Natural Security Index for the United States and China

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Introduction

The goal of the Natural Security Index is to quantify the importance of bilateral trade relationships to the national security of the United States and China, with a focus on key natural resources. It provides a contemporaneous snapshot of countries' natural resource, military, diplomatic, and soft-power relationships, and functions as a means of comparison between states' military alignments, their international objectives as represented through formal posturing, and organic relationships of their citizenry and economies.

We create this index with an eye towards understanding the effects of two major trends in global resource security: climate change and increasing U.S.-China tensions. The Natural Security Index intends to give us a reference point to understand the underpinnings of trade and natural resource relationships, and which are likely to be less or more essential to the U.S. and China.

Background

Climate change is likely to be a major source of destabilization in the international system. By impacting agricultural productivity and displacing traditional livelihoods, climate change has the potential to substantially alter the systems that humans depend on to survive. Combating this will require mitigation and adaptation strategies that influence the consumption and production of natural resources ranging from critical minerals to agriculture and water. Because we live in a hyperconnected world, with nations on one side of the globe relying on others for vital resources from oil to soy, trade relations between and amongst states will undoubtedly change as well. Changing rainfall patterns may remove once productive agricultural land while northern latitudes will see longer growing seasons, but one factor will remain the same; humans will demand food and water. In other words, nations that are at present self-sufficient or otherwise secure in their natural resource consumption may no longer have that advantage.

Because the U.S. and China are two of the world's largest consumers and producers of natural resources, capturing the dynamics of each nation's natural security—the intersection of prosperity, security, and natural resources, a condition of reliable, affordable, and sustainable access to sufficient natural resources for short and long-term stability and prosperity—can lend insights into how climate change may alter global resource trade. With the two agricultural and industrial behemoths locked in what the U.S. National Defense Strategy refers to as "long-term strategic competition," understanding existing resource relationships as well as how climate change may influence those relationships is a step toward ensuring the U.S. does not suffer from "reduced access to markets that will contribute to a decline in our prosperity and standard of living."[1] Additionally, reduced access to a free and fair market could greatly hamper any nation's ability to compete geopolitically. The Natural Security Index can help identify where the U.S.-China strategic competition is likely to playout, and which instruments of statecraft each nation utilizes for specific relationships.

Lithium and cobalt are striking examples because they are geographically concentrated in production, making relationships with the countries that are endowed with these minerals of paramount importance to a greening economy. Demand for lithium and cobalt is increasing and will likely continue to do so in order to store energy and make the batteries that fuel the electric vehicle industry. In fact, between 1997 and 2017 global mine production of lithium and cobalt increased by over 20 percent each. China is already investing in close relations with the Democratic Republic of the Congo (where 60 percent of the world's cobalt is mined), having financed large infrastructure projects to aid in extracting and transporting resources. The same is true for China's relationship with Australia, where China's Tianqi Lithium Corporation purchased a majority stake in Talison Lithium, the company with the rights to Australia's Greenbushes Lithium mine and processing facilities.

Lithium and cobalt are but two examples in a long list of resources that are included in the index in order to capture a more holistic view of international resource relationships. Other policies may include anything ranging from subsidies for the agriculture and mining industries, protectionist tariffs, or frantic stockpiling that exacerbates supply chain disruptions. All of these policies have implications for international trade and geoeconomics more generally. Thus, having an idea of the ways that climate change can influence state behavior in the natural resource space is inherently beneficial when it comes to planning for long-term strategic competition. Likewise, given that China's Ministry of Land and Natural Resources and the U.S. Defense Logistics Agency's (DLA) Strategic Materials ascribe strategic importance to many of the same minerals, there are clear national security implications, as well.

Existing research focuses on import reliance for resources that are geographically concentrated in production, but falls short of capturing the competitive space dynamics of resource security. The global scope and overall structure of the Natural Security Index, however, quantifies bilateral resource relationships in a meaningful way while taking other non-resource indicators into account.

Methodology

Indicator selection

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[1] United States Department of Defense, Summary of the 2018 National Defense Strategy of The United States of America: Sharpening the American Military's Competitive Edge, [Washington DC, 2018]. https://dod.defense.gov/Portals/1/Documents/pubs/2018-National-Defense-Strategy-Summary.pdf.

The Natural Security Index has two main components, *Resource Dependence* and *National Power*, comprised of seven sub-categories: *Energy*, *Food*, *Commodity Metals*, and *Strategic Minerals* under Resource Dependence; *Military Coordination*, *Diplomacy*, and *Cultural and Economic Soft Power* under National Power. We selected indicators based on the following criteria:

- Relevance to U.S. and Chinese national security.
- Availability of contemporaneous bilateral data for the U.S. and China.
- Perceived accuracy of data, preferring indicators for which data is tracked over time from official sources or peer reviewed publications.
- Coverage, in that indicators capture variation between countries and regions.
- Consistency, in that indicators track the same underlying dynamics for both the U.S. and China.

