Review of International Political Economy

ISSN: 0969-2290 (Print) 1466-4526 (Online) Journal homepage: https://www.tandfonline.com/loi/rrip20

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To cite this article: Eugene Gholz & Llewelyn Hughes (2019): Market structure and economic sanctions: the 2010 rare earth elements episode as a pathway case of market adjustment, Review of International Political Economy, DOI: 10.1080/09692290.2019.1693411

To link to this article: https://doi.org/10.1080/09692290.2019.1693411

Published online: 25 Nov 2019.

REVIEW OF INTERNATIONAL POLITICAL ECONOMY
https://doi.org/10.1080/09692290.2019.1693411

Market structure and economic sanctions: the 2010 rare earth elements episode as a pathway case of market adjustment

Eugene Gholz[a] and Llewelyn Hughes[b]

[a]Department of Political Science, University of Notre Dame, Notre Dame, IN, USA; [b]Crawford School of Public Policy, Australian National University, Canberra, Australia

ABSTRACT

Studies identify cost as a key factor determining the effectiveness of economic sanctions. We argue that failing to account for market dynamics in the sector in which sanctions are imposed undermines the validity of estimates of the economic costs imposed on target countries, and we propose that market structure powerfully conditions sanctions effectiveness. To examine the effect of market structure, we trace the causal path through which economic sanctions purportedly lead to targets' behavior changes, and we reveal the prevalence of adjustments that minimize the cost to the target. Our empirical data is drawn from a sanctions episode that can be evaluated as a best-case scenario for the imposition of effective economic sanctions: China's 2010 embargo of rare earth elements supply to Japan. We show that Japan was able to adjust to avoid the Chinese sanction's bite despite the dominance of Chinese producers and Japan's seeming vulnerability as a key downstream consumer of rare earths. Our results show that measures of economic cost that fail to capture key components of market structure are not valid in assessing sanctions effectiveness, and the ability to impose economic costs on target countries is limited.

KEYWORDS

Economic sanctions; coercion; rare earth elements; China; Japan; critical materials; market structure; economic adjustment

Studies find that higher costs imposed on target states are associated with the effectiveness of economic sanctions (Bapat, Heinrich, Kobayashi, & Morgan, 2013). We argue that market structure, and how it might change in response to sanctions imposition, is a key condition that determines the ability of states to impose costs on targets sufficient to change their behavior. Sanctions theories have considered the importance of market structure – specifically *via* its effect on the elasticities of supply and demand (Hufbauer, Schott, Elliott, & Oegg, 2007) – but few recent studies emphasize the adjustment mechanisms through which sanctions targets evade sanctions' economic bite. By incorporating market structure and dynamics,

CONTACT Eugene Gholz egholz@alum.mit.edu Department of Political Science, University of Notre Dame, Notre Dame, IN 46556, USA.

we show that adjustments by target states, occurring on multiple time scales, enable target states to undermine sanctions in a wide range of cases.

Our empirical strategy focuses on a 2010 sanctions episode in which China interrupted supplies of rare earth elements (REEs) to Japan. The REE case appears puzzling, as it seems to meet the conditions for effective coercion but only achieved a limited effect. We evaluate the REE episode as a pathway case (Gerring, 2007). A pathway case allows us to observe the causal mechanism. REEs meet the conditions for imposing economic costs on a target state by being important economically, having highly concentrated supply, and having few practical short-term substitutes. Our evidence suggests that the target state was nevertheless able to substantially reduce the costs of sanctions, even under relatively restrictive market structure conditions. We infer that effective coercion through the use of economic sanctions is unlikely because the causal path for target state adjustment occurs even when the value of the condition variable (market structure) seems relatively favorable for sanctions effectiveness.

Our argument is significant for theory and policy. Theoretically, our argument suggests that improving our understanding of sanctions effectiveness requires reconfiguring the conceptualization and measurement of key explanatory variables. In particular, aggregate measures of cost such as the total amount of bilateral trade between the sender and the target should be re-examined to account for variation in market structure in the economic sectors targeted by sanctions. This requires data on market power and the structure of supply chains, and also understanding of the target industry's investment and sales dynamics, to ensure that empirical findings are based on measures that are closely related to underlying concepts. In terms of policy, our findings suggest that economic sanctions face a high barrier not only because of the willingness of target states to incur punishment (Pape, 1997), but also because of market adjustments that make it very difficult to impose costs sufficient to potentially shift the behavior of a target state. Carefully considering market structure as a condition variable will substantially help to reconcile the disparate conclusions of previous studies of sanctions effectiveness.

This article proceeds in five additional sections. In the next section we review the literature on economic sanctions and discuss empirical tests used to examine sanctions effectiveness. We then explain the theory that links market structure to expected sanctions effectiveness. The subsequent two sections justify the choice of REEs as a pathway case to examine the causal mechanisms of target adjustment and empirically examine adjustment dynamics in that case. The final section concludes.

The correlates of sanctions effectiveness

Economic sanctions are defined as 'actions that one or more countries take to limit or end their economic relations with a target country in an effort to persuade that country to change its policies' (Morgan, Bapat, & Krustev, 2009, p. 94). The theory of economic sanctions applies a cost-benefit logic in which success occurs when 'the damage to the target is large relative to his cost of complying with the sender's will' (Eaton & Engers, 1999, p. 409).

Theory suggests three steps in the mechanism by which sanctions achieve their effect on the target state. First, the disrupted trade has to impose economic cost on the target. By increasing the cost of trade (e.g. by adding a tariff or export tax),

sanctions diminish the economic gains previously enjoyed. Even if trade between the sender and target completely ceases, the target may substitute trade with other countries or domestic production, meaning sanctions costs are the difference in value between the presanctions trade and the equilibrium that emerges postsanctions.[1]

Second, the economic losses need to translate into a cost for decision-makers in the target state, either because they threaten to remove the decision-maker from power or because the decision-makers themselves pay the costs (Kirshner, 1997). Scholars differ about the relative importance of regime leaders' personal finances, key constituents' economic wellbeing, and the health of the target state's economy. The recent move to impose 'smart sanctions' that attempt to affect key decision-makers while minimizing collateral economic damage reinforces the importance of this step in senders' consideration of the type and size of sanction to impose (Tostensen & Bull, 2002).

Finally, target-state decision-makers need to compare the political cost of accepting the post-sanctions economic equilibrium with the political cost of capitulation. The target decision-makers will adjust their policies if the political costs of resistance are worse than accepting the cost of policy change (Pape, 1997).

This causal logic implies that mid-level theories can identify the conditions under which sanctions might impose greater or lower costs, and under which the target might be more or less sensitive to a given level of imposed costs. Recent studies have emphasized correlates of target sensitivity to costs. An important area of research considers whether the target's regime type affects the likelihood sanctions will succeed (Brooks, 2002; Escribà-Folch & Wright, 2010; Major, 2012; Nooruddinn, 2002). Separately, Drezner (1999) suggests allies are more sensitive to a given level of sanctions costs than adversaries, a result that has been further developed by McLean & Radtke (2018).

Some scholars argue selection effects may lead to the undercounting of sanctions success if target states change their behavior before sanctions are imposed (Drezner, 2003; Nooruddin, 2002). Recognizing this, the Threat and Imposition of Sanctions (TIES) dataset includes the threat of sanctions in addition to imposed sanctions (Morgan et al., 2009). Using this dataset, Bapat et al. (2013) examine 18 factors used to explain sanctions outcomes, finding that many factors associated with positive sanctions outcomes are artifacts of choices about data and measures. Bapat et al. do find, however, that two factors are positively and robustly associated with sanctions success: international organizations' discussion of the sanctions and the magnitude of the costs to the target.

Unfortunately, studies do not yet address what types of sanctions, other than those imposed after discussion by international organizations, are more likely to impose large costs on the target, nor how much more likely a sanction is to succeed in response to a given increase in target cost. Policymakers have surely understood the logic of the desirability of increasing costs to the target, but sanctions still often fail. Even using the broadest definition of success in the TIES dataset, sanctions episodes only yield gains for the sender 56% of the time, and the percentage is much smaller for other definitions of success (Morgan, Bapat, & Kobayashi, 2014).

The centrality of target costs makes it important to identify the conditions under which they are likely to increase or decrease. Studies typically measure target costs

at a very aggregated level, using trade balances or bilateral trade as a share of the target state's GDP (Bayard & Elliott, 1992; Elliott & David Richardson, 1997); Zeng's (2002) effort to improve the data uses the complete list of the types of goods traded between the sender and the target, rather than the specific characteristics of the market(s) in which sanctions were applied. These are gross measures of potential vulnerability rather than measures of the true cost of sanctions, even though few sanctions episodes involve efforts to interrupt all trade (Nooruddin & Payton, 2010).

