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A Comparative Analysis of Canada and Greenland's Rare Earth Development Strategies

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MOBILIZING INSIGHTS IN DEFENCE AND SECURITY

Executive Summary

Rare earth elements are essential to industries the modern world relies on from defence to energy to digital technology. However, China's dominance of the rare earth market has led many countries to begin looking to develop new rare earth supply chains. This paper analyses the rare earth development strategies of Canada and Greenland and provides an explanation for what shaped the differences between these countries' strategies. The existing literature on mineral development policy is explored before comparing rare earth criticality in Canada and Greenland.

This paper found three features that distinguish the rare earth development strategies of Canada and Greenland: (1) the Government of Canada is investing significantly more in developing it's domestic rare earth reserves than the Government of Greenland; (2) Canada opted to block investment from Chinese State Owned Enterprises (SOEs) in it's rare earth industry, whereas Greenland did not, and; (3) the Government of Canada has used environmental concerns to justify rare earth development, whereas the Government of Greenland has used environmental concerns to justify not developing it's domestic rare earth reserves.

The final section of this paper builds a cohesive model to explain these differences. Canada's larger economy gives it both the ability to substitute Chinese SOE investment with domestic investment, and to have more independent policy-making capabilities than Greenland. Furthermore, Greenland's policy does not consider security concerns associated with Chinese investment that Canada is concerned with, which further incentivises Greenland to accept Chinese SOE investment. These findings provide insight to the behaviour of countries that have yet to fully develop their rare earth reserves. While both Canada and Greenland have yet to significantly develop their rare earth reserves, each country holds the resource potential to re-shape the world's rare earth supply chains.

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Introduction

From defense and renewable energy technology to digital equipment, rare earth elements (REEs) are essential for the development of a plethora of key technologies people have come to rely on in the modern era. Over the past decade, China's dominance of the rare earth market has raised concern for many countries and led many others to begin developing new supply chains.

However, only a select few countries are in possession of concentrations of rare earth minerals (REMs) that are economically viable to mine, and there are an even smaller group of countries that mine significant quantities of REMs. This paper investigates why countries adopt different rare earth development strategies.

To make an original contribution to the existing literature, this research analyses the rare earth development strategies of resource-abundant case countries that have received little attention in the existing literature: Canada and Greenland. Current theories in the academic literature have provided powerful explanations for the existence and shape of rare earth development policy. However, the existing literature has primarily focused on understanding the policies of actors with more mature rare earth development strategies such as China and the United States with an occasional emphasis on actors like Australia, Japan, the European Union, and South Korea. The actors just listed are in possession of less than half of the worlds REM reserves.[1] There is a distinct gap in the literature of explanations for the strategies of other and potentially important countries in the rare earth geopolitical landscape. Crucially, Canada and Greenland each hold the resource potential to re-shape the current rare earth geo-political landscape.

Prior to exploring the theoretical literature that has attempted to explain rare earth development strategy, it is important to clarify what is meant by 'rare earths'. REEs include scandium, yttrium and the 15 lanthanides.[2] They are generally placed in a singular category due to their similar geochemistry which often places them in the same host minerals and enables them to be used in similar applications after downstream processing.[3] Rare earths are hardly found in nature as pure elements or REEs.[4] When rare earths are mined, they are generally found in mineral form as REMs. Then, through downstream processing, they are broken down into their individual elements which can be utilized in various industrial products.[5] In this paper and the existing literature, the term 'rare earths' is used as a catchall term that include both REEs and REMs.

There are several significant uses for rare earths which can be used to illustrate their contemporary importance. Catalysts are products used to increase the rate of chemical reactions. Rare earths are used as catalysts in petroleum refinement as well as in some chemical processing.[6]

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[1] U.S. Geological Survey, 2023, Rare Earths Mineral Commodity Summaries, accessed February 25, 2023, https://pubs.usgs.gov/periodicals/mcs2023/mcs2023-rare-earths.pdf.
[2] U.S. Geological Survey, 2023, "Rare Earths Statistics and Information," accessed February 25, 2023. https://www.usgs.gov/centers/national-minerals-information-center/rare-earths-statistics-and-information.
[3] Texas Mineral Resources Corp, "Rare Earth Elements," accessed February 25, 2023. http://tmrcorp.com/ree/.
[4] U.S. Geological Survey, 2023, "Rare Earths Statistics and Information," accessed February 25, 2023. https://www.usgs.gov/centers/national-minerals-information-center/rare-earths-statistics-and-information.
[5] Ibid.
[6] "What are rare earths?" Lynas Rare Earths, accessed November 23, 2021, https://lynasrareearths.com/products/what-are-rare-earths/.

Rare earth catalysts are also used in catalytic converters (which decrease automotive toxic emissions) as well as industrial pollution scrubbers.[7] Special types of batteries are needed for electric cars to work properly, and rare earths are essential to the assembly of these batteries.[8] In the defense industry, examples of rare earth uses include products like precision-guided weapons and powerful magnets for motors.[9] In the aerospace/defense industry, the F-35 Lightning II aircraft requires 920 pounds of rare-earth materials to build.[10]

Rare earths are also used to make the luminescent phosphors in screens and glasses.[11] Luminescent phosphors are found in any kind of light-up screens, including televisions, smartphones, and computers.[12] Rare earths are also present in Light-Emitting Diode (LED) and fluorescent lighting.[13] Various imaging technologies use rare earths, including x-ray imaging and optical glass used for camera lenses. Magnets have built up one of the most diverse resumes of rare earth products. Rare earth magnets are far stronger than conventional magnets, giving them a vast range of technological applications.[14] This list includes but is not limited to: car parts like motors and anti-lock brake systems; audio devices like microphones and speakers; video devices like DVD drives and DVD drive motors; and essential services such as MRIs and communication systems.[15] There are also several other general electronics in which rare earths can be found. Fiber optics and lasers are prime examples of these. Fiber optics are used in the cables required for internet, phone, and tv services.[16] Lasers are used for industrial barcode scanners, surgical removal of tissue, and some industrial manufacturing processes.[17]

This research begins with an overview of the existing explanatory literature on mineral development policy, with a particular focus on rare earths and critical minerals. Consequently, the criticality of rare earths in Canada and Greenland is compared using indicators from an existing criticality matrix to illustrate the similar strategic needs of Canada and Greenland for rare earth development. Next, the rare earth development strategies of Canada and Greenland are defined so that the differences between each country's strategy can be highlighted and explained. This research identifies three features that distinguish the rare earth development strategies of Canada

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[7] Ibid.
[8] "Rare Earths - Vital to Modern Technologies and Lifestyles," U.S. Geological Survey, November 2014, 2, https://pubs.usgs.gov/fs/2014/3078/pdf/fs2014-3078.pdf.
[9] Todd C. Lopez, "DARPA Looks to Microbes to Process Rare Earth Elements," *U.S. Department of Defense*, September 8, 2021, https://www.defense.gov/News/News-Stories/Article/Article/2768268/darpa-looks-to-microbes-to-process-rare-earth-elements/.
[10] Russell Parman, "An elemental issue," *U.S. Army*, September 26, 2019, https://www.army.mil/article/227715/an_elemental_issue.
[11] "Rare Earths - Vital to Modern Technologies and Lifestyles," U.S. Geological Survey, November 2014, 2, https://pubs.usgs.gov/fs/2014/3078/pdf/fs2014-3078.pdf.
[12] Ibid
[13] Ibid.
[14] "Rare Earth Magnets," Master Magnet Inc., accessed June 3, 2023, https://www.magnetsource.com/pages/rare-earth-magnets.
[15] "What are rare earths?" Lynas Rare Earths, accessed June 3, 2023, https://lynasrareearths.com/products/what-are-rare-earths/.
[16] Ibid.
[17] J. Hecht, "Laser Applications," *Encyclopedia Britannica*, August 15, 2021, https://www.britannica.com/technology/laser.