Across all indicators, we attempt to capture the most recent available data: in this iteration, for the majority of indicators we use the 5-year period centered on 2015 (2013-2017). For the indicators which did not have data available for this period, we either use the most recent available period, or the most recent available single year.

We evaluated but ultimately decided not to include additional indicators beyond the ones included in the index. To minimize the complexity of the index, we sought to keep only the highest quality indicators in each category (by relevance, data availability, timeliness, coverage, and consistency).

Resource dependence indicators

Natural resources are the physical inputs into national economic engines. Countries both implicitly and explicitly seek to secure access to natural resources through state policy, trade partnerships, and direct purchases.

We measure the importance of natural resource relationships with four indicators, relating to four categories of natural resources: Energy, Food, Commodity Metals, and Strategic Minerals. For each resource, we measure the importance of the bilateral trade relationship as the portion of the importing country's consumption that is satisfied by imports. Greater dependence on trade to satisfy consumption results in a higher indicator score, as the loss of this trade would have greater impact on national economies or the ability to source critical minerals.

Within the Energy, Food, and Commodity Metals categories, we included resources that were traded internationally only if the total annual value of trade in that resource between 2013 and 2017 surpasses $20 billion. Within the Strategic Minerals category, we included resources that met at least three of the following criteria: (1) the United States and China depend on imports to meet domestic consumption; (2) the resource is identified by the U.S. Defense Logistics Agency (DLA)[2] as a strategic mineral for stockpiling, or by China's Ministry of Land and Natural Resources

[2] United States Defense Logistics Agency (DLA), *Strategic Materials* , https://www.dla.mil/HQ/Acquisition/StrategicMaterials/Materials/.

as a strategic mineral;[3] (3) the resource is a vital input for clean energy technologies as identified by The World Bank and the U.S. Department of Energy;[4] or (4) the resource is highly concentrated in production with an Herfindahl-Hirschman Index (HHI) of at least 1800.[5] However, some resources that matched our criteria for inclusion were excluded because we were unable to locate sufficient information to calculate trade dependence (Table A.1).

For each trade partner, we calculate a dependence ratio as the total imports for the given resource from that country divided by consumption. We then aggregate individual resource dependence ratios into four indicators corresponding to the four categories by averaging values.

Bilateral trade data by resource was sourced primarily from Chatham House's resourcetrade.earth database which aggregates international trade statistics from the UN Comtrade Database.[6] For China's trade in resources, we combine imports and exports to Hong Kong with those of mainland China as trade between Hong Kong and the mainland is often not fully recorded. For each resource, we matched import and export volumes (tonnage) from resourcetrade.earth with reported consumption, production, import and export volumes with other official sources (primarily the U.S. Geological Survey's National Minerals Information Center).[7] Several mineral commodities require conversion factors to be comparable. For example, antimony is often traded in its trioxide form (Sb_2O_3), but consumption and production are reported as tons of antimony content (83.5 percent by mass). Finally, for resources for which we were able to locate production, imports, and exports, but not consumption, we estimated consumption as *production + imports - exports.*

It should be noted that for most metals, we measure resource dependence in terms of trade in unwrought metals, rather than raw ore, as major statistics are reported in this way by USGS and other sources. This puts emphasis on countries with smelting and processing facilities, as opposed to the countries where the raw ore is mined. Nonetheless, these facilities are major capital investments that are unlikely to be rapidly replaced. One study estimated, for example, that since 2008 the largest U.S. rare earth mine in California required $500 million or more in pre-production financing, and this is a site with pre-existing infrastructure and a developed mine.[8]

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[3] Ministry of Land and Natural Resources of the People's Republic of China, China Mineral Resources 2017, http://g.mnr.gov.cn/201710/P020171017515944260115.pdf.

[4] The World Bank, *The Growing Role of Minerals and Metals for a Low Carbon Future*, [June, 2017], http://documents.worldbank.org/curated/en/207371500386458722/pdf/117581-WP-P159838-PUBLIC-ClimateSmartMiningJuly.pdf; see also United States Department of Energy, *Innovating Clean Energy Technologies in Advanced Manufacturing," in "Quadrennial Technology Review 2015*, [2015], https://www.energy.gov/sites/prod/files/2015/12/f27/QTR2015-6F-Critical-Materials.pdf; as well as World Economic Forum in collaboration with Bain & Company, *The Future of Electricity: New Technologies Transforming the Grid Edge*, [March 2017], http://www3.weforum.org/docs/WEF_Future_of_Electricity_2017.pdf.

[5] Federal Ministry for Sustainability and Tourism (Austria), *World Mining Data 2018*, http://www.world-mining-data.info/wmd/downloads/PDF/WMD2018.pdf.

[6] Chatham House [2018], 'resourcetrade.earth', http://resourcetrade.earth/.

[7] USGS National Minerals Information Center, https://www.usgs.gov/centers/nmic/mineral-commodity-summaries.

