomprom/Sumitomo, (10) Stans Energy, (11) Greenland Minerals and Energy, (12) Rare Element Resources, (13) Pete Mountain Resources, (14) Quest Rare Minerals, (15) Ucore Uranium, (16) US Rare Earths, (17) Matamec Explorations, (18) Etruscan Resources, (19) Montero Mining, (20) Tasman Metals, (21) Neo Material Technologies/Mitsubishi

Destination of Exports of Rare Earths (2012)



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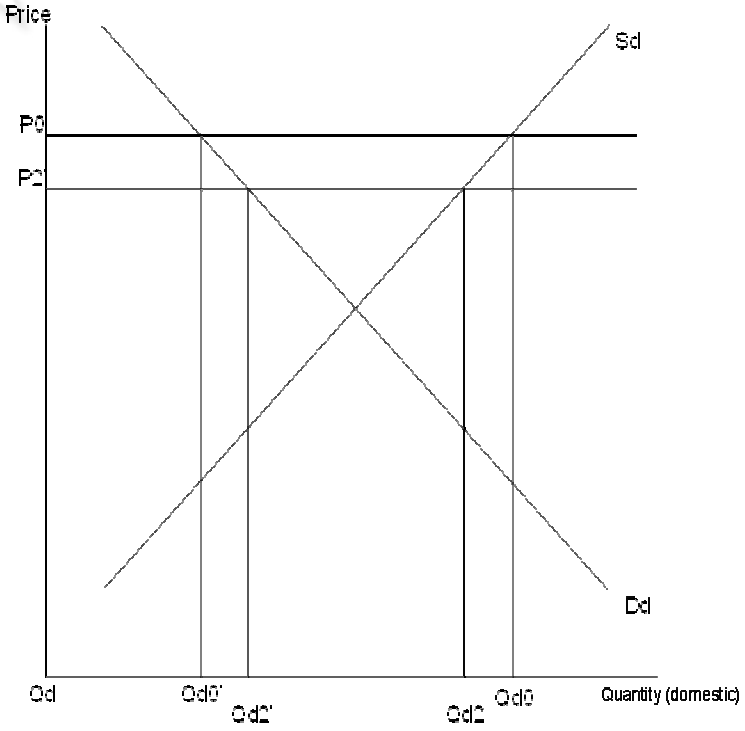
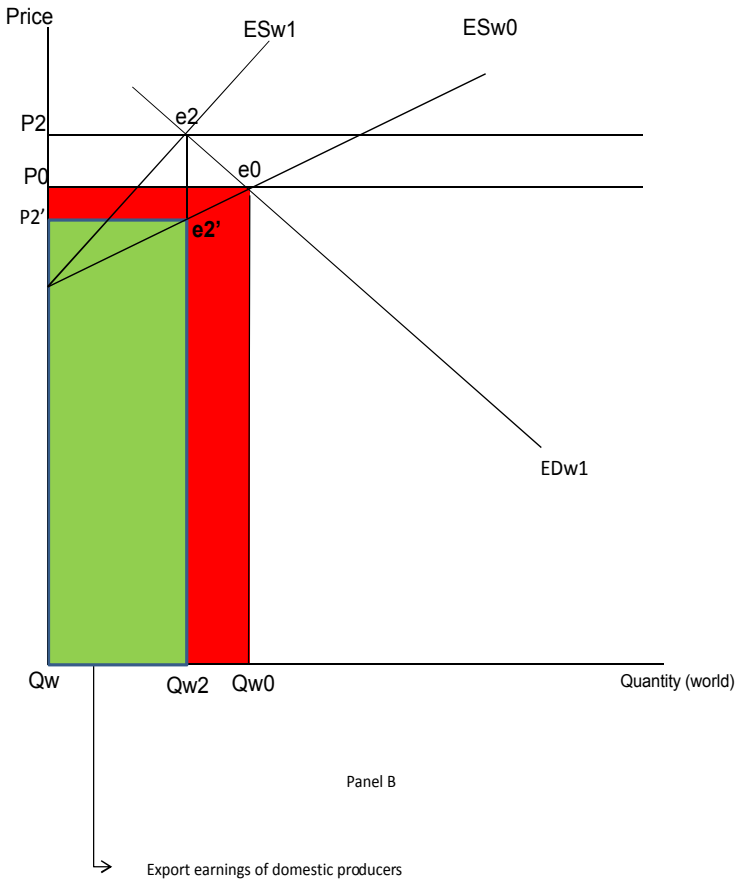
Background — Rationale for Export Controls