and Greenland: (1) the Government of Canada is investing significantly more in developing it's domestic rare earth reserves than the Government of Greenland is investing in developing it's domestic rare earth reserves; (2) Canada opted to block investment from Chinese State Owned Enterprises (SOEs) in its rare earth industry, whereas Greenland did not, and; (3) the Government of Canada has used environmental concerns to justify rare earth development, whereas the Government of Greenland has used environmental concerns to justify not developing it's domestic rare earth reserves. This research finds that these three differences are ultimately a product of differences in the economic capabilities of each country. Canada's larger economy has afforded Canada both the ability to substitute Chinese SOE investment with its own investment, and the capability to have more independent policy-making capabilities than Greenland. Greenland's policy does not consider security concerns associated with Chinese investment like Canada, which further incentivises Greenland to accept Chinese SOE investment. As a middle power with a substantial population and economy, Canada has greatly benefited the status quo rules-based international order. Conversely, Greenland's relatively small population and economy has limited independent decision-making capabilities in the status quo rules-based international order. So, while Canada's environmental policy and approach to China aim toward supporting this status quo rules-based international order, Greenland's environmental policy and approach to China is more accepting of changes to the status quo rules-based international order.

Literature Review

Barteková and Kemp (2016) attempted to answer the question of why different world regions responded differently to the global problem of securing stable supply of rare earths, using a small-n-comparative model to look in depth at the rare earth policies of China, the United States, the European Union, Japan and Australia.[18] Barteková and Kemp (2016) mapped each actor's policy to determine what it emphasizes and what it does not. In conclusion, this study found that differences in rare earth policy are shaped by actors' national interests, resource abundance, historical experience in dealing with supply risk, respective regulatory styles, and the influence of transnational organizations on national policy making.[19] This research found that resource-abundant countries are more likely to adopt policies that emphasize the development of the domestic mineral sectors and resource protection.[20] The extent to which they do so depends on whether they are consumers of these resources or only exporters.[21] China – which is a significant rare earth consumer – has a far more aggressive rare earth development strategy than Australia, which exports most of its rare earth production.[22]

[18] Eva Barteková, and René Kemp, "National strategies for securing a stable supply of rare earths in different world regions," *Resources Policy* 49, (September 2016): 153-154, https://doi.org/10.1016/j.resourpol.2016.05.003.
[19] Ibid., 161.
[20] Ibid.
[21] Ibid.
[22] Ibid.

Other existing research on rare earth development policy has used similar explanatory variables. Salim et al. (2022) found that rare earth mining operations in developed countries face the challenges of long administrative bureaucracy, lower labour costs, and advanced extraction technologies in China. These variables make it economically unattractive for mining companies outside China to stay in the public market, and raise concerns over the potential environmental impacts of mining and countries options for foreign direct investment.[23] He (2018) argued that the lack of comparable and sufficient substitutes and recycling, the high ratio of imports relative to consumption, the high concentration of import supply by country, and regulatory changes alone could not prompt the US to make significant changes in its policy that would increase the security of its rare earth supply chains.[24] Rather, serious US intervention only occurred once rare earth supply chain dependence was perceived as a security threat to the US and its allies.[25]

Explanatory models from previous research explain actors' approaches to rare earth development as a product of various aspects of mineral criticality. Rare earths are often referred to as 'critical minerals' due to their important end-uses and their vulnerability to supply chain disruption in many countries.[26] There is a long history to the conceptualization of critical minerals which began just after World War One, when the term 'strategic minerals' emerged to describe material shortages that hindered US military mobilization efforts.[27] Then, in the 1920s, the terms 'critical minerals' and 'strategic minerals' started to be used interchangeably when the US government generated a list of 28 materials that had been called "critical and strategic materials."[28] The criticality of rare earths, relative to different case countries, can be used to explain why countries adopt different domestic rare earth development strategies according to their rational strategic interests. The more critical rare earths are to a particular country, the greater interest that country would have in adopting an aggressive strategy to secure its supply chains.

Though the origins of critical minerals are strategic, contemporary literature varies in terms of its focus. How critical minerals are conceptualized often varies based on the extent to which a mineral supply can directly impact a country's security. More traditional conceptualizations of critical minerals, which revolve solely around defense applications, imply that security is strictly a concept that relates to military defense. An example of a stricter definition of critical minerals can be found in the Strategic Materials Protection Board's 2008 report: "the criticality of a material is a function of its importance in DOD [Department of Defense] applications, the extent to which DOD actions are required to shape and sustain the market, and the impact and likelihood of supply

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[23] Hengky Salim, Oz Sahin, Sondoss Elsawah, Hasan Turan, and Rodney A. Stewart, "A critical review on tackling complex rare earth supply security problem," *Resources Policy* 77, (August 2022): 5, https://doi.org/10.1016/j.resourpol.2022.

[24] Yujia He. "The trade-security nexus and U.S. policy making in critical minerals." *Resources Policy* 59, (December 2018), 238. https://doi.org/10.1016/j.resourpol.2018.07.010.

[25] Ibid.

[26] Mayer, Herbert and Benedikt Gleich, "Measuring Criticality of Raw Materials: An Empirical Approach Assessing the Supply Risk Dimension of Commodity Criticality," *Natural Resources* 6 (2015): 57, https://doi.org/10.4236/nr.2015.61007.

[27] David G. Haglund, "Strategic Minerals: A Conceptual Analysis," *Resources Policy* 10, no. 3 (1984): 147, https://doi.org/10.1016/0301-4207(84)90029.

[28] Ibid.

disruption."[29] This type of definition assumes that the impact of mineral supply chains on security is solely a function of their impact on military applications. Strict criticality definitions have been applied in many studies done by organizations and departments concerned with defense. One study from the Institute of Defense Analysis provided analytical support to the US Department of Defense (DOD) and the Defense National Stockpile Center to structuring and implementing a stockpile requirements process.[30] Additionally, Butler (2014) focuses specifically on the strategic implications of rare earth criticality.[31] China's dominance on the rare earth market could allow it to weaponize rare earth supply chains against the US in any future conflict.[32] By restricting the US' rare earth supply chains, China could starve the US of their ability to manufacture strategically important goods.[33]

More progressive definitions of critical minerals include factors such as the environmental or societal impacts of critical mineral production. If environmental impact can shape mineral criticality, this would imply that environmental concerns are directly related to security concerns. Mayer and Gleich (2015) identified the main measurement dimensions across various criticality studies – many of which were done by specific governments and government departments – and found many to be economic while others are environmental.[34] Graedel et al. (2012) used this type of definition to measure mineral criticality, which is illustrated by the fact that environmental impact was included in this study as an indicator of mineral criticality.[35] The previous research that has sought to explain rare earth development strategies has utilized more progressive definitions of criticality. One of the earliest attempts at measuring mineral criticality was done by Graedel et al. (2012).[36] This study later came to inform other mineral criticality measurement methodologies such as that of Eheliyagoda, Zeng and Li (2020).[37] Moss et al. (2013) analysed mineral criticality strictly in reference to low carbon energy technologies in Europe.[38] Eheliyagoda, Zeng and Li

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[29] U.S. Library of Congress, Congressional Research Service, *Rare Earth Elements: The Global Supply Chain*, by Marc Humphries, R41347 (2013), 8.