[8] David L. An, *Critical Rare Earths, National Security, and U.S.-China Interactions: A Portfolio Approach to Dysprosium Policy Design*, [RAND Pardee Graduate School, Dissertation, 2014], https://www.rand.org/content/dam/rand/pubs/rgs_dissertations/RGSD300/RGSD337/RAND_RGSD337.pdf.

Individual trade values for individual bilateral relationships should be taken with caution. Reported statistics may include errors, be misclassified, or may be rounded or withheld to avoid disclosing proprietary information. We attempt to overcome these limitations in two ways: First we average data over a five year period to minimize the effect of outliers. Second, where possible, we validate data across multiple sources, with the assumption that countries are unlikely to stockpile or deplete large volumes of commodities over a single year. For each resource, we calculate *estimated change in stock as production + imports - exports - consumption*. This serves as a rough accuracy measurement: for resources where this value is high relative to consumption it is more likely that there is error in reporting statistics. Notes on sources, commodity codes, conversion factors, and caveats for each individual resource are provided in Table A.1.

Military coordination

Our military coordination and diplomatic soft power indicators attempt to quantify where states are formally investing in building relationships.

We measure military coordination with two indicators: The number of combined military exercises involving both countries, and the volume of arms trade between countries divided by the importing country's total arms imports. Combined military exercises are high-investment endeavors that demonstrate countries' militaries' willingness and ability to work together. Arms trade indicates interdependency of military procurement and are often tightly controlled by national governments.

For combined military exercises for China, we use data from the National Defense University (NDU).[9] For the U.S., we use the list of combined military exercises published by The Bush School of Government and Public Service at Texas A&M University. The Bush School data serves as a starting point; we then turn to the Defense Visual Information Distribution Service (DVIDS) to gather a more full list of combined exercises.[10] We identified country participants for each exercise by searching public records and media reports for each exercise, each year. Since many military exercises occur on a biannual basis and the NDU dataset only covers through 2016, we use a 4-year period (2013-16) for both countries. Our list of U.S. combined military exercises, partners for each exercise, and sources are provided in Table A.2.

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[9] Kenneth Allen, Philip C. Saunders, and John Chen, "Chinese Military Diplomacy, 2003-2016: Trends and Implications," Center for the Study of Chinese Military Affairs, Institute for National Strategic Studies, National Defense University [July 2017], https://ndupress.ndu.edu/Portals/68/Documents/stratperspective/china/ChinaPerspectives-11.pdf?ver=2017-07-17-153301-093.

[10] Alaina Garret et al., "Exercises and Adversaries: The Risks of Military Exercises," The Bush School of Government & Public Service [2016], https://oaktrust.library.tamu.edu/bitstream/handle/1969.1/159129/Exercises%20and%20Adversaries.pdf?sequence=1&isAllowed=y; see also Defense Visual Information Distribution Service (DVIDS), https://www.dvidshub.net/.

We source arms trade data from the Stockholm International Peace Institute's (SIPRI) Arms Transfer Database.[11] We measure the importance of arms exports as a portion of the importing partner country's total arms imports averaged over the period 2013-17, under the assumption that countries that depend exclusively on the U.S. or China for arms are more likely to have a close military relationship with that country. We similarly normalize arms imports to the U.S. and China as a portion of total imports. The arms transfer indicator is the calculated average of imports and exports.

For both combined exercises and arms trade, it is likely that there are trades or exercises that are not publicly disclosed. In addition, for several U.S. military exercises, we were not able to locate documentation of participant countries.

Diplomatic soft power

We measure diplomatic coordination with two indicators: The voting agreement in the UN General Assembly (UNGA), and the volume of foreign aid as a portion of the recipient country's GDP. General Assembly voting is a means for countries to formally indicate their alignment. Official development assistance is a means for larger countries to both influence and aid others. For example, several studies suggest that foreign aid is correlated with UNGA voting alignment.[12]

We source UNGA voting records from Voten et al. (2019).[13] Since UNGA resolutions may be topically similar or repeated over time, we use Bailey et al.'s Ideal Point data which estimate annual relative voting positions as a function of each resolution's major topics and past voting records.[14] UNGA resolutions are often more symbolic than practical, and thus offer a measure of countries' willingness to demonstrate alignment on major issues.

We use foreign aid data for the U.S. from the U.S. State Department,[15] and overseas development assistance data aggregated by AidData for China.[16] Since the AidData dataset covers most recently though 2014, we use the period 2010-14 for both countries. We normalize aid by recipient country GDP,[17] under the assumption that donations that make up a larger portion of country budgets are more likely to influence the recipient country.