Detailed datasets informally estimate key components of the cost variable. The TIES dataset includes variables for 'anticipated target economic costs' (at the threat stage) and 'target economic costs' (for imposed sanctions) (Morgan et al., 2014). When a coder found reference to an exact cost estimate, the dataset includes that number. More often, without a precise numerical estimate to include, the coder estimated whether the sanctions threatened or actually led to an increase in inflation or unemployment of more than 5% or to a 'drastic reduction in trade,' but the dataset does not record the economic reasoning behind the coder's choice, and the codebook provides no guidance about how to think about the relevant economic issues.[2] The 'anticipated cost' variable differs from the actual 'target costs' variable in only a small fraction of the episodes in the dataset, with a lower actual cost in 23 of 27 episodes where the values were not equal; the complete dataset has anticipated or actual target cost data for 1,214 episodes. Ultimately, the target cost variable that Bapat et al. (2013) reported as robust to thousands of model specifications was a dummy, with a value of 1 for 'severe or major cost' and 0 otherwise – a very blunt indicator.

Hufbauer et al.'s dataset (2007) provides greater detail on the derivation of values for each observation of its 'cost to target' variable. In some episode histories, they describe the target's ability to find alternative sources to compensate for supplies disrupted by sanctions. In all episodes, they estimate the sum of the supply and demand elasticities for the disrupted trade, which they multiply by the change in trade volume to estimate the welfare loss to the target, but they do not systematically explain the reasoning behind their elasticity estimates.[3]

In recent years, countries have threatened and imposed financial sanctions in addition to, or in place of, trade sanctions. Financial sanctions are attractive for at least two reasons: first, the United States, through its dominance of institutions such the SWIFT network for processing financial transactions, may gain the benefit of particularly high market power if it uses financial sanctions; and second, sanctions that deny access to financial markets may disrupt all of the target country's international trade, rather than trade in particular sectors or trade with particular countries (Drezner, 2015; Farrell & Newman, 2019). Nevertheless, market structure and target states' dynamic adjustment remain important to financial sanctions effectiveness. For example, evidence from Sino-North Korean border case – cited as a case of the successful application of financial sanctions – suggests the target state evaded financial restrictions by changing settlement methods, despite the fact that the sanctions initially had 'a devastating impact on North Korea's ability to engage with the global financial system' (Lee & Gray, 2017, p. 429). Relatedly, Russia was able to circumvent the existing system governing financial transactions, mitigating the impact of some financial sanctions (Arnold 2016).

Ultimately, while some studies note that the structure of economic markets can affect sanctions effectiveness (Elliott, 1998; Kaempfer & Lowenberg, 1988; Nooruddin, 2002), the details remain underdeveloped. Taking into account market structure and dynamics, we propose, helps to explain why sanctions fail even when anticipated economic costs incurred by targets appear to be high. We suggest the ability of target economies to adjust, through a combination of public and private actions, weakens a key causal pathway through which economic sanctions might lead target states to concede.

Market structure and the ability to impose costs

Predictions about sanctions effectiveness require information about the economic and political dynamics of the trade and investment relationship between the target and sender states. When senders impose sanctions, they rarely attempt to disrupt all trade with the target, instead inhibiting trade in a particular sector or sectors of the economy. Specifically, they impose tariffs to reduce the sender's import demand for key export products or impose selective quotas, taxes, or prohibitions on exports of certain products to consumers or industry in the target state.

Choosing the sectors in which to disrupt trade requires defining 'key' products – often sectors in which the sender thinks the target will bear substantial economic and political costs, and often sectors described as 'strategic' or 'critical' goods (Chen & Garcia, 2016, p. 46). Senders also tend to choose sectors that they think will impose the 'right' amount of cost, proportional to the size of the issue at stake in the sanctions episode, given that trade disruptions impose costs on the sender (Smith 1995). Of course, if the target does not yield in the face of an initial set of sanctions, a sender may expand the list of targeted sectors. Imposing sanctions sequentially may give the target time to adjust in advance of the escalation of sanctions, or the target may wait until sanctions escalate before adjusting. During the anticipatory adjustment phase, non-sanctioned parts of the target's economy might boom as trading partners rush orders or stockpile to avoid anticipated sanctions. On the other hand, anticipatory adjustment might spur firms in the sender country in unsanctioned sectors to find alternate trading partners before additional sanctions are imposed, spreading the drop in trade to sectors not on the initial sanctions list.[4] These varied possibilities suggest the need to study the dynamics of sanctions episodes more carefully.

We propose that three factors determine whether a target is vulnerable to sanctions in a given sector: the extent to which the sender dominates supply or demand in the global market (sender concentration); the extent to which target dominates consumption or supply in the sector (target concentration); and the intensity of the target's preference for continuing the normal pattern of trade in the disrupted sector (target elasticity). The logic behind each of these considerations derives from straightforward economic principles.

A sender cannot impose large economic costs on a target in a market in which alternatives are readily available (Peksen & Peterson, 2016). If a sanction is imposed through a temporary tariff on a particular product, the sender needs to be the major consumer of that product, otherwise the sender's effort will have only a marginal effect on the target's overall sales in that sector. Moreover, a target with many other established customers in a particular sector (that is, in a situation with

low sender concentration) would find it easy to divert sales to other consumers such that the export industry only suffers a minor increase in cost. Alternatively, if the sanction is imposed by taxing or restricting exports to the target state, then the sender needs to be the dominant supplier in the global market, otherwise the target will be able to purchase from alternative suppliers at a minor cost increase. These market adjustments are one form of what has been called 'sanctions busting' (Drezner, 2000; Early, 2015). Thus for sanctions to bite, the sender needs market power in the sector it chooses to convey punishment: the more market power, the more potential bite.[5]

The logic of target concentration is similar to that of sender concentration: if many countries besides the target participate in the sanctions-disrupted market, then the sanctions will not impose a substantial cost on the target. Specifically, if the sender restricts imports from the target of a product for which the target is but one of many suppliers, the main effect of the sanction will be to reallocate trade rather than change the total volume of trade. With the possibility of reallocation, the target would only feel the marginal cost of shifting its exports from the sender's market to the alternative market, not the cost of being unable to export at all.[6] Reallocation is the key insight behind the logic that multilateral sanctions are more effective than unilateral sanctions, though that literature has normally emphasized multilateralism as a way to establish sender concentration rather than as a way to limit the adverse effect of low target concentration (Drezner, 2000; Martin, 1993).

If sanctions disrupt the target's access to a product (that is, if the sanction restricts some of the sender's exports to the target), but the sender continues to sell the same product to other countries, then third parties may profitably re-sell some of what they purchase from the sender to the target. This adjustment would be the equivalent of 'trade deflection' that sometimes occurs with bilateral or regional free trade agreements (Krueger, 1997). Even if sender concentration is high, and even if the sender cares enough about the issue to credibly threaten secondary sanctions limiting sales to countries that re-sell product to the principal sanctions target, re-sale may be an important form of sanctions busting in nontransparent markets, such as those dominated by private transactions.[7] Smuggling is another, even less visible, alternative by which a target may maintain access to supply even in the face of sanctions, if enough of the product is sloshing around international markets. Studies that estimate the reduction in bilateral trade between a sanctions sender and target in the wake of sanctions threats or imposition (e.g. Afesorgbor, 2019) miss important economic adjustment mechanisms that can reduce the cost imposed by sanctions on their target – market dynamics that should be included in assessments of sanctions' causal path.[8]

Finally, sanctions can impose more costs if conveyed *via* disruption of trade that matters a great deal to the target – that is, if target elasticity is low. If a sender applies a tariff to a product produced by the target in factories with high fixed costs or that rely on specialized labor whose skills might atrophy if not maintained by steady work, it will impose higher costs than if the sender applied the sanction against other products with more flexible production technology. The same logic suggests that a sanction on a perishable product might impose greater costs than one imposed on a good that could be held in inventory for future sale (Afesorgbor, 2019). And if substitutes are available for the sanctioned product, then demand is more elastic: the target may prefer to buy the sanctioned product, but if that

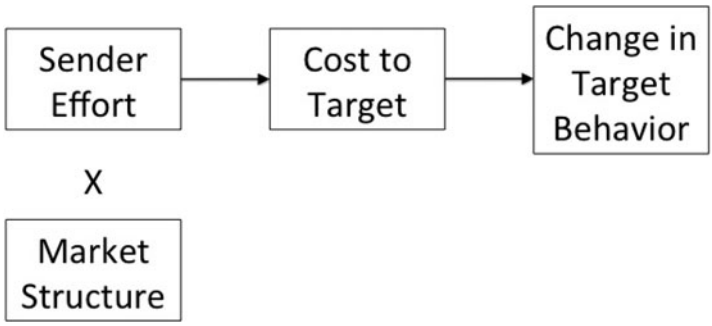

Figure 1. The causal path of sanctions effectiveness.

product is unavailable it will bear a smaller cost if it can shift to using an alternative product.

Separately, if the sector chosen to convey the sanctions' punishment is tied to important governmental functions or decision-makers' public initiatives, then the imposition of economic pain in that sector is more likely to have political effects.

A country considering sanctions on a target always faces the challenge of understanding not just the pre-threat state of trade, but also the cost the target would have to pay to shift to a post-sanctions pattern of trade. Market structure, summarized as sender concentration, target concentration, and target elasticity, affects the size of these adjustment costs. Sanctions change the market, and understanding those dynamics is necessary to understand sanctions effectiveness.