[30] James S Thomason, Robert J Atwell, Ylli Bajraktari, James P Bell, D S Barnett, Nicholas S Karvonides, Michael F Niles, and Eleanor L Schwartz, From National Defense Stockpile (NDS) to Strategic Materials Security Program (SMSP): Evidence and Analytic Support, *Volume 1* (2010), iii.

[31] Butler, Charles J. Butler, "Rare Earth Elements: China's Monopoly and Implications for U.S. National Security., *The Fletcher Forum of World Affairs* 38, no. 1 (2014): 32.

[32] Ibid.

[33] Ibid.

[34] Mayer, Herbert, and Benedikt Gleich, "Measuring Criticality of Raw Materials: An Empirical Approach Assessing the Supply Risk Dimension of Commodity Criticality," *Natural Resources* 6 (2015): 59, https://doi.org/10.4236/nr.2015.61007.

[35] Thomas E Graedel, Rachel Barr, Chelsea Chandler, Thomas Chase, Joanne Choi, Lee Christoffersen, Elizabeth Friedlander, et al., "Methodology of Metal Criticality Determination," *Environmental Science & Technology* 46, no. 2 (2012): 1063. https://doi.org/10.1021/es203534z.

[36] Ibid.

[37] Disna Eheliyagoda, Xianlai Zeng, and Jinhui Li, "A Method to Assess National Metal Criticality: The Environment as a Foremost Measurement," *Humanities & social sciences communications* 7, no. 1 (2020): 1, https://www.nature.com/articles/s41599-020-00537-4.

[38] Raymond Moss, Peter Willis, Espinoza Luis Tercero, Evangelos Tzimas, Josephine Arendorf, Paul Thompson, Adrian Chapman, et al., "Critical Metals in the Path Towards the Decarbonisation of the EU Energy Sector:

(2020) devised a matrix for measuring criticality which placed environmental risk as a foremost measure.[39] To do so, this study places environmental risk alongside supply risk and supply restrictions risk as metrics of criticality.[40] The rationale behind an emphasis of environmental risk as a criticality measure is that environmental risk and damage leads to high economic risks due to the costs of mitigating damages.[41] An adequate explanatory model to account for the differences in the rare earth development strategies of Canada and Greenland should be able to account for elements relating to expanded security, such as environmental regulation and economic security.

Methodology

To explain why Canada and Greenland have adopted different rare earth development strategies, this research employs a mixed design that utilizes tools from both comparative and single case study research. Small number comparisons based on theoretical relations, such as with rare earth criticality, can be complemented by process tracing.[42] Canada and Greenland are well suited countries for answering this research question due to the similarities of rare earth criticality in each country and the differences in the two countries' rare earth development strategies.

The first portion of this research consists of a comparative design that exploits known similarities of rare earth criticality in each case country for potentially confounding variables, and known differences in other aspects of rare earth criticality in each case country to explain the unknown differences in the outcomes of rare earth development strategy in each case country.[43] A most similar systems design is appropriate for this research, since it utilizes deductive logic by applying existing theories of mineral criticality to new data with REMs in Canada and Greenland.[44] All aspects of mineral criticality are potentially confounding variables in this research, as the criticality of rare earths in Canada and Greenland provides the rational explanation as to why those in Canada and Greenland would be interested in developing their REM reserves. Thus, all aspects of mineral criticality will have to be accounted for. Eheliyagoda, Zeng, and Li (2020) provide the most ideal framework for a comparison of aspects of mineral criticality, since this methodology is replicable (except for some metrics for which data is not available) and provides a complete picture of mineral criticality that encompasses the potentially confounding variables and explanatory variables from the existing literature.[45]

Assessing Rare Metals as Supply-Chain Bottlenecks in Low-Carbon Energy Technologies," (2013): 3, https://data.europa.eu/doi/10.2790/46338.

[39] Disna Eheliyagoda, Xianlai Zeng, and Jinhui Li, "A Method to Assess National Metal Criticality: The Environment as a Foremost Measurement," *Humanities & social sciences communications* 7, no. 1 (2020): 1, https://www.nature.com/articles/s41599-020-00537-4.

[40] Ibid., 4-6.

[41] Ibid., 2.

[42] Dimiter Toshkov, *Research in Political Science* (London: Palgrave, 2016), 320-321.

[43] Ibid., 265.

[44] Ibid., 264.

[45] Disna Eheliyagoda, Xianlai Zeng, and Jinhui Li, "A Method to Assess National Metal Criticality: The Environment as a Foremost Measurement," *Humanities & social sciences communications* 7, no. 1 (2020): 1, https://www.nature.com/articles/s41599-020-00537-4.

In comparison to the first portion of this research, the methodology for the second and third portions of this research is relatively straightforward. The second portion of this research analyses the policies of Canada and Greenland to define the rare earth development strategies of each country. The third and final portion of this research then consists of a single case study design to explain the differences between Canada and Greenland that resulted in their differing approaches to rare earth development. This involves the use of process tracing to examine the chain of events that shaped the different policy outcomes in each country, which draws out a clear explanatory model that accounts for the differing outcomes in the rare earth development strategies of Canada and Greenland.[46]

Prior to beginning this analysis, it is important to note a substantial difference between Canada and Greenland and how this will impact the analysis. That is, Canada is an independent country whereas Greenland is a country within the Kingdom of Denmark. Thus, Canada and Greenland have different policy-making capabilities. This is a difference which does impact the differences between the rare earth development strategies of Canada and Greenland, as will be elaborated on later in this paper. However, this difference does not negate the vast similarities between Canada and Greenland that make their differences in rare earth development strategy worth studying. That is that rare earths are similarly critical to Canada and Greenland.

Rare Earth Criticality in Canada and Greenland

Canada and Greenland make for ideal cases of comparison due to their different strategies for rare earth development and the overwhelming similarities in metrics used to measure mineral criticality in each country. To illustrate the similarities between each country and illuminate differences that could have shaped each countries' rare earth development strategy, the following section provides a comparison of the criticality of rare earths in Canada and in Greenland. Mineral criticality refers to the extent of a mineral's importance to a country and a minerals' vulnerability to supply chain disruptions in a country. A mineral that is highly critical to a country would also be highly important to that country and highly vulnerable to supply chain disruption. Criticality can vary from mineral to mineral and from country to country. The criticality of rare earths relative to Canada and Greenland defines the rational interests of each country that would shape each countries' rare earth development strategy. The benefits of rare earth development are far greater for countries that are more vulnerable to rare earth supply chain disruption and for countries where rare earths are of greater importance. To develop the rare earth mines and refineries necessary for a secure supply chain takes years and can cost a fortune. Due to the immense costs required for a successful rare earth development strategy, it can be assumed neither Canada or Greenland would adopt a rare earth development strategy without rational and self-interested motivations. The results of this comparison show that rare earths are similarly critical to Canada and Greenland.

[46] Dimiter Toshkov, *Research in Political Science* (London: Palgrave, 2016), 299.

This comparison has primarily been modeled off the work of Eheliyagoda, Zeng, and Li (2020), which provides comprehensive methodology that can measure the criticality of any mineral in any country using indicators that can impact mineral's supply risk and importance, including: geological and technical risks; economic risk and importance; environmental risks, and; adaptiveness. In contrasting indicators for these factors in Canada and Greenland, this comparison can describe the similarities and differences between each country that could have resulted in the variation of each countries' rare earth development strategies. Another advantage of using the methodology of Eheliyagoda, Zeng, and Li (2020) is that most of the indicators it uses can be replicated for rare earths in Canada and Greenland. However, according to the availability of data and the utility of certain indicators in the context of this research, some indicators used by Eheliyagoda, Zeng, and Li (2020) are modified, and others are removed from this analysis. For an explanation of the changes in this comparison from the original methodology of Eheliyagoda, Zeng, and Li (2020), see Appendix A.