It is likely that less politically influential countries will choose to align with a major power in their voting. Similarly, by its nature, aid is biased towards small and developing countries, and is likely

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[11] Stockholm International Peace Research Institute (SIPRI), *Importer/Exporter TIV Cables*, http://armstrade.sipri.org/armstrade/page/values.php.
[12] Axel Dreher et al., "Does US Aid Buy UN General Assembly Votes? A Disaggregated Analysis," Public Choice 136, no. 1/2 [July 2008], pp. 139-164.
[13] Erik Voeten, Anton Strezhney, and Michael Bailey, "United Nations General Assembly Voting Data," (2019), https://dataverse.harvard.edu/dataset.xhtml?persistentId=hdl:1902.1/12379.
[14] Bailey, Michael A., Anton Strezhnev, and Erik Voeten, "Ideal Point Data," (2017), https://dataverse.harvard.edu/dataset.xhtml?persistentId=hdl:1902.1/12379.
[15] "Foreign Aid Explorer (FAE)," USAID, https://explorer.usaid.gov/data.
[16] AidData. 2017. Global Chinese Official Finance Dataset, Version 1.0., http://aiddata.org/data/chinese-global-official-finance-dataset.
[17] "GDP (current US$)," The World Bank, https://data.worldbank.org/indicator/ny.gdp.mktp.cd?view=map.

biased towards countries that have experienced severe disasters, wars, or other humanitarian crises. Since aid data is several years old, it is likely that donation patterns have changed over time.

Cultural and economic soft power

In addition to formal state relationships, we measure three indicators of cultural and economic soft power: total value of trade in goods and services, foreign direct investment, and number of students exchanged.

We measure total trade volume as the sum of the value of imports and exports from World Bank statistics.[18] Regardless of dependence on countries for individual resources, significant trade relationships will place countries as important international partners.

We source foreign direct investment (FDI) statistics for the U.S. from the U.S. Bureau of Economic Analysis (BEA).[19] For China, we use investment data from the American Enterprise Institute's (AEI) China Global Investment Tracker.[20] For both countries we use the four period (2014-17) due to data coverage constraints. We selected these sources for their coverage and recency, but we also note that these values are not directly comparable, as their definitions differ. In addition, they differ from other sources of FDI statistics, notably the International Monetary Fund's Coordinated Direct Investment Survey. China does not report outward FDI statistics to the IMF, and inward direct investment reported by recipient countries often differs from outward reported statistics. Some direct investment statistics may be withheld to protect proprietary data. Nonetheless they should give an indication of where U.S. and Chinese corporations are investing overseas.

Student exchange data are from the UN Educational, Scientific and Cultural Organization (UNESCO).[21] We evaluate both inward and outward student exchange. Student exchange gives an indication of countries soft power in attracting students, but is biased by country's willingness to accept foreign students.

While our formal diplomatic indicators are likely biased towards small and developing countries, these cultural and economic soft power indicators are implicitly biased towards major economies. Though these indicators do not directly capture mutual admiration, it is possible that such attitudes affect individual decisions around student exchange and business investment. They may also be biased by language differences.

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[18] The World Bank, *World Integrated Trade Solutions (WITS)*, https://wits.worldbank.org/WITS/WITS/Restricted/Login.aspx.

[19] United States Department of Commerce Bureau of Economic Analysis*, Direct Investment by Country and Industry*, [2017] https://www.bea.gov/data/intl-trade-investment/direct-investment-country-and-industry.

[20] American Enterprise Institute and Heritage Foundation, China Global Investment Tracker, http://www.aei.org/china-global-investment-tracker/.

[21] The United Nations Educational, Scientific and Cultural Organization, *Inbound and Outbound internationally mobile students by country of origin*, [UNESCO, 2017] http://data.uis.unesco.org/index.aspx?queryid=172.

Index scoring

We normalize and aggregate indicators to allow comparison between them. All indicators are mathematically transformed to a 0-10 scale, and averaged together to produce an overall score. As with the selection of indicators, normalizing and aggregating indicators is an inherently subjective process, and different choices will result in slightly different rankings in the aggregated scores.

We use two approaches to normalizing indicators. For indicators where raw values already represent a percentage or relative value, we normalize these on a linear scale with a maximum score threshold (1). For example, for each of the resources in the four resource dependence indicators, raw values range between 0-100% representing the portion of the U.S. or China's supply that is imported from that country. We normalize these values such that resource dependence of ≥25% receives the maximum score of 10, and values less than 25% scale linearly between 0-10.

(1) $$score = clamp(\,(raw\_value / max\_threshold), 0, 10\,)$$

The maximum score threshold for each indicator is selected based on the distribution of values and our intended meaning of the indicator. For resource dependence indicators, we select the 25% threshold under the assumption that a disruption of a relatively small percentage of supply can be economically disruptive. This slightly discounts situations in which the U.S. or China import more than 25% of their supply from one country, e.g. palm oil from Indonesia, while putting more emphasis on smaller import relationships. For arms exports, countries where 50% or more of their arms imports come from the U.S. or China receive a maximum score. For arms imports into the U.S. or China if at least 20% of the U.S. or China's arms imports originate from a country, that country receives the maximum score. We use different thresholds for imports and exports because arms imports have higher strategic importance. For foreign aid, countries for which U.S. or Chinese aid is at least 5% of their GDP receive the maximum score.