To summarize, the traditional theory of economic sanctions proposes that a bigger sanctions effort from the sender – a higher tariff or export tax, or the application of a given level of tariff or export tax to a broader range of products – has a greater chance of achieving behavior change in the target. The independent variable is the level of sender effort, and the dependent variable is target behavior. We argue, following standard economic principles, that this effect is conditional on another variable, market structure: a given level of sender effort imposes varying levels of cost on the target, because the market structure and adjustment dynamics vary across the sectors to which sanctions are potentially applied. Figure 1 summarizes the theory's causal chain.[9]

Case selection: an introduction to rare earths and the 2010 sanctions episode

Assessing the roles of sender concentration, target concentration, and target elasticity in sanctions episodes requires detailed sector-specific information. Sanctions episodes are complex, and the datasets used thus far have not been detailed enough to discern the economic sectors used to transmit the sanction or the market structure and dynamics of those sectors. When a theory's structure and the correlation between its key variables are relatively well established – as is true for the cost-benefit framework of economic sanctions and the role of costs to the target state in encouraging sanctions success (Bapat et al., 2013) – researchers can select a case study to maximize observability of the causal process, sometimes called a 'pathway case,' to assess whether the theory in fact works as surmised (Gerring, 2007).

Choosing a case with high values of the explanatory variables makes the effects of those variables most readily observable through the case's sequence of events and in its outcome. Maximizing the value of a variable also makes that variable's effect in a particular case likely to dominate the effect of chance variation in driving the case's outcome, increasing our confidence that the case study provides useful insight into the theory (Odell, 2001; Plümper, Troeger, & Neumayer, 2016; Van Evera, 1997). In this instance, our goal is to observe the causal process through which a condition variable (market structure) influences the effect of an independent variable (level of sender effort in imposing sanctions), so we should choose a case study with high sender concentration, high target concentration, and low target elasticity.[10]

A 2010 sanctions episode between China and Japan in which China allegedly embargoed rare earth element (REE) exports to Japan meets those criteria. To establish this episode as a pathway case, we need to show that China supplied most of Japan's REEs, that Japan was the largest global consumer of REEs, and that Japanese decision-makers believed that they could not readily adjust to the interruption of rare earth supplies.

In early September, the captain of a Chinese fishing trawler sailed into waters near the Senkaku/Diaoyu Islands, rammed Japanese Coast Guard vessels that tried to enforce Japanese claims to administer the islands and their environs, and was detained by the Japanese government. The Chinese government demanded the captain's release and an official apology from Japan – and presumably implicitly desired a favorable adjustment of the legal status of the islands. Japan's major business newspaper, *Nihon Keizai Shimbun* reported from Beijing on information they received that Chinese authorities had stopped two cargoes, and that an order had been issued to ban rare earth exports to Japan.[11] Japanese industry also asserted that China suspended exports of rare earth elements to Japan, although the Chinese government officially denied this.[12] The Japan Society of Newer Metals (the relevant industry association) noted that China implemented an 'embargo, in reality.'[13] An official from the nonferrous metals group of Japan's Ministry of Economy, Trade, and Industry (METI) noted exports clearly slowed and speculated that an oral order may have been given because they did not find evidence of a written order.[14] Japanese Ministry of Foreign Affairs officials said they interpreted the incident as a sanctions episode in which China was attempting to change the islands' status.[15] Even the Chinese state media later referred to the episode as an economic sanctions incident (Wilson, 2018). Japan quickly released the fishing captain, and *The New York Times* cited the high-profile event as a 'humiliating retreat' for Tokyo.[16] Japan's then Minister for Economy, Trade and Industry Banri Kaeda stated that the episode was an 'extremely serious problem.'[17]

Rare earth elements are a group of materials whose properties make them valuable for use in modern, high technology applications. The rare-earth supply chain actually involves a number of value-added steps. After mining ore, rare-earth firms must use physical and chemical differences between rare earths and other minerals to concentrate the valuable rare-earth oxides (Hurst, 2010). Those oxides are then converted into rare-earth metals, combined with other metals into alloys, processed into components like magnets, and then assembled into goods such as generators, motors, and lasers that are used in products ranging from wind turbines to electric cars to radars and missile guidance systems (Bleiwas & Gambogi, 2013; US

Department of Energy, 2011). Rare-earth production is driven more by chemical engineering expertise than mining ability.[18]

By the early 2000's, China mined around 97% of the world's REEs, with the specific amount varying element-by-element among the seventeen specific materials (Bleiwas & Gambogi, 2013; Humphries, 2012).[19] China not only supplied Japan's rare-earth material but also nearly had a global monopoly of rare-earth oxide production: a very high level of sender concentration.

Target concentration was also high. Japan imported rare-earth oxides from China and had the largest market share in the next phase of the value chain, including high-strength, high-temperature permanent magnets, which Japan either exported to downstream manufacturers (e.g. in the United States) or used to make consumer products such the Toyota Prius (Humphries, 2012).[20] Japanese companies hold key intellectual property in processing rare earths, with 12 of the top 13 firms headquartered in Japan, when measured in terms of total patents held.[21] That dominant market position allowed Japanese companies to enjoy bargaining advantages and high profits in normal times, but it also made Japan a highly concentrated target for disruptions in rare-earth oxide and metal supplies: other countries lacked the intellectual property and installed capital stock to manufacture key rare earth products, meaning that there were few other buyers for rare earths that could mask trade deflection, resell inventories, or otherwise help Japan evade China's embargo.[22] In terms of our theory's explanatory variables, the Chinese sanction in the rare earths sector thus benefited from high target concentration.

Finally, the Japanese government recognized the importance of rare earth elements to Japanese industry and the risks associated with seller concentration, noting that 'rare earths are indispensable elements in renewable energy and other areas in frontier industries for our country, and it is necessary to secure new sources of supply given the experience of the risk of a supply interruption revealed by the strengthening of China's export restraint measures.'[23] The kinds of products whose production would be disrupted by a lack of rare earth supply were precisely the signature products of the Japanese high-tech manufacturing economy – along with certain defense and energy products that pushed the buttons of Japan's 'small, island nation mentality' (Samuels, 2013). In terms of our theory's explanatory variables, Japanese decision-makers believed that Japan had low target elasticity.

The standard sanctions theory predicts that under the market structure conditions of the China-Japan rare earth sanctions episode, Japan should have been vulnerable. From the perspective of market dynamics, the initial conditions meant that Japan either faced a large cost of supply interruption or a lot of market adjustment to ensure alternative supply. Either way, the case should offer clear evidence of the causal mechanisms in operation, making it a good pathway case.

Beyond the literature on economic sanctions, scholars have developed theories to explain variation in sectors' and countries' costs of adjusting to new economic conditions (Hamermesh & Pfann, 1996; Hiscox, 2001). We should expect related variation in the relative ease with which different sanctions targets can adjust, given a level of need to adjust created by the sender's level of sanctions effort and the initial market structure in the sector through which sanctions are imposed. With respect to our case study of China's suspension of rare-earth exports, Japan's high level of economic development offered both advantages and disadvantages to its potential adjustment process. On one hand, Japan has a diversified economy, high

state capacity, and sophisticated capital markets that allow companies to invest in technology and training to adjust production processes and to borrow to cover temporarily higher expenses or diminished revenues before adjustment efforts come to fruition. On the other hand, industries in developed countries like Japan tend to have more installed capital and specialization in particular niche products, so they might face higher adjustment costs.

Our goal in this article is to track the causal process of economic sanctions episodes, not to develop or test theories explaining variation in adjustment costs. We seek to show that substantial adjustment occurs even in cases that appear favorable for sanctions senders and to establish that market structure and dynamics in the sector in which sanctions were imposed should be considered in studies of economic sanctions. Whether adjustment was relatively easy or relatively hard for Japan should not affect our determination that the China-Japan rare earth elements sanctions episode is a good pathway case for studying the causal process of the theory of economic sanctions.

The case

In the case of REE, the values of the key variables conditioning sanctions effectiveness appeared to create conditions under which China, as the sender state, could effectively target Japan. Yet, the evidence below suggests any political leverage proved fleeting and difficult to exploit because of the dynamics of market structure, the condition variable. Indeed by 2010, supply concentration, target concentration, and target elasticity were already moving against China's ability to exploit the rare earths sector for political gain (Gholz, 2014). After the crisis, Japan's vulnerability rapidly dissipated. The rapid changes around the 2010 crisis suggest that even under favorable conditions for effective sanctions, the total cost that China was able to impose was small.

In the fall of 2010, people in the rare earths industry already expected that non-Chinese production and processing capacity would increase, though that message was sometimes lost in the headline-grabbing reports of the Chinese sanctions (Gholz, 2014). A new mine was scheduled to open in Australia, and an old US mine, which had dominated global rare earths output before China entered the market, planned to resume production. Concentrated production had thus already attracted new entry to the market.