- **Export controls are used to:**
  - Promote value-added downstream industries
  - Raise government revenues
  - Control price volatility
  - Achieve non-economic goals such as protecting animal, human, and plant health, and reducing environmental pollution
- **In the case of an export tax imposed by a major exporter:**
  - Foreign consumers cannot buy lower-priced supplies, leading to a higher world price
  - In the exporter's economy, lower prices result in higher domestic consumption
  - In the short-run, higher likelihood of net income transfer from importing to exporting countries
  - Export tax may also lead to domestic inefficiency in downstream industries in home country because prices are kept artificially low

Impact of Ad-Valorem Tax on Export Flows for a Major Exporter





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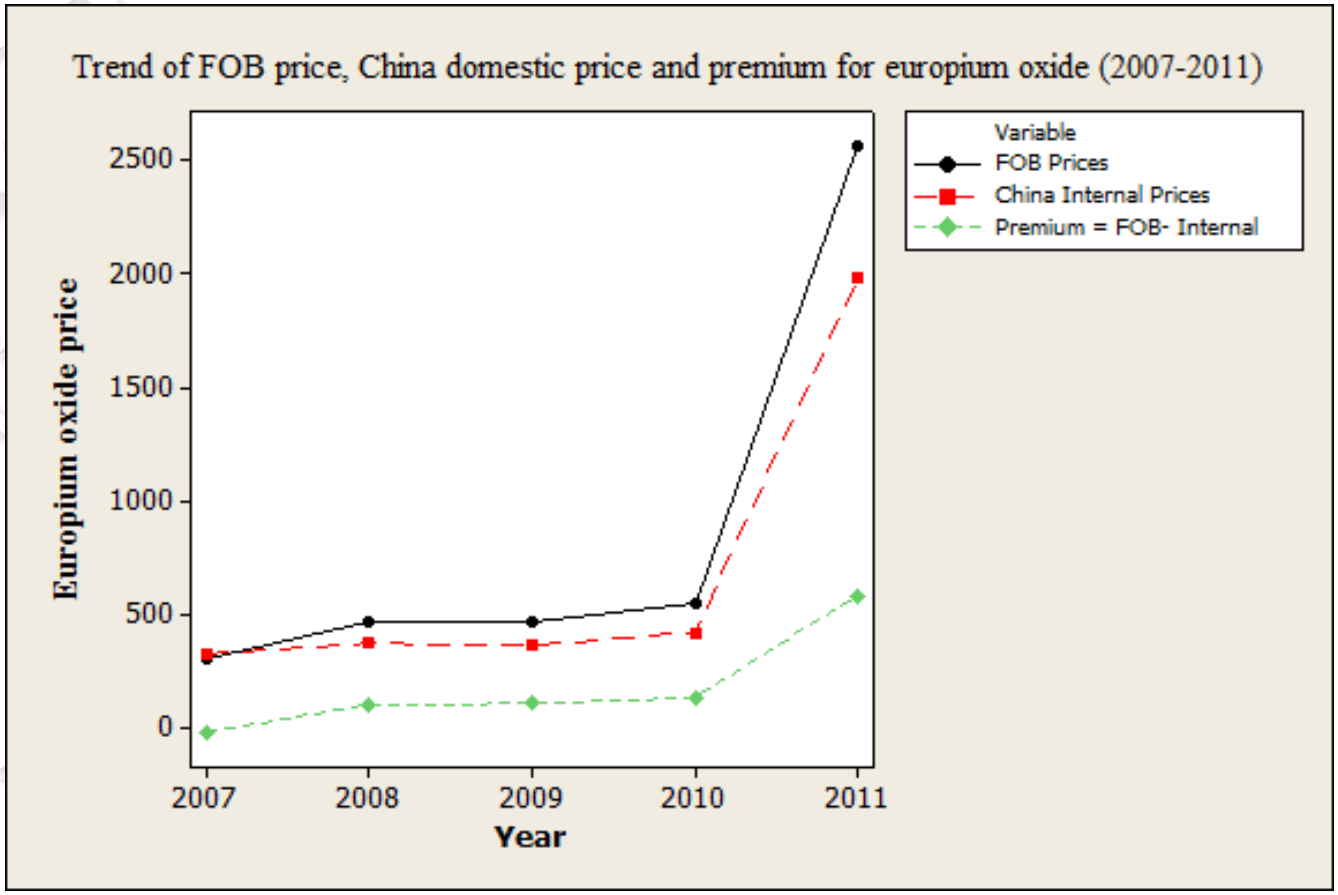
Background — Trends of Domestic Prices, FOB Prices, and Premium Prices