Geological and Technical Risks

In conjunction with one another, the reserves and mine production of rare earths in Canada and Greenland can describe the supply chain risks each country faces on the geological and technical front.[47] If a country has a high percentage of the world's REM reserves and mine production, rare earths would be less critical to that country as it would have easier access to secure rare earth supplies.[48] Hence, countries with high concentrations of the world's rare earth reserves and mining production would be less likely to adopt costly rare earth development strategies that would only build toward goals the country has already achieved.

Canada and Greenland are similarly each one of 16 countries whose' REM reserves are sufficiently abundant to be recorded on the US Geological Survey's most recent mineral commodity summary for rare earths.[49] Canada has approximately 0.64% of the rounded world total reserves (830,000 tons of REM reserves) while Greenland has approximately 1.15% of the rounded world total reserves (1,500,000 tons of REM reserves).[50] According to the methodology of Eheliyagoda, Zeng, and Li (2020), this places Canada in the center of the high risk category (countries with 0.1-1% of the world total reserves) and places Greenland in the lower end of the substantial risk category (countries with 1-5% of the world total reserves).[51] According to the US Geological Survey (2023), neither of these countries are producers of REMs.[52] This is not

[47] Disna Eheliyagoda, Xianlai Zeng, and Jinhui Li, "A Method to Assess National Metal Criticality: The Environment as a Foremost Measurement," *Humanities & social sciences communications* 7, no. 1 (2020): S3, https://www.nature.com/articles/s41599-020-00537-4.
[48] Ibid.
[49] U.S. Geological Survey, 2023, Rare Earths Mineral Commodity Summaries, accessed February 25, 2023, https://pubs.usgs.gov/periodicals/mcs2023/mcs2023-rare-earths.pdf.
[50] Ibid.
[51] Disna Eheliyagoda, Xianlai Zeng, and Jinhui Li, "A Method to Assess National Metal Criticality: The Environment as a Foremost Measurement," *Humanities & social sciences communications* 7, no. 1 (2020): S19, https://www.nature.com/articles/s41599-020-00537-4.
[52] Ibid., S4.

technically true for Canada since the first Canadian rare earth mine began operating in the Northwest Territories in 2021.[53] However, Canada's REM production can be considered negligible since Canada's only operating rare earth mine is still in its infancy and the mine production numbers are not recorded.[54] The ratio of mine production to reserves is used by Eheliyagoda, Zeng, and Li (2020) as an indicator of a mineral's criticality, as it measures the amount of time a country has before its mineral reserves are depleted.[55] Since Canada and Greenland produce REMs in quantities that are negligible and non-existent respectively, depletion time at current rates is effectively infinite for both countries.

The comparable reserves, mine production, and depletion time of rare earths in Canada and Greenland show that both countries have a similar domestic rare earth supply capability. As such, the risks to Canada and Greenland's rare earth supplies posed by the physical availability of REMs to each country are comparable. Both Canada and Greenland have abundant reserves capable of being developed but are for the most part untouched. Consequently, both countries face similar geological risks to supply chain disruption and have similar opportunities to overcome those disruptions. These similar risks and opportunities cannot explain the differences in the rare earth development strategies of Canada and Greenland.

Economic Risk and Importance

Economic measures can be used to indicate degree of risk to rare earth supply chain disruption in each country, and to indicate the importance of rare earths to each country. Import reliance can be used to describe the extent to which each country is reliant on foreign imports of rare earths to fuel their domestic consumption.[56] A greater reliance on rare earth foreign imports to meet domestic consumption needs places countries at greater risk of rare earth supply chain disruption.[57] Hence, countries with greater import reliance of rare earths would be more incentivized to devise strategies to develop their domestic REM supply chains, as this would allow them to avoid the supply chain risks posed by reliance on other countries. In systems without domestic production like Canada and Greenland, import reliance and domestic consumption is equivalent to the amount of rare earths that travels through the country – this is a country's trade balance.[58] In 2022, Canada imported 6,184,630 USD of rare earth metals: scandium, yittrium, and compounds/mixtures

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[53] Government of Canada, "Success Stories: Cheetah Resources," last modified September 8, 2022, https://ised-isde.canada.ca/site/accelerated-growth-service/en/success-stories-cheetah-resources.
[54] U.S. Geological Survey, 2023, Rare Earths Mineral Commodity Summaries, accessed February 25, 2023, https://pubs.usgs.gov/periodicals/mcs2023/mcs2023-rare-earths.pdf.
[55] Disna Eheliyagoda, Xianlai Zeng, and Jinhui Li, "A Method to Assess National Metal Criticality: The Environment as a Foremost Measurement," *Humanities & social sciences communications* 7, no. 1 (2020): S5, https://www.nature.com/articles/s41599-020-00537-4.
[56] Dominic Wittmer, Cynthia Latunussa, Gian Andrea Blengini, and David Pennington, "European Innovation Partnership on Raw Materials: Annual Monitoring Report 2017" 29443 (2018).
[57] Disna Eheliyagoda, Xianlai Zeng, and Jinhui Li, "A Method to Assess National Metal Criticality: The Environment as a Foremost Measurement," *Humanities & social sciences communications* 7, no. 1 (2020): 5, https://www.nature.com/articles/s41599-020-00537-4.
[58] Dominic Wittmer, Cynthia Latunussa, Gian Andrea Blengini, and David Pennington, "European Innovation Partnership on Raw Materials: Annual Monitoring Report 2017" 29443 (2018).

thereof.[59] In the same year, Canada exported 1,535,002 USD of the same product, placing Canada in a trade deficit of 4,649,628 USD for 2022.[60] Notably, the majority of Canada's imports (3,562,855 USD) had come out of China, while the US was Canada's second largest import source (2,150,636 USD).[61] Greenland, on the other hand, had a trade balance of zero with no imports or exports in 2022.[62] The risk Canada faces from reliance on foreign actors for rare earth imports provides Canada with an incentive to develop secure supply chains of rare earths that do not exist for Greenland. However, import reliance alone does not tell the complete story of the difference of the economic value of rare earths in between Canada and Greenland.

Eheliyagoda, Zeng, and Li (2020) use 'local importance in economy' to measure the differences in countries' rare earth import reliance and consumption relative to the economy of each country as a whole, as this can describe how important the consumption of rare earths is to each country.[63] If rare earth consumption makes up a larger portion of a country's overall economy (as measured by GDP), rare earths would be more important to that country's economy. This economic importance would further incentivize the country to adopt a strategy that ensures its rare earth supply chains are secure. Greenland has no rare earth consumption, so rare earth consumption would make up 0% of its GDP. Canada's most recently recorded GDP by the World Bank in 2021 was 1.99 trillion (current USD).[64] Thus, rare earth consumption makes up only about 0.00000234% of Canada's GDP. As such, rare earths are of very low importance in the economies of both Canada and Greenland.[65] This would imply that the difference in the importance of secure rare earth supply chains to each country's economy cannot account for the differences in each country's rare earth development strategy, since neither country has a significant economic interest in ensuring their rare earth supply chains are secure.