Demand for rare earths was also already showing signs of change: before the crisis of 2010, government and industry closely watched China ratchet down rare-earth export quotas. For the first several reductions, the Chinese quota remained higher than demand for Chinese exports, but many analysts predicted that it would start to bind by 2011 (Wilson, 2018). In response, the Japanese government had already implemented a number of measures targeting the structure of the market for REEs, beginning with the May 2006 New National Energy Strategy.[24] Concern that the quotas would constrain exports drove up export prices and spurred efforts to innovate to reduce demand. During and after the crisis, demand elasticity proved much greater than anticipated: industrial users sped up the application of innovations, found ways to recycle rare earth materials in some uses, and stopped using rare earths in some less-valuable products.

The key point is not that China's suspension of rare earth elements exports was unable to impose economic costs on Japan. Prices soared in the REE spot market, and prices remained high even after China resumed rare-earth exports to Japan at the end of the year. Downstream users filled inventories to protect themselves from future disruptions, and many small mining companies attracted capital with promises to develop non-Chinese sources of rare earths. Fear of Chinese economic power fueled a two-year speculative bubble in rare earths.[25]

Even without the steady stimulus of a continuing Chinese embargo, Japan's economy adjusted, as firms wanted to alleviate future risk. Much of the 'demand destruction' in the wake of the crisis was actually permanent. The adjustments, combined with increased availability of non-Chinese supply, led to a sustained *glut* in the supply of rare earth oxides, and prices collapsed. Very low rare earth prices after 2012 fueled a partial rebound in demand.

New market entrants struggled, and several brokers and downstream users lost money on the inventories they had built up during the bubble.[26] Furthermore, the new Australian mine only narrowly stayed in business through the post-crisis glut, supported by Japanese investment.[27] Production at the US mine using an innovative, efficient, and less polluting process ramped up just as the glut intensified, and the mine was mothballed for about two years (2015-2017). But ultimately, the non-Chinese mines reduced sender concentration, and the now-reopened US mine has capacity available for relatively rapid ramp-up in a future crisis or if demand increases.[28] On the other hand, much downstream rare earth processing still takes place in China – actually a higher level of downstream concentration than in 2010 but still far below the level of sender concentration that China enjoyed in 2010 with respect to the raw material.[29]

Overall, China's potential leverage today is now lower, with less sender concentration, less target concentration, and higher target elasticity than analysts thought in 2010. The market structure of the moment in 2010 offered China some leverage over Japan, but that market structure opportunity was fleeting because of adjustments in all three variables. We next trace the causal path of the adjustment process during and after the sanction's episode.

Supply-side adjustment

Studies of sanctions often focus on supply-side adjustments, notably use of stockpiles, purchases from alternative suppliers, and investment to bring new suppliers online. In the canonical case of the OAPEC embargo of 1973–74, for example, the rise in oil prices led to a supply response, centered on Alaska, Mexico, and elsewhere (Hughes, 2014).

The immediate supply-side adjustment in response to the rare-earths embargo occurred through two mechanisms: the circumvention of export restraints by domestic Chinese producers and the release of commercial and government stockpiles. In the 2010 crisis, the former was more significant, but the latter was available for more extensive use had the supply interruption from China lasted longer.

Circumvention of the embargo by Chinese exporters likely involved expansion of existing smuggling routes. Even in normal market conditions, 'unofficial' rare earth exports from China may have satisfied as much as 40% of the global market

demand, making it easy to believe that some Chinese producers could find pathways to continue exporting despite the embargo (Packey & Kingsnorth, 2016).

Simultaneously, trade deflection increased during the crisis. In one mechanism, Chinese exporters minimally alloyed rare earths, for example with iron or nickel, legitimately disguising the exports (e.g. as 'steel composites' or 'alloy powder for negative electrodes') (Mancheri & Marukawa, 2016, pp. 54, 159–161). In another trade-deflection mechanism, Japanese firms obtained materials from alternative suppliers in the rare earths value chain, not specifying where the primary materials came from but buying from plants that typically sourced from China. Those third-country plants may have increased their sales of downstream products to Japan, substituting for rare earth concentrates and oxides that would otherwise have gone to Japan for processing, or third-country plants may have purchased more inputs than they could use and simply sent the inputs on to Japanese plants (Seaman, 2012).[30]

The other short-term supply adjustment mechanism tapped rare earth inventories.[31] In 2010, Japanese companies held stockpiles they could have drawn from in an extended crisis. However, with rare earths imports available throughout the fall of 2010, many Japanese companies declined to release stockpiles and indeed chose to expand them in the immediate aftermath of the embargo – helping drive the price bubble that lasted until the end of 2011.[32] This feedstock could have been used as a near-term market adjustment in the face of a total embargo or a sustained supply interruption.

At a slightly longer time scale, companies recycled significant quantities of material. For example, within a few months of the embargo glass companies started to reuse cerium polish, dramatically reducing their need to purchase new cerium.[33] Postconsumer recycling of most rare earth elements is difficult, due to constraints on both collection and efficient processing, but pilot efforts offer hope for more recycling in the medium-to-long term (Binnemans et al., 2013; Sprecher et al., 2015). Additionally, as shown in Table 1, the Japanese government funded a number of projects designed to develop recycling opportunities.

Finally, the most powerful supply-side adjustment, opening new rare-earth mines outside of China, took about two years to bring substantial quantities of material to the market – and would have taken longer had two companies in particular, Molycorp in the United States and Lynas in Australia, not anticipated growing demand for rare earths and started investing in mining and ore-processing plants almost a decade before the crisis (Gholz, 2014). Both began producing at levels below planned production capacity (just under 20% and over 10% of 2012 global consumption, respectively), due to a combination of 'teething troubles' with new separation technologies and low market prices that may not have covered variable costs, but both planned to double their initial capacity rapidly.[34]

The Japanese government played an important role in the Lynas project. The Japan Oil, Gas and Metals National Corporation (JOGMEC), along with Sojitsu, a Japanese trading house, invested 250 million US dollars in Lynas in return for a long-term supply contract for approximately 30% of total Japanese consumption. This commitment allowed Lynas to weather the post-crisis glut that the American company, Molycorp, did not survive. Today, Lynas profitably produces approximately 15% of global rare earths supply. Separately, another company, MP Materials, is now profitably operating the US mine that Molycorp had revived, also contributing some 15% of global rare earth supply.[35] Overall, there is now

Table 1. Japanese efficiency and substitution projects.[48]

Material	Application	Project content	Project partner
Reduce cerium and lanthanum use	Steel bearing	Develop substitutes for cerium and lanthanum	
	Polishing for hard drive and LCDs	Reduce cerium use through alternative polishing techniques, etc.	Ritsumeikan University, Admatechs, Crystal Optics, heavy industries firms (NEDO-sponsored project)
Reduce and substitute for use of neodymium and dysprosium	Motor for next generation vehicle	Reduce use of neodymium	Shit-etsu Chemical, TDK, Hitachi Metals
	Motor for next generation vehicle	Cut dysprosium use by 40% by reducing size of neodymium pellets	Intermetalics, Tohoku University (NEDO-sponsored project)
	Small electric motors	Develop, and begin producing in 2011, magnets that do not use dysprosium	Aichi steel
	Motor for next generation vehicle	Develop technology to increase coercivity of neodymium magnets	Geomaterials Group, National Institute for Materials Science
	Small electric motor components	Develop small motors that use amorphous metal in place of rare earths	Hitachi
	Motor for next generation vehicle	Develop iron nitride that does not use neodymium	Toda Kogyo, Tohoku University (NEDO-sponsored project)
	Motor for next generation vehicle	Develop new ferrite magnet motor	Hokkaido University (NEDO-sponsored project)
	Motor for next generation vehicle, and other uses	Develop SR motor that does not use permanent batteries	Nihon Denki
	Motor for next generation vehicle	Develop coil that does not use permanent motor	Mitsubishi electric (NEDO-sponsored project)

substantial non-Chinese supply in the market, and market-structure adjustment has meant supply concentration is no longer so high as to make rare earths a promising sector for effective economic sanctions.[36]

Demand-side adjustment

A target state can also adjust to economic sanctions by reducing demand, either through private-sector responses to higher prices or through government efforts. Even in episodes in which experts consider demand highly inelastic, disruption can spur creativity and bring about unforeseen adjustment. Adjustments can lead to a structural change in demand, as they did following the oil shocks of the 1970s, when governments and firms in many countries reduced the role of oil in the electricity-generation mix.