The remaining indicators are scored on an exponential scale relative to the combined range of values for both the U.S. and China. For each of these indicators, we clip (i.e. winsorize[22]) the range to ignore the 2.5% of the highest and lowest values to limit the effect of outliers on scores (2). For example, coordinated military exercises values range between 0 and 75, but the 97.5th percentile of values across both U.S. and China is 38. Countries for which the U.S. or China have at least 38 exercises receive the maximum score of 10, while values less than 38 fall between 0-10. Values are log-transformed onto an exponential scale such that the difference between 2-4 exercises (i.e. a doubling) is the same as the difference between 4-8 exercises. Exponential scales show percentage change between values and emphasize differences between smaller values. We use the same scales for both the U.S. and China so that they are comparable.

(2) $$score = clamp\left(\frac{ln(raw\_value) - ln(Q2.5)}{ln(Q97.5) - ln(Q2.5)}, 0, 10\right)$$

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[22] Charles P. Winsor et al., "Low Moments for Small Samples: A Comparative Study of Order Statistics," *The Annals of Mathematical Statistics* 18, no. 3 [1947], pp. 413-426.

Indicators that are comprised of multiple sub-components are calculated as average value of their components. For example, the critical minerals indicator is the average of the scores for each mineral resource, and can be interpreted to indicate which country the U.S. or China depends on the most. Scoring for each indicator and its components is listed in Table 1.

Since averaging sub-components causes indicator scores to shift towards the mean, we rescale all indicators to extend to the full range of 0-10 (3). For example, without rescaling, scores for the four resource dependence indicators are near zero since for most country-resource combinations the U.S. and China have either domestic production or rely on imports from only a few partner countries. This should not affect the interpretation of each indicator, but effectively re-weights indicators so that the relative distribution of each of the indicators has equal weight towards the overall score.

(3) $$recsaled = (score - min\_score) / (max\_score - min\_score)$$

Table 1: Indicator scoring

Indicator	Equation
Strategic minerals	*mean(component_scores)*
Antimony, Beryllium, Bismuth, Cadmium, Chromium, Cobalt, Graphite, Lithium, Magnesium, Manganese, Molybdenum, Niobium, Palladium, Platinum, Rare earths, Rhodium, Selenium, Tantalum, Thorium, Titanium, Tungsten, Uranium, Vanadium, Zirconium	*raw_value / 25%*
Commodity metals	*mean(component_scores)*
Aluminium, Copper, Gold, Iron & steel, Lead, Nickel, Silver, Tin, Zinc	*raw_value / 25%*
Agriculture	*mean(component_scores)*
Coffee, Maize, Milk, Palm, Pork, Poultry, Rice, Soy, Sugar, Wheat	*raw_value / 25%*
Energy resources	*mean(component_scores)*
Coal, Oil, Gas	*raw_value / 25%*
Military exercises	$\frac{ln(raw\_value) - ln(Q2.5)}{ln(Q97.5) - ln(Q2.5)}$
Arms trade	*mean(component_scores)*
Arms imports	*raw_value / 20%*
Arms exports	*raw_value / 50%*
Voting agreement	*raw_value / 100%*
Foreign aid	*raw_value / 10%*

Trade volume	$\frac{ln(raw\_value) - ln(Q2.5)}{ln(Q97.5) - ln(Q2.5)}$
Foreign direct investment	$\frac{ln(raw\_value) - ln(Q2.5)}{ln(Q97.5) - ln(Q2.5)}$
Student exchange	*mean (component_scores)*
Inbound students, Outbound students	$\frac{ln(raw\_value) - ln(Q2.5)}{ln(Q97.5) - ln(Q2.5)}$

Notes: All scores are clamped to the range 0-10 such that values over 10 are set to 10. Q2.5 and Q97.5 are the 2.5th and 97.5th percentiles of values respectively for both the U.S. and China combined.