Environmental Risks

Eheliyagoda, Zeng, and Li (2020) used the Worldwide Governance Indicator for regulatory quality to measure how countries contend with the negative environmental impacts that often come as a

[59] Government of Canada, "Canadian trade balances," accessed March 12, 2023, https://www.ic.gc.ca/app/scr/tdst/tdo/crtr.html?grouped=INDIVIDUAL&searchType=KS_CS&naArea=9999&countryList=ALL&toFromCountry=CDN&reportType=TB&customYears=2022&timePeriod=%7CCustom+Years&currency=US&productType=HS6&hSelectedCodes=%7C2846%7C280530&runReport=true.
[60] Ibid.
[61] Ibid.
[62] United Nations, "UN Comtrade Database," accessed March 12, 2023, https://comtradeplus.un.org/TradeFlow?Frequency=A&Flows=X&CommodityCodes=2805&Partners=0&Reporters=124&period=2022&AggregateBy=none&BreakdownMode=plus.
[63] Disna Eheliyagoda, Xianlai Zeng, and Jinhui Li, "A Method to Assess National Metal Criticality: The Environment as a Foremost Measurement," *Humanities & social sciences communications* 7, no. 1 (2020): S15, https://www.nature.com/articles/s41599-020-00537-4.
[64] World Bank, "Current GDP (US$) – Canada," accessed March 4, 2023, https://data.worldbank.org/indicator/NY.GDP.MKTP.CD?locations=CA.
[65] Disna Eheliyagoda, Xianlai Zeng, and Jinhui Li, "A Method to Assess National Metal Criticality: The Environment as a Foremost Measurement," *Humanities & social sciences communications* 7, no. 1 (2020): S16, https://www.nature.com/articles/s41599-020-00537-4.

product of critical mineral production.[66] In the original methodology of Eheliyagoda, Zeng, and Li (2020), this index was used in context of countries' production, but since production for each country is non-existent and/or negligible, this research simply compares the index scores of each country.[67] The Worldwide Governance Indicator for regulatory quality illustrates the ability of governments to design and implement policies and regulations that enable and promote the development of the private sector.[68] This indicator is important to demonstrate the environmental flexibility of mining operations within different countries, as countries with higher scores that promote the private sector would be more likely to implement rare earth development policies that promote the private sector over the environment.[69]

Canada scored slightly higher for this index with a 94.23 in 2021, whereas Greenland scored an 89.42 in the same year.[70] These relatively similar scores suggest that both countries similarly prioritize private sector development over the environment. As such, the rare earth development strategies of both countries are likely to have been impacted similarly by each country's tendency to prioritize private sector development, over negative environmental impacts that can be associated with REM development. This implies that the tendencies of Canada and Greenland to promote the private sector over the environment likely did not produce the differences in the rare earth development strategies of Canada and Greenland.

Adaptiveness

Eheliyagoda, Zeng, and Li (2020) used the Global Innovation Index as an indicator of countries' ability to overcome a supply disruption.[71] The Global Innovation Index ranks countries based on their capacity to innovate, a measure which is valuable in relation to criticality since more innovative countries possess a greater capability to overcome supply chain restrictions.[72] Countries that can more easily overcome supply chain restrictions would be less incentivized to pursue costly strategies to develop their rare earth supply chains because they would be less threatened by supply chain restrictions.

Greenland is not listed on the Global Innovation Index, so Denmark's score is used in its place for this comparison. By using Denmark in place of Greenland, this research assumes Greenland has access to Denmark's innovational capabilities. It is reasonable to assume Denmark would share its innovational resources with Greenland in the event of a rare earth supply chain disruption due to the position of Greenland within the Kingdom of Denmark. While the

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[66] Ibid., S10.
[67] Ibid., 5.
[68] World Bank, "WGI-FAQ," accessed March 12, 2023, https://info.worldbank.org/governance/wgi/Home/FAQ.
[69] Disna Eheliyagoda, Xianlai Zeng, and Jinhui Li, "A Method to Assess National Metal Criticality: The Environment as a Foremost Measurement," *Humanities & social sciences communications* 7, no. 1 (2020): S10, https://www.nature.com/articles/s41599-020-00537-4.
[70] World Bank, "WGI-Interactive Data Access," accessed March 12, 2022, https://info.worldbank.org/governance/wgi/Home/Reports.
[71] Ibid., S22.
[72] Ibid.

innovational capacities of Greenland and Denmark may not be perfectly identical, it still holds value to show Canada's scores compared to Denmark in the absence of a score for Greenland.

Eheliyagoda, Zeng, and Li (2020) utilized a version of the Global Innovation Index rankings that gives each country a score between 0 and 100, with 0 representing a lack of innovative capacity and 100 representing an abundance.[73] Both Canada and Denmark scored similarly on this index, as Denmark was given a score of 57.70 and Canada was given a score of 55.73.[74] The similar scores seen on the Global Innovation Index imply both Canada and Greenland/Denmark are similarly capable of adapting to supply chain disruptions. This would suggest that concerns from each country about its own ability to adapt to supply chain restrictions would not explain the differences in each countries' rare earth development strategy.

Canada's Rare Earth Development Strategy

The Government of Canada has yet to release a singular cohesive document that articulates its strategy for rare earth development. Rather, the Government of Canada's rare earth development initiatives and ambitions are part the Canadian Critical Minerals Strategy. While some of the goals and initiatives of the Canadian Critical Minerals Strategy pertain to rare earth development, others do not, as they only pertain to the development Canada's other critical minerals. To describe Canada's rare earth development strategy, which is a part of but distinct from the Canadian Critical Minerals Strategy, the following section of this paper first describes the Canadian Critical Minerals Strategy. Consequently, rare earth development in Canada and the Government of Canada's involvement in it is described so the parts of the Canadian Critical Minerals Strategy that pertain to rare earth development can be highlighted. With all of this information, Canada's rare earth development strategy can be coherently described.

The Canadian Critical Minerals Strategy

REEs are included on Canada's list of 31 critical minerals because they are at least one of the following: "essential to Canada's economic security and its supply is threatened; or required for our national transition to a low-carbon economy; or a sustainable source of highly strategic critical minerals for our partners and allies."[75] Although rare earth supply chains may be threatened by China's dominance, it is unlikely the Government of Canada would label them as "essential to Canada's economic security" when considering the negligible impact of rare earths on Canada's GDP.[76] However, essential purposes for rare earths in manufacturing renewable energy technologies would make them necessary for Canada's transition to a low-carbon economy. Additionally, the importance of rare earths in manufacturing various defense technologies could

[73] Ibid.
[74] World Intellectual Property Organization. "Global Innovation Index 2015: Effective Innovation Policies for Development." Accessed March 12, 2023. https://www.wipo.int/edocs/pubdocs/en/wipo_gii_2015.pdf.
[75] Government of Canada, "The Canadian Critical Minerals Strategy," last modified February 15, 2023, https://www.canada.ca/en/campaign/critical-minerals-in-canada/canadian-critical-minerals-strategy.html.
[76] Ibid.

make them a sustainable source of highly strategic critical minerals for Canada's partners and allies.