Unsurprisingly, Japanese firms and the government tried hard to reduce the importance of REEs in product manufacturing during and after the crisis. The most rapid adjustments to the increase in prices occurred because of companies' success in reducing their needs for REEs. Japanese companies and government-industry consortia quickly initiated 11 programs that focused on the more efficient use of REE materials or substituting alternative materials for REE. A project sponsored by the New Energy Development Organization (NEDO) and involving the company Intermetallics and Tohoku University, for example, aimed to reduce the amount of dysprosium used in vehicle electric motors by 40% through more finely grinding neodymium. Shinetsu, TDK, and Hitachi Metals also worked to reduce the amount of dysprosium used in electric motors.[37]

Some programs succeeded more rapidly than others. The Japan Society of Newer Metals highlighted research into reducing the amount of dysprosium used in batteries that commenced in 2007 but had impact after the crisis.[38] The group concluded that 'the "Rare Earth Shock" had the result of pushing forward domestic research and development into substitutes for rare earths, and their more efficient use, which had the effect of reducing the risks of supply interruptions.'[39]

This assessment is supported by Kazuhiko Komumura of the Nomura Research Institute, to whom METI assigned the role of examining the effect of government support for adjustment to the supply crisis. After visiting 100 locations within Japan, he reported that companies initially focused on responses that were 'rapid and certain' and summarized that 'programs were introduced across Japan that aimed to reduce the use of REEs, and that almost all of these were able to achieve the desired effect.' He attributes this success to the companies' ability to develop machine tools that precisely applied changes to production technologies.[40]

Finally, the highest profile market for rare earth elements, the magnet market, adapted through 'demand destruction'. Some users did not need the high performance of specialized rare earth magnets but were using them before 2010 because they were cheap. When prices rose, firms stopped using rare earth magnets in consumer goods like purses, golf hat clips and ball markers, and headphones.[41] For those uses that still required rare earth magnets, firms reduced the proportion of both neodymium and dysprosium in the magnet alloys.[42] For example, both Hitachi and a joint venture of Mitsubishi, Daido Steel, and Molycorp built factories in Japan to produce new types of low-dysprosium magnets.[43]

Aggregate statistics show the change in Japanese demand for REE (Table 2). Total demand fell by 20.9% year-on-year (YoY) from 2010 to 2011, and an additional 31.4% YoY between 2011 and 2012. As the table shows, the extent of demand reduction varied by element. The industry association noted that, when normalizing measurement on an oxide basis, total demand for REE fell by 60% between 2008 and 2013, with demand for nickel hydrate remaining stable (the 'metal' used in nickel-metal-hydride batteries particularly involves the rare earth element lanthanum), but demand for cerium (used for glass polishing) falling by 75%, neodymium and dysprosium (used in magnets) falling 70%, yttrium (used in fluorescent lighting) falling by 60%, and lanthanum (not in its nickel hydrate form) falling by 40%.[44]

Did Chinese sanctions succeed?

China's ability to impose costs on Japan in 2010 did not yield a major commercial or political victory. Commercially, non-Chinese REE mining increased; meanwhile, many rare-earths users reduced their need for REE, though other users built factories for downstream rare earth products (e.g., magnets) in China to alleviate the risk of future Chinese export restrictions. Politically, while China seemingly 'won' the 2010 confrontation with Japan, it actually achieved very little.[45] The release of the fishing boat captain was a tactical victory with little strategic effect: Japan still administers the disputed islands and has not slackened its diplomatic and legal defense of its claims.[46]

Following the causal pathway, adjustment to market structure limited the political effect of the sanctions. The target decision-makers foresaw that increases in non-Chinese REE supplies would undermine China's leverage; that administrative difficulties in China would undercut the effectiveness of the suspension of exports; and that real-time adjustments in the market would circumvent the embargo – all of that even though the market structure in rare earths at the time of the embargo appeared to be a best-case situation for sanctions effectiveness. Overall, the sanctions episode demonstrates the causal mechanisms through which sanctions targets act to limit sanctions' effectiveness: the rare earths sanctions episode is a pathway case that shows the causal process of adjustment that shifts the market structure to mitigate the economic impact of imposed sanctions.

Implications

The market response in rare earths offers lessons about the challenges of achieving international political goals using economic sanctions. Few sanctions episodes are likely to seem as perfectly orchestrated to make the target vulnerable as the 2010 rare earth episode: in other cases, trade between the sender and the target may be dominated by prosaic products or commodities with diffuse rather than concentrated supply and demand. But even in a best-case scenario for a sanctions sender – China's near-monopoly supply of rare earth elements, the demand for which was concentrated in the country that China wanted to target with its economic sanction, and the inflexible need for which was recognized by the target's political leaders – the problem faded.

Table 2. Rare earth consumption in Japan, 1998–2012 (tons).[49]

	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Yttrium	380	400	520	360	380	500	500	1000	1600	1750	1670	580	1500	1300	800
Europium	15	16	20	14	15	15	14	14	40	40	44	18	35	30	20
Lanthanum	760	800	900	600	700	900	1000	1800	2200	3300	3300	2450	3850	3200	2000
Cerium	5500	6000	7000	6000	6000	5500	5700	10300	14800	16100	16100	9300	11500	7200	5200
Mix metal	1200	1400	2000	1300	1200	1200	1700	2400	2800	2900	2800	3200	3200	2950	3350
Samarium	200	200	200	120	120	120	100	100	100	100	100	70	80	80	80
Neodymium/Didymium	2000	2300	2700	1800	1900	2100	2700	5700	6500	7100	7000	4200	5500	5500	2500
Others	295	310	350	280	290	320	350	1000	1000	1100	1050	700	1000	820	520
Total	10350	11426	13690	10474	10605	10655	12064	22314	29040	32390	32064	20518	26665	21080	14470
YoY change	6.0%	10.0%	20.0%	−23.0%	1.3%	0.5%	13.2%	85.0%	30.1%	11.5%	−1.0%	−36.0%	30.0%	−20.9%	−31.4%

Source: Shinginzokukyokai.

Some supply and demand adjustments had rapid effects, while others took longer. In the short term, recycling and substitution dramatically reduced demand, and smuggling, trade deflection, inventory management, and other adjustments ensured residual supply. In the medium term, innovations in magnet design and other rare-earth applications reduced demand and changed its elasticity. Even long-term adjustments like opening new mines influenced the 2010 crisis dynamics. Business and government leaders anticipated the vulnerability that concentrated rare earths supply entailed and started adaptation efforts before China imposed its 2010 embargo. Through the combination of adjustment efforts on different time scales, both sender and target concentration changed in the rare-earth sector, reducing the vulnerability and taking rare earths from an almost ideal case for expected sanctions success to a much less threatening economic sector – though one that as of 2019 the US and Chinese governments still considered a potential lever in a trade war.[47]

This finding has important implications for research on economic sanctions. The rare-earth embargo case shows that future research needs to carefully measure not only the size of the trade disruption but also market structure and dynamics to assess the effectiveness of economic sanctions. The causal pathway works as most theorists surmise: the costs that sanctions impose on a target and the benefits to the target of continuing the behavior that precipitated the sanctions are important to explaining the outcomes of sanctions episodes. However, a key conditioning variable, market structure, powerfully influences the cost that sanctions can inflict on their target, and market structure adjusts through a complex causal pathway at multiple time scales and on both the supply and demand sides of the market. The role of market structure in conditioning sanctions effectiveness, including for financial sanctions and other forms of targeted sanction, thus requires attention to detail beyond what has been included in past studies of sanctions effectiveness.

Notes

1. Farmer (2000) considers these factors in estimating the cost that a sender pays by imposing sanctions.
2. The codebook is available at http://www.unc.edu/~bapat/tiesusersmanualv4.pdf. It is not clear from the codebook whether "anticipated costs" refers to costs anticipated by participants in the sanctions episode themselves or to the coder's estimate of what the imposed costs would have been.
3. Van Bergeijk and Siddiquee (2017) discuss other aspects in which lack of transparency in the Hufbauer et al. dataset causes difficulties for sanctions research.
4. Those additional industries would then also be forced to adjust, and we would argue that the size of the cost imposed on the target country would depend on the market structure and dynamics of the additional sectors – following the same causal logic that we discuss in the sectors initially disrupted in the sanctions episode.
5. One straightforward way to measure this concentration is the Herfindahl-Hirschman Index (HHI) (Hughes & Long, 2015; Silberglitt, Bartis, Chow, An, & Brady, 2013).
6. This kind of reallocation famously took place in response to disruptions in oil markets, including the 1973 Arab oil embargo (Griffin, 2015).
7. The primary sanctions sender's ability to use secondary sanctions to force alternative suppliers to cooperate – that is, the sender's ability to increase effective sender or target concentration – also depends on the cost-benefit logic of sanctions effectiveness. We argue that scholars should use the same three explanatory variables

and study the same causal dynamics in studies of cases that involve secondary sanctions as describe here in the simpler case where one sender sanctions one target.