Results

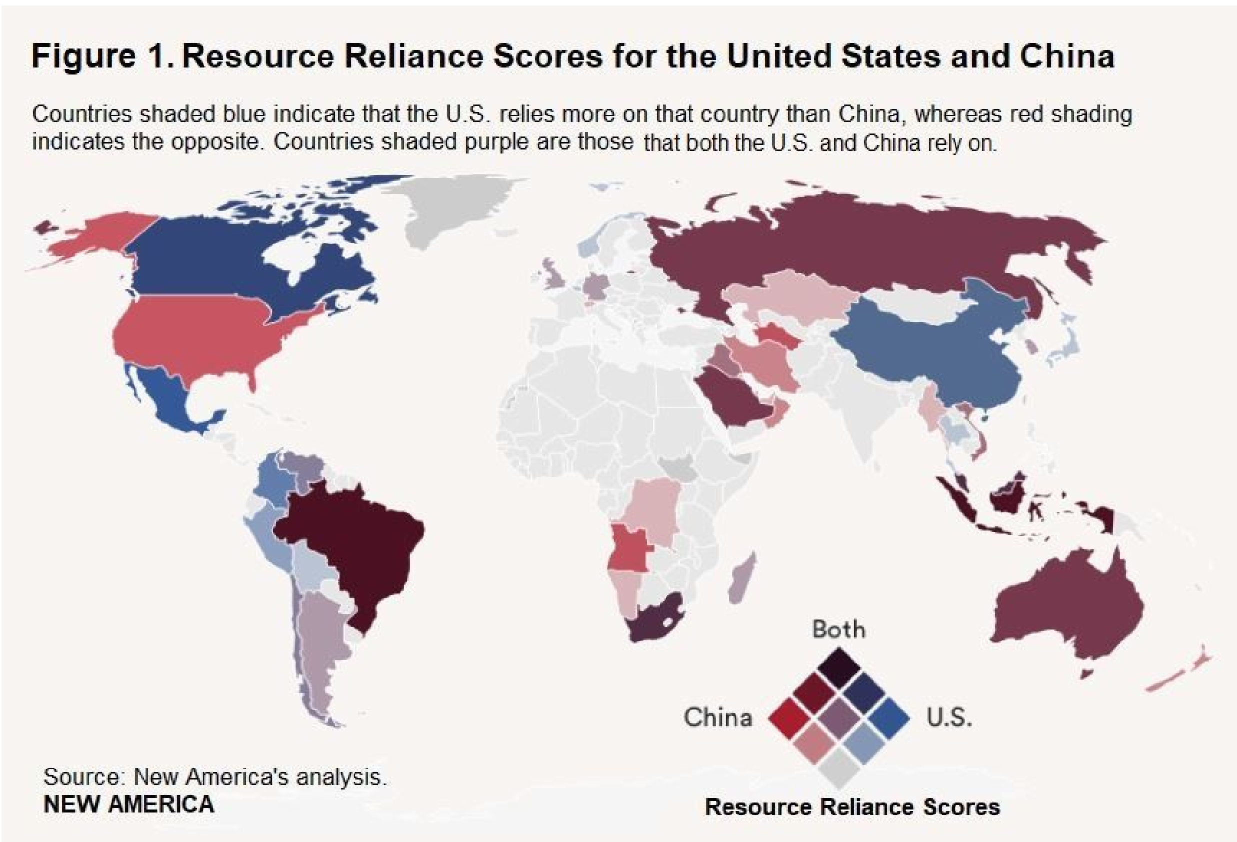
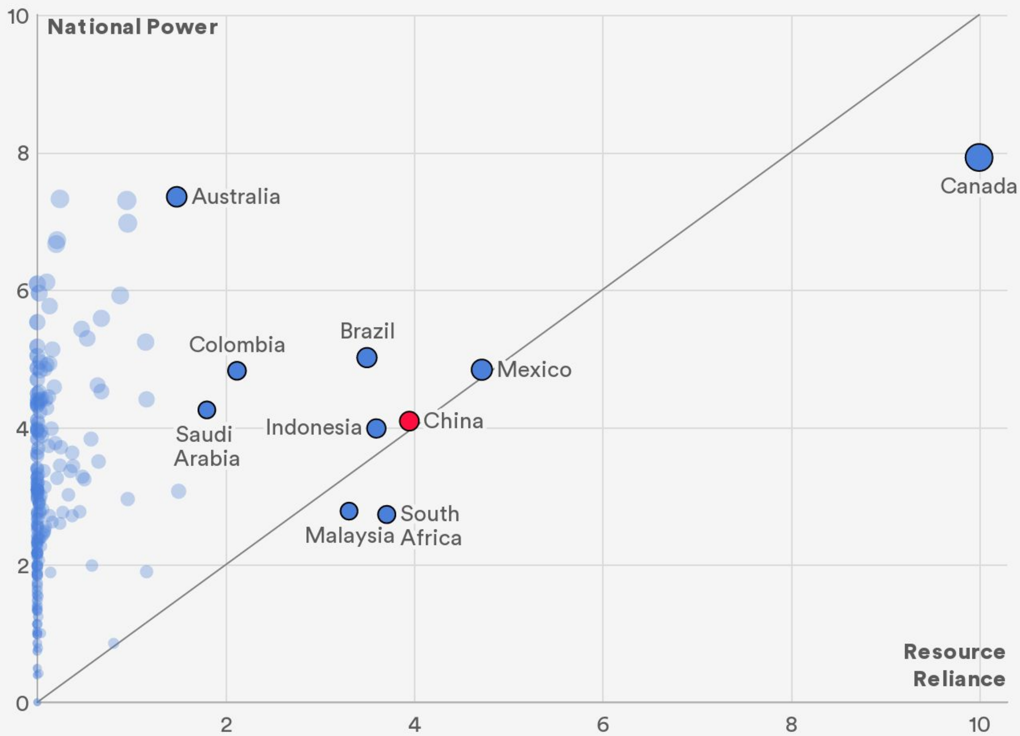


Figure 1. Resource Reliance Scores for the United States and China

Countries shaded blue indicate that the U.S. relies more on that country than China, whereas red shading indicates the opposite. Countries shaded purple are those that both the U.S. and China rely on.