Further, rare earths are one of six minerals that Canada has initially prioritized in its critical minerals strategy for receiving federal investments because of their potential to generate economic growth and their necessity as inputs for Canada's high priority supply chains.[77] The Canadian Critical Minerals Strategy highlights the importance of rare earths for manufacturing flat screens, touch screens, LED lights, permanent magnets, electronic components, EV drive trains, wind turbines, aircraft components, vehicle components, speakers, steel manufacturing, battery anodes, chemical catalysts, glass manufacturing, and specialized glass lenses.[78] Additionally, the Canadian Critical Minerals Strategy highlights the following uses for scandium (one of the 17 REEs): metal alloys (aluminum); commercial and military aircraft; rockets and vehicle components; high-end sports equipment; specialized light bulbs; solid oxide fuel cells, and; laser research.[79]

The Canadian Critical Minerals Strategy aims to achieve five goals: (1) supporting economic growth, competitiveness, and job creation; (2) promoting climate action and environmental protection; (3) advancing reconciliation with Indigenous peoples; (4) fostering diverse and inclusive workforces and communities, and; (5) enhancing global security and partnerships with allies.[80] To achieve these five objectives, the Canadian Critical Minerals Strategy includes six focus areas through which funding is allocated.[81] The first focus area is driving research, innovation, and exploration.[82] This focus includes a 30% Critical Mineral Exploration Tax Credit for targeted critical minerals as well as close to 300 million CAD of funding that includes: 79.2 million CAD for public geoscience and exploration to better identify and assess mineral deposits; 47.7 million CAD for targeted upstream critical mineral research and development through Canada's research labs, and; 144.4 million CAD for critical mineral research and development, and the deployment of technologies and materials to support critical mineral development chain.[83]

The second focus area, accelerating project development, is the costliest of the six. Through this focus area, Canada's Budgets for 2021 and 2022 included 1.5 billion CAD for the Strategic Innovation Fund to support Canadian critical minerals projects, 40 million CAD to support northern regulatory processes in reviewing and permitting critical minerals projects, and 21.5 million CAD to support the Critical Minerals Centre of Excellence to design federal policies and programs for critical minerals and to help guide project developers through regulatory processes and federal support measures.[84] The third focus area, building sustainable infrastructure, is also one of the costliest. The 2022 Canadian Federal budget proposed 1.5 billion CAD for infrastructure

[77] Ibid.
[78] Ibid.
[79] Ibid.
[80] Ibid.
[81] Ibid.
[82] Ibid.
[83] Ibid.
[84] Ibid.

development for critical mineral supply chains, with a focus on priority deposits (which include rare earths).[85]

The fourth and fifth focus areas have more socio-economic aims that focus on how the wealth from critical mineral development is distributed, rather than ensuring critical minerals are developed in the first place. The fourth goal, advancing reconciliation with Indigenous peoples, provides funding to support Indigenous participation and early engagement in the Canadian Critical Minerals Strategy. This includes hosting critical minerals related roundtables and workshops in prospective regions, and meeting with Indigenous partners to honour treaty rights and promote Indigenous reconciliation.[86] The fifth focus area, growing a diverse workforce and prosperous communities, includes initiatives for diversity and inclusion through a continuation of federal government efforts to attract, train, and retain employees, including women, youth, Indigenous peoples, and other equity-seeking groups.[87] These socio-economic focus areas are continuations and extensions of existing efforts by the Government of Canada which affect how wealth from critical mineral development is to be distributed, rather than affecting how critical minerals are developed. As such, these two focus areas are not of great importance for understanding Canada's rare earth development strategy.

The final focus area is strengthening global leadership and security.[88] This focus area includes initiatives that aim to ensure the Canadian Critical Minerals Strategy is contributing to a rules-based international order which advances Environmental, Social and Governance (ESG) standards.[89] In the Government of Canada's Budget 2022, 70 million CAD was allocated for global partnerships to promote Canadian mining leadership, which includes promoting ESG standards and supporting bilateral and multilateral critical mineral commitments.[90] The ESG standards advocated for in the Canadian Critical Minerals Strategy are made in line with Canada's Responsible Business Conduct (RBC) Strategy.[91] Canada's RBC Strategy notably mentions the human rights violations of Uyghur ethnic minorities and other minorities within the Xinjiang Uyghur Autonomous Region of China. This resulted in the prohibition of the importation into Canada of goods mined, manufactured, or produced using forced or compulsory labour, so that companies must do their due diligence to ensure their suppliers in China are not implicated with forced labour or other human rights violations.[92]

The Canadian Critical Minerals Strategy mentions how within multilateral organizations – including the Organisation for Economic Cooperation and Development, the G7/G20, the International Energy Agency, the World Bank, the International Renewable Energy Agency, the Intergovernmental Forum on Mining, Minerals, Metals and Sustainable Development, the

[85] Ibid.
[86] Ibid.
[87] Ibid.
[88] Ibid.
[89] Ibid.
[90] Ibid.
[91] Ibid.
[92] Government of Canada, "Responsible Business Conduct Abroad Canada's Strategy for the Future," last modified January 25, 2023, https://www.international.gc.ca/trade-commerce/rbc-cre/strategy-2022-strategie.aspx?lang=eng.

Extractive Industries Transparency Initiative, and the Energy Resource Governance Initiative – there is a developing interest in collective action on critical minerals to support the green energy transition.[93] Along with Australia, France, Germany, Japan, the United Kingdom, and the United States, Canada also helped to launch the Sustainable Critical Minerals Alliance to support environmentally sustainable and socially inclusive mineral production.[94] Additionally, Canada has bi-lateral cooperation agreements on critical minerals with the US, the EU, and Japan, and is actively engaging with the United Kingdom and the Republic of Korea on Critical Minerals.[95] In 2022, the US announced that 250 million USD of Defense Production Act Title III funding would be made available companies in Canada and the US that mine and process critical minerals for electric vehicle and stationary storage batteries.[96] Recipients of this award are yet to be announced.

The Canadian Critical Minerals Strategy is intertwined with Canada's Indo-Pacific Strategy, as both strategies antagonize China for its challenges to the rules-based international order and both strategies seek greater cooperation with Japan and the Republic of Korea.[97] To defend Canadian infrastructure from interference, Canada's Indo-pacific strategy includes an initiative to update the Investment Canada Act to "protect Canada's national interests" when investments from SOEs and other foreign entities in Canada's critical minerals supply chain threaten Canada's national security.[98] In November 2022, the Government of Canada announced it would be requiring three Chinese SOEs to divest their investments in Canadian critical minerals companies.[99] At this time, the Canadian Government also announced its updates to the Investment Canada act to protect critical minerals from SOE investment that could pose a risk to national security.[100] The three Chinese SOEs were ordered to divest investments in lithium companies, not rare earths.[101] However, the updates to the Investment Canada Act would protect all critical mineral supply chains alike, including rare earths.[102] In addition to its protective measures on critical minerals with China, Canada's Indo-Pacific strategy also highlights the economic opportunities for cooperation on critical minerals and Canada's strategic obligations for preventing critical

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[93] Government of Canada, "The Canadian Critical Minerals Strategy," last modified February 15, 2023, https://www.canada.ca/en/campaign/critical-minerals-in-canada/canadian-critical-minerals-strategy.html.
[94] Government of Canada, "Our critical minerals strategic partnerships," last modified March 6, 2023, https://www.canada.ca/en/campaign/critical-minerals-in-canada/our-critical-minerals-strategic-partnerships.html.
[95] Government of Canada, "The Canadian Critical Minerals Strategy," last modified February 15, 2023, https://www.canada.ca/en/campaign/critical-minerals-in-canada/canadian-critical-minerals-strategy.html.
[96] The White House, "Joint Statement by President Biden and Prime Minister Trudeau," March 24, 2023, https://www.whitehouse.gov/briefing-room/statements-releases/2023/03/24/joint-statement-by-president-biden-and-prime-minister-trudeau/.
[97] Ibid.
[98] Government of Canada, "Canada's Indo-Pacific Strategy," last modified January 10, 2023, https://www.international.gc.ca/transparency-transparence/indo-pacific-indo-pacifique/index.aspx?lang=eng.
[99] Government of Canada, "Government of Canada orders the divestiture of investments by foreign companies in Canadian critical minerals companies," last modified November 2, 2022, https://www.canada.ca/en/innovation-science-economic-development/news/2022/10/government-of-canada-orders-the-divestiture-of-investments-by-foreign-companies-in-canadian-critical-mineral-companies.html.
[100] Ibid.
[101] Ibid.
[102] Ibid.