8. Trade deflection and smuggling may be muted in multilateral sanctions episodes because the target might struggle to find substitute trading partners or to get neighboring governments to tacitly cooperate with smuggling. Slavov (2007) found negative effects on sanctions targets' neighbors' trade volumes in a study of seven post-Cold War UN-initiated sanctions episodes. On the other hand, Chen & Garcia (2016) document extensive trade deflection, smuggling, and other types of sanctions busting that limited the impact of the unilateral Chinese sanction on Norwegian salmon exports starting in 2010. Unilateral (or minilateral) sanctions are more common than truly multilateral ones, so it is worth studying the adjustment dynamics to unilateral sanctions. Clarifying the causal pathways of economic adjustment might also help build the case for multilateral sanctions.
9. We follow Van Evera (1997, pp. 11–13)'s recommendation for drawing arrow diagrams of theories that show their causal mechanism, with the multiplication symbol used to show a condition variable that "govern[s] the size of the impact that IVs or intVs [independent variables or intervening variables] have on the DVs [dependent variables] or other intVs."
10. In the future, researchers could build large-n datasets that include variables for sender concentration, target concentration, and target elasticity in the particular economic sectors involved in sanctions episodes.
11. See Shunsuke Tabeta, "Chugoku no rea aasu, tainichi yushutsu todokoru, nicchu seifu kinyu hitei, [Chinese Rare Earth Exports to Japan Stagnate: Japanese and Chinese Governments Deny Embargo]" *Nihon Keizai Shimbun*, September 23, 2010. The same newspaper explicitly linked the territorial dispute over the Senkaku Islands with the rare earths embargo. Yasuhiko Futoda, "Rea aasu ha doro ka takara ka: chugoku gaiko no buki no seitai [Rare Earths: Mud or Treasure: The Real Face of the Weapon of Chinese Foreign Policy]," *Nihon Keizai Shimbun*, September 26, 2018.
12. "Chugoku: "Rea aasu, taiko shudan ni tsukawazu" Senkaku Jiken go [China: "Rare Earths Not Used as Retaliation" Following Senkaku Incident]" *Nihon Keizai Shimbun* 15 October, 2010. The Chinese government's denial has led Iain Johnston to question whether the alleged rare earths incident should even count as a sanction's episode (Johnston, 2014). Japanese customs data, measured at the ports where rare earths enter Japan, showed 'no obvious pattern' of changes, while Johnston suggests that a Chinese embargo should have led to systematic drops of all kinds of rare earth arrivals at all ports. But the normal volume of trade in rare earths is quite small, and even a small ship with a cargo partially composed of rare earths smuggled out of China would be sufficient to account for deliveries that satisfied a substantial fraction of normal Japanese demand. We believe China in fact tried to interrupt REE exports and that China made resumption of rare earth exports contingent on Japan's acquiescence to a political demand – that is, that the episode was an economic sanction. Chen & Garcia (2016) discuss similar evidence regarding the China-Norway salmon sanctions episode, along with a possible theoretical explanation for China's 'subtle' sanctions. For purposes of examining the causal pathways of target adjustment and decision-making, it matters much more that the Japanese *thought* that they were facing an economic sanctions episode; determining whether in fact China intended to sanction Japan is less relevant.
13. "Jisshitsuteki na kinyu sochi [Voluntary emergency measures]". Rare Earth Elements Committee, Japan Society of Newer Metals, "Rea aasu sangyo ga chokumen shita mondai to sono taio [Issues Faced by Rare Earth Elements Industry, and Response]" Presentation to Mining Subcommittee, Resources and Fuels Committee, Energy Research Council, Ministry of Economy, Trade, and Industry. 5 June, 2014, p. 3.
14. Official from Non-Ferrous Metals Bureau, Ministry of Economy, Trade, and Industry. Interview with authors. 13 March 2014. This assessment was independently noted by a reporter who covered the sector for the major Japanese business daily, the *Nihon Keizai Shimbun*. He noted that the Chinese central government always faces difficulties implementing central orders so it was unsurprising that different customs

houses responded differently, but he asserted that it was clear that at the time of the Senkaku Incident there was a central government order. Reporter from *Nihon Keizai Shimbun*, interview with authors, 14 March 2014.

15. Officials from Ministry of Foreign Affairs, Interview with Authors, 14 March 2014.
16. Martin Fackler and Ian Johnson, "Japan Retreats in Test of Wills with the Chinese," *New York Times*, September 25, 2010, p. A1.
17. Kaeda Keizaisho, "Rea aasu mondai 'keizai seicho no ookina shogai ni' [The Rare Earths Problem will be a 'Large Impediment to Economic Growth']" *Nihon Keizai Shimbun*, September 24, 2010.
18. The tonnage of material processed in a rare earth operation is tiny compared to the amount involved in better-known mining industries like iron ore and coal. Interview with rare earth expert Dudley Kingsnorth, Perth, Australia, October 2015.
19. China's mining dominance stemmed from a combination of low labor costs, relatively lax environmental regulation, and the fact that China's biggest rare-earth mine also produces iron ore, providing another revenue stream to help cover the mine's fixed costs. Ted Niles, "Western Rare Earth Discoveries May Just Feed China," *Financial Post*, February 9, 2012.
20. Hiroko Tabuchi, "Block on Minerals Called Threat to Japan's Economy," *New York Times*, September 29, 2010, p. B1; Rare Earth Elements Committee, Japan Society of Newer Metals, "Rea Aasu Sangyo ga chokumen shita mondai to sono taio [Issues Faced by Rare Earth Elements Industry, and Response]" Presentation to Mining Subcommittee, Resources and Fuels Committee, Energy Research Council, Ministry of Economy, Trade, and Industry. 5 June 2014.
21. Development Bank of Japan, "Rea aasu no jukyu doko to gijutsu rikkoku ni muketa kadai [Supply and Demand Changes for Rare Earths, and Issues related to becoming a Technology Leader]" *Kongetsu no Toppikusu* No. 169-1, Development Bank of Japan 20 December 2011. Available at: http://www.dbj.jp/pdf/investigate/mo_report/0000008822_file5.pdf (accessed April 22, 2017).
22. Another way to describe the combination of high sender concentration and high target concentration would be a situation of symmetry or mutual dependence. One might presume that if China depends on selling REE to Japan and cannot readily send the REE to any other market, then the cost of imposing the REE sanction would be high to China. However, that fact would be unlikely to change the expected effectiveness of the sanction: by imposing the sanction, China accepted the costs (revealed preference), and Japan was confronted with the decision of whether to comply with China's demand so that Japan would stop bearing *its* cost of the disruption. It is possible that the high cost to the sender would tempt the target to turn the sanctions episode into a "war of attrition," where the target would refuse to concede, draw out the episode, and hope that the cost to the sender would lead the sender to back down first (van Bergeijk & van Marrewijk, 1995). Such an extended episode would actually aid our "pathway case" research design by providing more opportunity to observe market dynamics.
23. "Rea aasu ha, saisei enerugii nado no wagakuni no sentan sangyo ni fukaketsu na genso de aru ga, chugoku no yushutsu seisai sochi no kyoka ni kiin suru kyokyu risuku no kenzaika no keiken wo fumae, arata na kyokyugen no kakuho ga motomerarete iru tokoro de aru." JOGMEC, *Rea aasu taisekibutsu no shigen potensharu hyoka hokokusho* [Report on the Resource Potential of Rare Earth Deposits], 6 July, 2016.
24. Nihon no rea aasu seisaku to WTO teiso [Japan's Rare Earths Policy and the WTO Case]," *Kaikanko Senryaku Kenkyu* vol. 5, no. 2 (2015), pp. 119–122.
25. Manuel Quiñones, "'Sick Industry' Struggles to Take on China," *E&E News*, September 9, 2015.
26. Author interviews with rare earth traders and consumers, Tokyo, March 2014.
27. Glenda Korporaal, "Lacaze Puts Struggling Lynas Back on Track," *The Australian*, May 17, 2016; Jeff Yoders, "Rare Earths MMI: Japanese Investors Save Lynas Corp." *MetalMiner*, November 8, 2016, https://agmetalminer.com/2016/11/08/rare-earths-mmi-japanese-investors-save-lynas-corp/ (accessed March 14, 2017).