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Trade in Rare Earths

- **Rare earths are traded in many different forms**
  - Monazite concentrates from heavy mineral sand deposits
  - Mixed and separated rare earth (oxides, carbonates, chlorides, nitrates, fluorides, etc.)
  - Rare earth metals and specialist alloys such as NdFeB and Sm-Co used in magnet manufacturing
  - Rare earth-bearing misch metal
- **Main factor affecting trade in rare earths since 2000 has been Chinese government trade policy**
  - Rare earth exports increased sharply from 1995 to 2003
  - Rare earth exports sharply declined since then due to a number of trade restrictions — export taxes, quotas, licenses, and prohibitions (CRS, 2012)
  - The gap between domestic and world prices constitutes both an implicit advantage to domestic downstream processors of targeted products and a competitive advantage

How Is the World Responding to Chinese Export Restrictions?

- **Several countries, including the United States, are taking steps to mitigate the supply shortages of rare earths**
  - In 2012, Molycorp Inc. started Project Phoenix-- a rare earths facility at Mountain Pass, CA. The initial cracking facility has been completed and feedstock from stockpiled material has been fed into the system
    - Other operations include milling and mineral extraction, expanded cracking, rare earth oxide (REO) separations, and product completion
  - The Government of Japan is developing a national strategy with emphasis on
    - Increasing stockpiles
    - Recycling from discarded electronics
    - Finding new sources in Mongolia and Vietnam
  - In Australia, Lynas Corporation's Mt. Weld Mine will provide new sources of supply
    - Lynas is constructing a rare earths processing plant in Malaysia that will have the capacity to meet one-fifth of world demand
  - In Canada, Great Western Minerals Group has one of the highest proportions of neodymium oxide present among different REOs
    - Company is working on designing an optimal concentration/leaching process with the goal of starting production in 2015-16

Questions

- Effect of trade costs on export flows can come from five different sources: (a) traditional demand sources — per capita income or population; (b) natural distance; (c) Explicit beyond the border costs — export taxes and the real exchange rate; (d) “Behind the border costs” in exporting country — trade & transport infrastructure, customs and port reforms, investment in storage infrastructure; (e) “Implicit beyond the border” costs of importing countries — removing regulations on trade
- To which countries did China’s rare earth exports decline due to an increase in ‘behind the border’ trade costs ?
- With which countries did China’s rare earth exports increase due to a decrease in ‘implicit beyond the border’ trade costs?
- Analysis was conducted on a sample of 24 trading partners of China for two periods — 2001 and 2009 to examine the above questions
- What is the future of Rare earth element (REE) trade?

Model for Rare Earth Export Growth Decomposition

- **Stochastic frontier model using a gravity trade framework**
- $y_j = f(x_j, \beta) + v_j - u_j = f(x_j, \beta) + \varepsilon_j$
  - v_j denotes the two-sided noise component
  - u_j denotes the non-negative technical inefficiency term
  - ε_j is not symmetric, because $u_j \geq 0$
- **Least squares estimation provides consistent estimates except the parameter β_0, because $E(\varepsilon_j) = -E(u_j) \leq 0$**
- **Main objective is to estimate the technical inefficiencies caused by export taxes**