mineral supply chain disruption with the Republic of Korea and Japan.[103] Cooperation with these two countries is described as particularly important to Canada's Indo-Pacific Strategy, due to the economic ties Canada has with these two countries and the shared interests of all three countries to uphold a rules-based international order that promotes ESG standards.[104]

Rare Earth Development in Canada

According to the most recent information published by Natural Resources Canada, there are 21 rare earths projects across Canada.[105] Of these 21 projects, six are inactive or suspended/on-hold.[106] The Alces Lake project in Saskatchewan is currently being explored for rare earth deposits.[107] The Falcon Point project in Saskatchewan, the Montviel project in Quebec and the Red Wine project in Newfoundland and Labrador are currently undergoing resource estimates to see how much rare earths are in each of these locations.[108] The Wicheeda project in British Columbia, Eldor (Ashram) project in Quebec, Strange Lake project in Quebec, Crater Lake project in Quebec, the Kwyjibo project in Quebec, and the Port Hope Simpson (Foxtrot) project in Newfounland and Labrador are undergoing preliminary economic assessments to determine the costs of developing the rare earths in these locations.[109] The remaining five projects in Canada are active at the processing stage, where they are under construction or already producing rare earths, and active at the feasibility where they are being considered for serious investment to begin development. The St-Bruno Rare Earth Recycling Demonstration Plant project in Quebec is at the processing stage and is currently under construction.[110] Two downstream processing facilities are built and active at the processing stage in Saskatchewan: Vital Metals' Saskatoon Rare Earth Processing Facility project and the Saskatchewan Research Council (SRC) Rare Earth Processing Facility project.[111] The Kipawa (Zeus) project in Quebec is active at the feasibility stage and is currently undergoing environmental impact review.[112] Lastly, the first active rare earth mine in Canada is the Nechalacho project, which is located in the Northwest Territories.[113]

Several of these projects have received millions of dollars in government support from a variety of sources In March 2023, the Government of Canada unveiled the recipients of the first 14 million CAD of the total 192.1 million CAD in critical minerals research and development

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[103] Government of Canada, "Canada's Indo-Pacific Strategy," last modified January 10, 2023, https://www.international.gc.ca/transparency-transparence/indo-pacific-indo-pacifique/index.aspx?lang=eng.
[104] Ibid.
[105] Government of Canada, "Rare earth elements facts," last modified February 14, 2023, https://natural-resources.canada.ca/our-natural-resources/minerals-mining/minerals-metals-facts/rare-earth-elements-facts/20522.
[106] Ibid.
[107] Ibid.
[108] Ibid.
[109] Ibid.
[110] Harold Von Kursk, "Geomega Resources to launch magnet recycling in Quebec," *Sustainable Biz*, February 8, 2023, https://sustainablebiz.ca/geomega-resources-launch-pioneering-magnet-recycling-plant-quebec.
[111] Government of Canada, "Rare earth elements facts," last modified February 14, 2023, https://natural-resources.canada.ca/our-natural-resources/minerals-mining/minerals-metals-facts/rare-earth-elements-facts/20522.
[112] Government of Canada, "Kipawa Rare Earths Project," last modified August 29, 2022, https://ceaa-acee.gc.ca/050/evaluations/proj/80029.
[113] Vital Metals. "Nechalacho Project, Canada." Accessed March 26, 2023. https://vitalmetals.com.au/portfolio/nechalacho-project/.

funding that would be primarily spent on rare earth development.[114] Of the 14 million CAD that was distributed, Search Minerals received the highest share of $5 million.[115] Search minerals holds a 100% interest in the Port Hope Simpson (Foxtrot) rare earth project in Newfoundland and Labrador.[116] Geomega Resources received $3 million.[117] Geomega Resources owns the Montviel Project in Quebec and the St-Bruno Rare Earth Recycling Demonstration Plant project in Quebec.[118] On September 20, 2022, PrairiesCan announced 7.5 million CAD to support rare earth processing facilities in Saskatchewan.[119] Vital Metals Canada Ltd. received $5 million for its Saskatoon Rare Earth Processing Facility.[120] This investment is an interest-free repayable contribution under the Jobs and Growth Fund.[121] The Saskatchewan Research Council received the other 2.5 million CAD in interest-free repayable funding under the Western Diversification Program to purchase the equipment needed to establish its rare earth processing facility in Saskatoon.[122] In January 2022, the Canadian Northern Economic agency provided an unspecified amount of funding to help develop the Nechalacho demonstration project.[123] Before the Canadian Critical Minerals Strategy was even conceived, Geomega Resources, who owns the St-Bruno Rare Earth Recycling Demonstration Plant project, received a 3 million CAD loan from the Government of Quebec for the purchase of equipment and engineering for the Recycling Demonstration Plant project in September 2020.[124]

Canada's Rare Earth Development Strategy

Canada has just embarked on what is on track to be a multi-billion-dollar journey to develop its critical mineral supply chains. While only a few million dollars have been spent on rare earths so far, rare earths make up a significant portion of the existing critical minerals funds that have already been distributed, and there are still billions of dollars to be spent. Canada is attempting to build a

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[114] Naimul Karim, "Ottawa uses 'carrot and stick' approach as it announces $14 million for Canadian miners," *Financial Post*, March 7, 2023, https://financialpost.com/commodities/mining/ottawa-invest-14-million-canadian-mining-projects.

[115] Ibid.

[116] Search Minerals, "Deep Fox and Foxtrot Projects," accessed March 26, 2023, https://searchminerals.ca/project/deep-fox-and-foxtrot-project/.

[117] Naimul Karim, "Ottawa uses 'carrot and stick' approach as it announces $14 million for Canadian miners," *Financial Post*, March 7, 2023, https://financialpost.com/commodities/mining/ottawa-invest-14-million-canadian-mining-projects.

[118] Geomega, "REE Recycling," accessed March 26, 2023. https://geomega.ca/ree-recycling/.

[119] Government of Canada, "Minister Vandal announces investment in processing of rare earth elements in Saskatchewan," last modifies September 20, 2022. https://www.canada.ca/en/prairies-economic-development/news/2022/09/minister-vandal-announces-investment-in-processing-of-rare-earth-elements-in-saskatchewan.html.

[120] Ibid.

[121] Ibid.

[122] Ibid.

[123] Government of Canada. "Nechalacho Rare Earth Demonstration Project." Last modified January 24, 2022. https://www.cannor.gc.ca/eng/1642129076800/1642168573307.

[124] Megan Smalley, "Geomega Resources secures $3M loan from Quebec Government," *Recycling Today*, September 30, 2020, https://www.recyclingtoday.com/news/geomega-resources-secures-loan-quebec-government-rare-earth-metal-recycling-plant/.

complete rare earth supply chain within its territory that includes everything from mining to recycling operations. Although rare earth applications for military equipment and digital technologies are occasionally mentioned, the applications for rare earths and other critical minerals are most often discussed in documents and statements by the Government of Canada relate to decarbonization efforts. Most funds that have been allocated thus far for rare earth development – including those from PrairiesCan, the Canadian Northern Economic Agency, and the Government of Quebec – are primarily designed to stimulate local economic growth and job creation, although they also serve Canada's other interests for rare earth development.