Figure 2. U.S. Resource Reliance and National Power

The X axis represents how much the US relies on each country for natural resources. The Y axis represents the average value of the three national power indicators

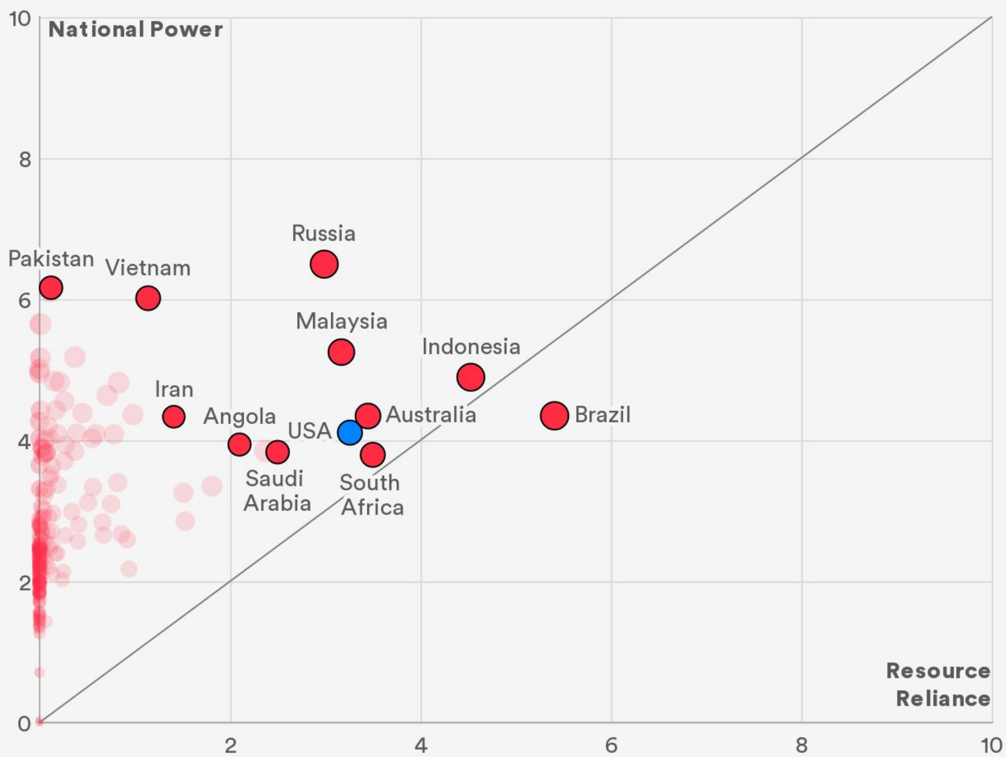


Source: New America's analysis.

NEW AMERICA

Figure 3. China's Resource Reliance and National Power

The X axis represents China's reliance on each country for natural resources. The Y axis represents the average value of the three national power indicators



Source: New America's analysis.

NEW AMERICA

Code for calculating aggregated scores, and additional maps and figures for individual indicators are available at https://github.com/fgassert/na-resource-security/blob/master/aggregate.ipynb.

Discussion and Limitations

There are several limitations to take into account when interpreting this index. Selection of indicators and aggregation methods is an inherently subjective process. Although we endeavor to be consistent and transparent in our choices, different researchers may determine other indicators or methods to be more meaningful. Trade data within the index only runs through 2017, thus it does not capture the effects of more recent escalating trade tensions and tariffs between the US and China. It is likely that this 'trade war' is pushing both countries to rely more on other partners as global supply chains shift. There are also data availability constraints and potential outliers or errors in individual indicators. Where we are aware of these, they are noted in the indicator selection section. We welcome comments and corrections to this information.

US-China competition is not the sole cause of the profound shifts occurring throughout the global economy. A number of other factors are causing major multinational companies to shift supply chains, including but not limited to, the geographic location of emerging markets, and increased trade in services combined with a simultaneous decrease in trade in intermediate goods as those emerging economies consume more of what they produce domestically.[23]

Countries that both the US and China rely upon are likely to become a new competitive space, as both countries seek to win favor to secure natural resource flows. These countries likewise may see an increased role in international politics as brokers between the US and China or benefit from their unique resource endowments by hedging on certain issues that involve the two.

Increased investment in green energy and semiconductors may reduce the importance of the oil-rich Middle East, while increasing the importance of lithium and rare-earth producing regions. This is not to say that lithium is the new oil; the global economy will continue to demand traditional sources of energy. However, nations throughout the world are pledging (in differing capacities) to reduce emissions in order to combat climate change, and that process requires altering the makeup of energy portfolios toward clean energy and away from fossil fuels.

Yet, the current US administration's retrenchment from diplomacy and increase investment in hard power plays in the opposite direction. Except in unstable regions, hard power is unlikely to secure these resources, even if it serves as a useful deterrent. Investing in lethality ensures that the military wins the next war, but long-term strategic competition with adversaries that the Pentagon itself refers to as 'near peers' requires investing in much more than lethality.