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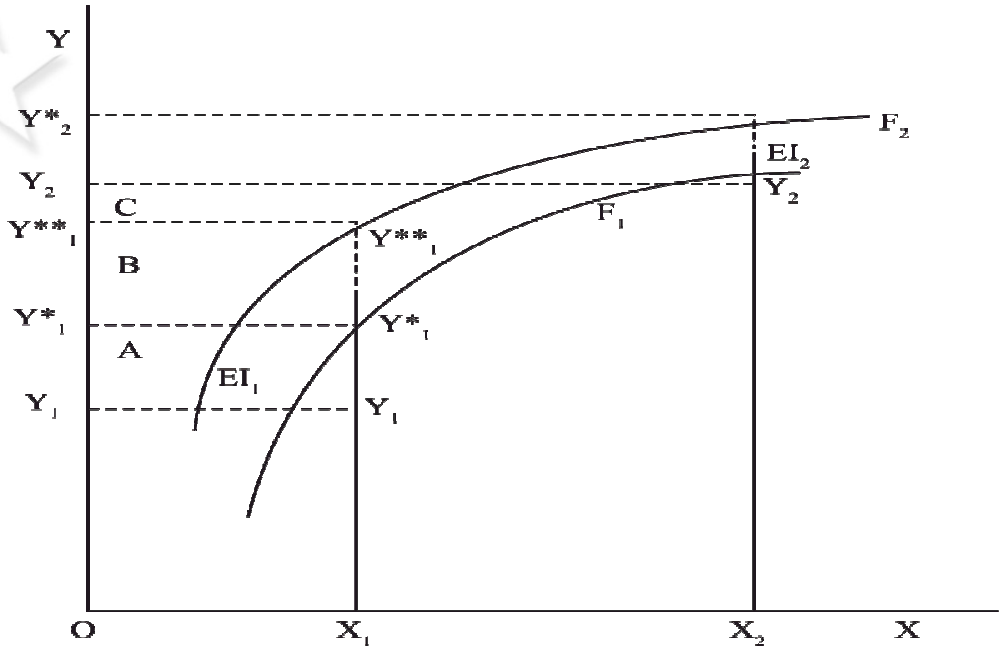
Rare Earth Export Growth Decomposition (cont.)



- $\omega = Y_2 - Y_1 = A + B + C = [Y_1^* - Y_1] + [Y_1^{**} - Y_1^*] + [Y_2 - Y_1^{**}] = \{[Y_1^* - Y_1] - [Y_2^* - Y_2]\} + [Y_1^{**} - Y_1^*] + [Y_2^* - Y_1^{**}]$
- $[Y_1^* - Y_1] - [Y_2^* - Y_2]$ = Difference between export inefficiency in period 1 and period 2 arising from changes in 'behind the border' trade costs in the home country
- $[Y_1^{**} - Y_1^*]$ = Changes in exports due to trade facilitation steps taken by Chinese partner countries; also called "implicit beyond the border costs"
- $[Y_2^* - Y_1^{**}]$ = Changes in exports due to the sum of the changes in the core determinants of trade like income per capita, distance, and changes in "explicit beyond the border costs" such as export taxes and the real exchange rate.

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Main Results

- **Coefficients in the model are of the expected sign, but the significance level of independent variables changes dramatically**
  - Geographical distance matters in trade flows
  - Per capita GDP was not significant during 2009 owing to financial crises and trade protectionism both in the developed and developing world
- **Estimated 'behind the border' cost based total export losses increased by three-fold over the period 2001 to 2009**
- **Similarly, by looking at 'implicit beyond the border' trade costs, we find China is gaining in some markets, but other countries are substituting away from Chinese exports either through opening new mines or substituting other materials for rare earths**

Some Opportunities and Capability Development

- Substituting rare earths with other materials
- Additional information on the use of rare earths at the product level
- Additional information on time dimension can help in identifying which rare earths are critical in the short-, medium-, and long-runs
- Study can support "Economic Capability" aspects of the "Critical Materials Hub" at Sandia through econometric/simulation tools

Implications

- **Countries are likely to research substitutes for REEs**
  - Rate of technological and product innovations is critical
- **REEs will remain a key component in clean energy and defense technologies in the short run**
- **New mining development is not feasible in the short term due to initial investment costs and regulatory constraints**
- **The challenge of developing substitute materials to REEs remains a national lab problem**