28. Peg Brickley, "Mountain Pass Rare Earths Mine Gets Financing," *Wall Street Journal*, August 31, 2016; Timothy Puko, "Prized 'Rare Earth' Minerals Feel Scorch of Tariffs," *Wall Street Journal*, November 29, 2018.
29. Eugene Gholz, "The Rare Earths Industry Can Weather Any Chinese Trade Battle," *CNN Business Perspectives*, July 23, 2019.
30. Rare metals manager of a major Japanese trading house, interview with authors, 10 March 2014.
31. The Japanese government's stockpiling program includes the 17 rare earth elements as a specialized category within the 31 types of rare metals. It does not stockpile all of the metals that it monitors in the program, and it is not clear from public documents that the Japanese government had a rare earths stockpile at the time of the crisis in 2010, nor that it has one today.
32. Managers at a Japanese rare earth manufacturer, interview with authors, 12 March 2014. Sprecher (2016, pp. 89–91) reports a similar inventory expansion at Santoku, a major Japanese rare earths company that had stored a one-year supply of grinding waste from magnet manufacture to recycle into new magnets – a process that was immediately technically feasible but not economically profitable at precrisis prices. Rather than tapping the inventory, Santoku's customers demanded that Santoku expand it to two years' supply during the crisis.
33. Interview with rare earth mine executive, January 2015; Rare Earth Elements Committee, Japan Society of Newer Metals, "Rea aasu sangyo ga chokumen shita mondai to sono taio [Issues Faced by Rare Earth Elements Industry, and Response]" Presentation to Mining Subcommittee, Resources and Fuels Committee, Energy Research Council, Ministry of Economy, Trade, and Industry. 5 June, 2014, p. 4.
34. "Lynas Triples Production," *Kalgoorlie Miner*, January 9, 2014, p. 10.
35. Akiko Fujita, "US Mine Aims to Loosen China's Grip on Rare Earth Materials," *Yahoo Finance*, May 30, 2019.
36. Peter Ker, "Rare earths miner Lynas Corporation posts $78.5m half-year profit," *Australian Financial Review*, March 5, 2018; Michael Bailey, "China rare earth quota cut to help ASX producers," *Australian Financial Review*, April 29, 2018.
37. Yoshitaka Taniguchi, "Rea aasu wo meguru chugoku no senryaku to nihon no taio [Rare Earth Elements, Chinese Strategies and Japanese Responses]", International Energy Economics Japan, 25 October, 2012, p. 9.
38. Rare Earth Elements Committee, Japan Society of Newer Metals, "Rea aasu sangyo ga chokumen shita mondai to sono taio [Issues Faced by Rare Earth Elements Industry, and Response]" Presentation to Mining Subcommittee, Resources and Fuels Committee, Energy Research Council, Ministry of Economy, Trade, and Industry. 5 June, 2014, p. 4.
39. "Nihon kokunai de rea aasu kaku genso no daitai ya shoshigenka no kenkyu kaihatsu ga ikki ni susumi, kyokyutozetsu risuku wo teigen saseru koka ha atta. Ippo, ichibu no rea aasu ni tsuite ha, heiji ni modotte kara mo juyo ha kaifuku sezu, jukyu baransu ga akka shite iru." Rare Earth Elements Committee, Japan Society of Newer Metals, "Rea aasu sangyo ga chokumen shita mondai to sono taio [Issues Faced by Rare Earth Elements Industry, and Response]" Presentation to Mining Subcommittee, Resources and Fuels Committee, Energy Research Council, Ministry of Economy, Trade, and Industry. 5 June, 2014, p. 10.
40. "Nihon kakuchi de rea aasu shiyo sakugen wo tema to shita jigyo ga jikko sare, sono hotondo ga sakugen koka wo hatsugen suru jotai made itatte iru." Kazuhiko Komumura, "Rea aasu kiki wo hete, nihon no seizo gyokai ni mieta mono [What I Saw of Japan's Manufacturing Industry through the Rare Earths Crisis] NRI Public Management Review], vol. 123 (October 2013), p. 5.
41. Consumer products using rare earth magnets are listed in Hitachi Metals, LTD. and Hitachi Metals North America, LTD.'s Complaint under Section 337 of the Tariff Act of 1930, as Amended, filed with the US International Trade Commission in August 2012.
42. Interview with rare earth magnet producer executive, December 2013; Megan Geuss, "Toyota's New Magnet Won't Depend on Some Key Rare-Earth Minerals," *Ars Technica*, February 28, 2018.

43. "Hitachi Metals Reduces Rare-Earth Dysprosium in Electric-Motor Magnets," *Automotive Engineering Online*, April 5, 2013; John Kell, "Molycorp in Venture for Japan Facility," *Wall Street Journal*, November 30, 2011; Jim Witkin, "A Push to Make Motors with Fewer Rare Earths," *New York Times*, April 22, 2012, p. AU2. Other magnet manufacturers like Shin Etsu and Vacuumschmelze make similar products.
44. Rare Earth Elements Committee, Japan Society of Newer Metals, "Rea ga chokumen shita mondai to sono taio [Issues Faced by Rare Earth Elements Industry, and Response]" Presentation to Mining Subcommittee, Resources and Fuels Committee, Energy Research Council, Ministry of Economy, Trade, and Industry. 5 June, 2014, p. 9. Some demand changes can be attributed to factors other than innovation. The shift to LED lighting, for example, contributed to the fall in demand for yttrium separately from government and industry efforts to recycle or reduce the amount of yttrium used in fluorescent lighting.
45. It is also possible that the embargo failed because China did not really commit to it. We do not have access to evidence of the internal Chinese decision-making regarding the embargo, so we cannot assess China's level of effort or whether they view the episode as a success or a failure. We do know China ended the embargo upon return of the fishing boat captain—the proximate issue in the episode but not the long-run goal of changing in the status of the Senkaku Islands.
46. Japanese Ministry of Foreign Affairs, "Trends in Chinese Government and Other Vessels in the Waters Surrounding the Senkaku Islands, and Japan's Response," July 3, 2018, available at https://www.mofa.go.jp/region/page23e_000021.html; "Japan Coast Guard Seeks to Boost Response Time with New Bases for Large Patrol Ships," *Japan Times*, January 16, 2018.
47. Jason Rogers, David Stringer, and Martin Ritchie, "China Gears Up to Weaponize Rare Earths in Trade War," *Bloomberg*, May 28, 2019; Ernest Scheyder, "Exclusive: Pentagon Races to Track US Rare Earths Output Amid China Trade Dispute," *Reuters*, July 12, 2019.
48. Development Bank of Japan, "Rea aasu no jukyu doko to gijutsu rikkoku ni muketa kadai [Supply and Demand Changes for Rare Earths, and Issues related to becoming a Technology Leader]" *Kongetsu no Toppikusu* No. 169-1, Development Bank of Japan 20 December 2011. Available at: http://www.dbj.jp/pdf/investigate/mo_report/0000008822_file5.pdf (accessed April 22, 2017).
49. Data from Rare Earths Division, Japan Society for Newer Metals. Note that the original table lists "Neojim" (usually written as neodymium) and "Jijim" (usually written as "didymium," for a blend of neodymium and praseodymium used in magnet production).

Acknowledgments

The authors thank seminar participants at the Council on Foreign Relations, Hong Kong University, the American Political Science Association annual meeting, and their home institutions, and two anonymous reviewers, for comments on previous versions of this paper. None of those commenters are responsible for any of the content.

Funding

Eugene Gholz also thanks the University of Texas at Austin's Edward A. Clark Center for Australia and New Zealand Studies and the LBJ School of Public Affairs' Policy Research Institute for their support of his research travel related to this project. Neither organization had any influence on the analysis, the writing of the article, or the decision about where and when to submit the manuscript for publication.

ORCID

Eugene Gholz http://orcid.org/0000-0002-5320-7684
Llewelyn Hughes http://orcid.org/0000-0002-8352-2693

References

Afesorgbor, S. K. (2019). The impact of economic sanctions on international trade: How do threatened sanctions compare with imposed sanctions? *European Journal of Political Economy*, *56*, 11–26. doi:10.1016/j.ejpoleco.2018.06.002

Arnold, A. (2016). The true costs of financial sanctions. *Survival*, *58*(3), 77–100. doi:10.1080/00396338.2016.1186981

Bapat, N. A., Heinrich, T., Kobayashi, Y., & Morgan, T. C. (2013). Determinants of sanctions effectiveness: Sensitivity analysis using new data. *International Interactions*, *39*(1), 79–98. doi:10.1080/03050629.2013.751298

Bayard, T., & Elliott, K. (1992). Aggressive unilateralism and Section 301: Market opening or market closing? *The World Economy*, *15*(6), 685–706. doi:10.1111/j.1467-9701.1992.tb00545.x

Binnemans, K., Jones, P. T., Blanpain, B., Van Gerven, T., Yang, Y., Walton, A., & Buchert, M. (2013). Recycling of Rare Earths: A Critical Review. *Journal of Cleaner Production*, *51*, 1–22. doi:10.1016/j.jclepro.2012.12.037

Bleiwas, D. I., & Gambogi, J. (2013). *Preliminary estimates of the quantities of rare-earth elements contained in selected products and in imports of semimanufactured products to the United States*, 2010 (U.S. Geological Survey Open-File Report 2013–1072). Reston, VA: U.S. Geological Survey.

Brooks, R. (2002). Sanctions and regime type: What works and when? *Security Studies*, *11*(4), 1–50. doi:10.1080/714005349

Chen, X., & Garcia, R. J. (2016). Economic sanctions and trade diplomacy: Sanction-busting strategies, market distortion and efficacy of China's restrictions on Norwegian Salmon imports. *China Information*, *30*(1), 29–57. doi:10.1177/0920203X15625061

Drezner, D. W. (1999). *The sanctions paradox: Economic statecraft and international relations*. Cambridge, UK: Cambridge University Press.

Drezner, D. W. (2000). Bargaining, enforcement, and multilateral sanctions: When is cooperation counterproductive? *International Organization*, *54*(1), 73–102. doi:10.1162/002081800551127

Drezner, D. W. (2003). The hidden hand of economic coercion. *International Organization*, *57*(3), 643–659. doi:10.1017/S0020818303573052

Drezner, D. W. (2015). Targeted sanctions in a World of Global Finance. *International Interactions*, *41*(4), 755–764. doi:10.1080/03050629.2015.1041297

Early, B. R. (2015). *Busted sanctions: Explaining why economic sanctions fail*. Palo Alto, CA: Stanford University Press.