On the other hand, China is investing heavily in both public opinion and economic ties through a variety of mechanisms, the Belt and Road Initiative (BRI) chief among them. Through the BRI, China is strategically investing, constructing, and sometimes taking an ownership stake in major infrastructure projects the world over, which is returning both economic and geopolitical influence to Beijing.

Ultimately, reduced trade interdependence is potentially harmful to both national security and economic growth. Protectionist tariffs and trade disputes foster an environment wherein reduced market efficiency can increase the risk of conflict.[24] Free, open, and transparent trade, on the other hand, is a more hospitable environment within which consumers and producers can quickly adapt to the negative impacts of climate change.

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[23] McKinsey Global Institute, *Globalization in Transition: The Future of Trade and Value Chains*, [January 2019], https://www.mckinsey.com/~/media/mckinsey/featured%20insights/innovation/globalization%20in%20transition%20the%20future%20of%20trade%20and%20value%20chains/mgi-globalization%20in%20transition-the-future-of-trade-and-value-chains-full-report.ashx.

[24] Richard Rosencrance, *The Rise of the Trading State: Commerce and Conquest in the Modern World* [New York, NY: Basic Books, 1987]; see also Paul A. Papayoanou, *Power Ties: Economic Interdependence, Balancing, and War* [Ann Arbor: University of Michigan Press, 1999]; as well as K.H. O'Rourke and R. Findlay, *Power and Plenty: Trade, War and the World Economy in the Second Millenium,* [Princeton University Press, 2007].

Appendix A. Key Mineral and Metal Resources in the U.S.-China Competition

Percentages in the supply columns are percent share of U.S. or China's supply for that resource.

Resource	Supply (U.S.)	Supply (China)	Military Applications	Clean Energy Applications	Medical Applications	Consumer Applications
Antimony	China (52%) Domestic (14%)	Domestic (78%) Tajikistan (6%)	Armor penetrating rounds.	Lead-acid storage batteries.	Treatment for certain parasitic diseases.	
beryllium	Domestic (93%) Kazakhstan (3%)	Madagascar (56%) Domestic (23%)	Housings for optical targeting systems and real-time imagery surveillance for UAVs.		MRI, X-ray imaging and detector applications.	Communication equipment, computers, and mirros in satellites.
bismuth	China (75%) Belgium (8%)	Domestic (97%) Kazakhstan (1%)	Ammunition.	Thermoelectric devices.	Compounds to treat stomach illnesses, and implanted medical devices.	Cosmetics.
chromium	South Africa (44%) Domestic (29%)	South Africa (65%) Turkey (10%)	Component in nickel super-alloys for land based turbines and jet engines.	Pipelines and heat resistant wiring.	Various medical equiptment and dental tools.	Kitchen appliances and food processing equipment.
cobalt	Domestic (24%) Norway (14%)	DRC (82%) Domestic (11%)	Component in nickel super-alloys for land based turbines and jet engines.	Lithium-ion, nickel-cadmium, and nickel-metal-hydride batteries.	Medical implants.	Cell phones and computers.
lithium	Domestic (46%) Argentina (31%)	Domestic (71%) Chile (20%)	Key ingredient in producing alloys for aerospace industry.	Lithium-ion and recharchable batteries, and air purification.	Compounds to aid in controlling bipolar disorder.	Ceramics and glass.
manganese	South Africa (29%) Gabon (26%)	South Africa (33%) Australia (22%)	Steelmaking, and alloys for high-temperature bolts and fasteners.	Batteries and dry cells.	Water treatment.	Glass making and coloring.
niobium	Brazil (75%) Canada (22%)	Brazil (88%) Canada (6%)	Rocket subassemblies, turbocharger systems.	Catalyst in conversion of palm oil to biodiesel.	Superconducting magnets for MRI.	Cell phones and computers.
palladium	South Africa (27%) Russia (21%)	UK (25%) Domestic (18%)	High-temperature and corrosion resistant metals.	Catalytic converters.	Cancer-fighting drugs.	LCD/Flat panel displays and internal computer components.
platinum	South Africa (38%) UK (12%)	South Africa (39%) Domestic (25%)	High-temperature and corrosion resistant metals.	Catalytic converters.	Pacemakers.	Electronic devices, hybridized integrated circuits, and multilayer ceramic capacitors.
rhodium	South Africa (44%) Domestic (25%)	South Africa (33%) United States (21%)	High-temperature and corrosion resistant metals.	Catalytic converters.	Catalyst to make l-DOPA, used for treating Parkinson's disease.	Financial assets and investment.
rare earths	China (80%) Estonia (13%)	Domestic (81%) Malaysia (4%)	Night vision, radar, targeting, and guidance and control systems.	Battery alloys and catalyst in fuel processing.	Magnets for MRI and X-ray.	Phoshpors and ceramics.

Source: U.S. Defense Logistics Agency (DLA) , U.S. Geological Survey (USGS), and Lars Öhrström "Rhodium Roles," [Nature Chemistry 8, January 2016], pp. 90.