Eaton, J., & Engers, M. (1999). Sanctions: Some simple analytics. *American Economic Review*, *89*(2), 409–414. doi:10.1257/aer.89.2.409

Elliott, K. A. (1998). The sanctions glass: Half full or completely empty? *International Security*, *23*(1), 50–65. doi:10.2307/2539262

Elliott, K. A., & David Richardson, J. (1997). Determinants and effectiveness of "aggressively unilateral" U.S. trade actions. In R. C. Feenstra (Ed.), *The effects of U.S. trade protection and promotion policies* (pp. 215–243). Chicago, IL: University of Chicago Press.

Escribà-Folch, A., & Wright, J. (2010). Dealing with tyranny: International sanctions and the survival of authoritarian rulers. *International Studies Quarterly*, *54*(2), 335–359. doi:10.1111/j.1468-2478.2010.00590.x

Farmer, R. D. (2000). Costs of economic sanctions to the sender. *The World Economy*, *23*(1), 93–117. doi:10.1111/1467-9701.00264

Farrell, H., & Newman, A. L. (2019). Weaponized interdependence: How global economic networks shape state coercion. *International Security*, *44*(1), 42–79. doi:10.1162/isec_a_00351

Gerring, J. (2007). Is there a (viable) crucial-case method? *Comparative Political Studies*, *40*(3), 231–253. doi:10.1177/0010414006290784

Gholz, E. (2014). *Rare earth elements and national security*. New York, NY: Council on Foreign Relations.

Griffin, J. M. (2015). Petro-nationalism: The futile search for oil security. *The Energy Journal*, *36*(SI), 25–41. doi:10.5547/01956574.36.SI1.jgri

Hamermesh, D. S., & Pfann, G. A. (1996). Adjustment costs in factor demand. *Journal of Economic Literature*, *34*(3), 1264–1292.

Hiscox, M. J. (2001). Class versus industry cleavages: Inter-industry factor mobility and the politics of trade. *International Organization*, *55*(1), 1–46. doi:10.1162/002081801551405

Hufbauer, G. C., Schott, J. J., Elliott, K. A., and Oegg, B. (2007). *Economic sanctions reconsidered* (3rd ed.). Washington, DC: Institute for International Economics.

Hughes, L. (2014). *Globalizing oil: The politics of oil market governance in France, Japan, and the United States*. Cambridge, UK: Cambridge University Press.

Hughes, L., & Long, A. (2015). Is there an oil weapon? Security implications of changes in the structure of the international oil market. *International Security*, *39*(3), 152–189. doi:10.1162/ISEC_a_00188

Humphries, M. (2012). *Rare earth elements: The global supply chain (CRS report for congress R41347)*. Washington, DC: Government Printing Office.

Hurst, C. (2010). *China's rare earth elements industry: What can the West learn?* Washington, DC: Institute for the Analysis of Global Security.

Johnston, A. I. (2014). How new and assertive is China's new assertiveness? *International Security*, *37*(4), 7–48. doi:10.1162/ISEC_a_00115

Kaempfer, W. H., & Lowenberg, A. D. (1988). The theory of International Economic Sanctions: A public choice approach. *American Economic Review*, *78*(4), 786–793.

Kirshner, J. (1997). The microfoundations of economic sanctions. *Security Studies*, *6*(3), 32–64. doi:10.1080/09636419708429314

Krueger, A. O. (1997). Problems with overlapping free trade areas. In T. Ito and A. O. Krueger (Eds.), *Regional versus multilateral trade arrangements* (pp. 9–23). Chicago, IL: University of Chicago Press.

Lee, J.-W., & Gray, K. (2017). Cause for optimism? Financial sanctions and the rise of the Sino-North Korean border economy. *Review of International Political Economy*, *24*(3), 424–453. doi:10.1080/09692290.2017.1301977

Major, S. (2012). Timing is everything: Economic sanctions, regime type, and domestic instability. *International Interactions*, *38*(1), 79–110. doi:10.1080/03050629.2012.640253

Mancheri, N. A., & Marukawa, T. (2016). *Rare earth elements: China and Japan in industry, trade, and value chain*. Tokyo: University of Tokyo.

Martin, L. L. (1993). Credibility, costs, and institutions: Cooperation on economic sanctions. *World Politics*, *45*(3), 406–432. doi:10.2307/2950724

McLean, E. V., & Radtke, M. T. (2018). Political relations, leader stability, and economic coercion. *International Studies Quarterly*, *62*(2), 357–370. doi:10.1093/isq/sqy008

Morgan, T. C., Bapat, N., & Krustev, V. (2009). The threat and imposition of economic sanctions, 1971–2000. *Conflict Management and Peace Science*, *26*(1), 92–110. doi:10.1177/0738894208097668

Morgan, T. C., Bapat, N., & Kobayashi, Y. (2014). Threat and imposition of economic sanctions 1945–2005: Updating the TIES dataset. *Conflict Management and Peace Science*, *31*(5), 541–518. doi:10.1177/0738894213520379

Nooruddin, I. (2002). Modeling selection bias in studies of sanctions efficacy. *International Interactions*, *28*(1), 59–75. doi:10.1080/03050620210394

Nooruddin, I., & Payton, A. L. (2010). Dynamics of influence in international politics: The ICC, BIAs, and economic sanctions. *Journal of Peace Research*, *47*(6), 711–721. doi:10.1177/0022343310381854

Odell, J. S. (2001). Case study methods in international political economy. *International Studies Perspectives*, *2*(2), 161–176. doi:10.1111/1528-3577.00047

Packey, D. J., & Kingsnorth, D. (2016). The impact of unregulated ionic clay rare earth mining in China. *Resources Policy*, *48*, 112–116. doi:10.1016/j.resourpol.2016.03.003

Pape, R. A. (1997). Why economic sanctions do not work. *International Security*, *22*(2), 90–136. doi:10.1162/isec.22.2.90

Peksen, D., & Peterson, T. M. (2016). Sanctions and alternate markets: How trade and alliances affect the onset of economic coercion. *Political Research Quarterly*, *69*(1), 4–16. doi:10.1177/1065912915620049

Plümper, T., Troeger, V., & Neumayer, E. (2016). *Case selection and the validity of causal inferences in qualitative comparative research*. Unpublished manuscript. Vienna, Austria: Department of Socioeconomics, Vienna University of Economics and Business.

Samuels, R. J. (2013). *3.11: Disaster and change in Japan*. Ithaca, NY: Cornell University Press.

Seaman, J. (2012). *Rare earths and the East China Sea: Why hasn't China embargoed shipments to Japan? (Op-ed Series)*. Paris and Tokyo: Institut Français Des Relations Internationales and Canon Institute for Global Studies.

Silberglitt, R., Bartis, J. T., Chow, B. G., An, D. L., & Brady, K. (2013). *Critical materials: Present danger to U.S. manufacturing*. Santa Monica, CA: RAND Corporation.

Slavov, S. T. (2007). Innocent or not-so-innocent bystanders: Evidence from the gravity model of international trade about the effects of UN sanctions on neighbour countries. *The World Economy*, *30*(11), 1701–1725. doi:10.1111/j.1467-9701.2007.01026.x

Smith, A. (1995). The success and use of economic sanctions. *International Interactions*, *21*(3), 229–245. doi:10.1080/03050629508434867

Sprecher, B. (2016). *When materials become critical: Lessons from the 2010 rare earth crisis* (Doctoral dissertation). University of Leiden, The Netherlands.

Sprecher, B., Daigo, I., Murakami, S., Kleijn, R., Vos, M., & Kramer, G. J. (2015). Framework for resilience in material supply chains, with a case study from the 2010 rare earth crisis. *Environmental Science & Technology*, *49*(11), 6740–6750. doi:10.1021/acs.est.5b00206

Tostensen, A., & Bull, B. (2002). Are smart sanctions feasible? *World Politics*, *54*(3), 373–403. doi:10.1353/wp.2002.0010

U.S. Department of Energy. (2011). *Critical materials strategy*. Washington, DC: U.S. Department of Energy. doi:10.2172/1000846

Van Bergeijk, P. A. G., & Siddiquee, M. S. H. (2017). Methodological change and bias in economic sanctions reconsidered. *International Interactions*, *43*(5), 879–893. doi:10.1080/03050629.2016.1242584

van Bergeijk, P. A. G., & van Marrewijk, C. (1995). Why do sanctions need time to work? Adjustment, learning, and anticipation. *Economic Modelling*, *12*(2), 75–86. doi:10.1016/0264-9993(94)00003-N

Van Evera, S. (1997). *Guide to methods for students of political science*. Ithaca, NY: Cornell University Press.

Wilson, J. D. (2018). Whatever happened to the rare earths weapon? Critical materials and international security in Asia. *Asian Security*, *14*(3), 358–373. doi:10.1080/14799855.2017.1397977

Zeng, K. (2002). Trade structure and the effectiveness of America's "Aggressively Unilateral" trade policy. *International Studies Quarterly*, *46*(1), 93–115. doi:10.1111/1468-2478.00224