In an international context, domestic rare earth development serves Canada's interests by enforcing the status quo rules-based international order which Canada contributes to and prospers from. Canadian rare earth development enables Canada and its allies to move forward with decarbonization efforts without having to choose between facing severe rare earth supply chain disruptions and supporting China – a country that the Government of Canada perceives to be challenging the rules-based international order. South Korea and Japan are particularly important partnerships for Canada's rare earth development strategy, as both countries lack domestic rare earth reserves and are in the same region as China.[125] Alternative rare earth suppliers grant South Korea and Japan greater independence from China, hence providing them with a greater capacity to resist China's challenges to the rules-based international order.

Greenland's Rare Earth Development Strategy

Like Canada, the Government of Greenland has yet to release a singular cohesive document that articulates its strategy for rare earth development. Rather, the Government of Greenland's current rare earth development strategy can be explained through analysis of Greenland's Mineral Strategy 2020-2024 in conjunction with Greenland's currently planned rare earth operations. This information can provide a comprehensive description of the Government of Greenland's initiatives and ambitions for rare earth development that would constitute the country's rare earth development strategy. Greenland's Mineral Strategy 2020-2024 contains a singular overall vision of economic growth for Greenland to "differentiate the economy; create new jobs, skills, and business for existing enterprises; contribute with revenue to the treasury, and; contribute to economic development to the benefit of all of Greenland."[126] To achieve this goal, the strategy has outlined five priority areas: improved sharing of geological knowledge; efficient, predictable and transparent case administration; simplified transition from exploration to exploitation; sustainable development of the mineral resources industry, and; competitive tax and royalty model.[127]

There are 13 objectives within these five priority areas which themselves contain a total of 34 initiatives, providing the concrete steps that are taking place to ensure the objectives are

[125] U.S. Geological Survey, 2023, Rare Earths Mineral Commodity Summaries, accessed February 25, 2023. https://pubs.usgs.gov/periodicals/mcs2023/mcs2023-rare-earths.pdf.
[126] Government of Greenland, "Greenland's Minerals Strategy 2020-2024," March 2, 2020, https://govmin.gl/2020/03/new-mineral-strategy-published-greenlands-mineral-strategy-2020-2024/.
[127] Ibid.

achieved. The first priority area is improved sharing of geological knowledge, which within it contains the objectives of providing high quality geological data, increasing access to data, and enhancing knowledge sharing and cooperation.[128] Under the second priority area of efficient, predictable and transparent case administration, the objectives are to strengthen cohesion in case administration, improve information about application procedures, shorten turnaround time, simplify guidelines and executive orders for field activities, revise reporting requirements for exploitation, and organise courses and workshops for small-scale licensees.[129] For a simplified transition from exploration to exploitation, Greenland's Mineral Strategy 2020-2024 has set the objective to simplify exploitation licence requirements.[130] For the priority area of sustainable development of the mineral resources industry, there are objectives to maximise the socio-economic benefits from mineral resource activities and ensure that all parties are informed of their rights in connection with consultation processes for mine development.[131] Lastly, the priority area of a "competitive tax and royalty model" sets the goal of securing a competitive tax and royalty model through initiatives, such as in-depth analysis of tax and royalty systems and monitoring Greenland's competitiveness relative to other mining countries.[132]

Greenland has become an international battleground for actors looking to expand their rare earth supply chains. In 2019, former US President Donald Trump proposed purchasing the autonomous territory for reasons related to the country's potential for rare earth development.[133] The idea of the US purchasing Greenland was viewed as absurd by Danish officials.[134] So, in April 2020, the US came back with a more moderate proposal by announcing a 12.1 million USD aid package that would be put towards developing energy, natural resources, educational exchange, and tourism in Greenland.[135] In the weeks following this announcement, the US announced the opening of a consulate in Greenland's capital, Nuuk, for the first time since 1953.[136] Over a year later, with Trump out of office, the United States Agency for International Development announced a second aid package priced at 10 million dollars that would be allocated to Greenland.[137] Like the first package, this second package was expected to be used for the mining sector, tourism, and education.[138]

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[128] Ibid.
[129] Ibid.
[130] Ibid.
[131] Ibid.
[132] Ibid.
[133] Vivian Salama, Rebecca Ballhau, Andrew Resuccia and Michael C. Bender, "President Trump Eyes New Real-Estate Purchase: Greenland," *Wall Street Journal,* August 16, 2019, https://www.wsj.com/articles/trump-eyes-a-new-real-estate-purchase-greenland-11565904223.
[134] Conor Finnegan, "After Trump tried to buy Greenland, US gives island $12M for economic development," *ABC News*, April 23, 2020, https://abcnews.go.com/Politics/trump-buy-greenland-us-island-12m-economic-development/story?id=70305163.
[135] Ibid.
[136] Ibid.
[137] Jacob Gronholt-pederson, "In Arctic push, US extends new economic aid package to Greenland," *Reuters*, September 15, 2021, https://www.reuters.com/world/europe/arctic-push-us-extends-new-economic-aid-package-greenland-2021-09-15/.
[138] Ibid.

These investments were given to the Government of Greenland rather than directly in rare earth projects. Thus, the line drawn between US investments in Greenland and Greenland's rare earths is indirect, but existent, nonetheless. A close relationship with Greenland provides the US with multiple advantages. For example, there is a possibility that investments in Greenland could have been motivated by Greenland's geographical position relative to Russia, as it relates to defense against Russian missiles.[139] However, real steps toward the US' investments in Greenland began in October of 2019, two months after Trump's gesture to purchase the territory and five months before the first aid package.[140] At this time, the former US Secretary of State, Mike Pompeo, sent his chief advisor, Thomas Brechbuhl, to Greenland where discussions were said to have primarily revolved around Greenland's rare earth industry.[141]

The EU also has its eyes set on Greenland's mineral wealth. In July 2021, Greenland joined the European Raw Materials Alliance, an alliance organized by the EU that coordinates investments and provides seed money for European mines, processing plants, and related industries.[142] While Greenland is in possession of a multitude of materials that are of interest to the European Raw Materials Alliance, it is Greenland's rare earths that can provide the most value to the European Raw Materials Alliance.[143] In connection with the introduction of the Alliance, the European commissioner responsible for development of the union's single market for goods and services, Thierry Bretton, stated: "By diversifying the supply from third world countries and developing the EU's own capacity for extraction, processing, recycling, refining, and separation of rare earths, we can become more resilient and sustainable."[144] Bretton further elaborated, "Rare-earth minerals are key to the further development of green technology and the fight against climate change, and Europe must cut its dependence on China for these minerals."[145]

While Greenland has yet to have any domestic rare earth production, there are numerous projects that have been under development in the country over the past couple of years. The largest of these is the Kvanefjeld Rare Earth Project, which is said to have "the potential to become the most significant western world producer of rare earths."[146] Upon the project's completion, it is expected to have complete mining and processing capabilities.[147] The Kvanefjeld Project is owned by an Australian Company called Greenland Minerals whose largest stakeholder – at nine percent

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[139] Martin Breum, "Russia's hypersonic missiles could be why Donald Trump wants to buy Greenland," *Arctic Today*, December 3, 2019, https://www.arctictoday.com/russias-hypersonic-missiles-could-be-why-donald-trump-wants-to-buy-greenland/.
[140] Martin Breum, "Controversial mine in Greenland enters decisive phase," *Martin Breum*, January 14, 2021, https://www.martinbreum.dk/controversial-mine-in-greenland-enters-decisive-phase/.
[141] Ibid.
[142] Kevin McGwin, "Greenland joins EU minerals group, *Nunatsiaq News*, July 12, 2021, https://nunatsiaq.com/stories/article/greenland-joins-eu-minerals-group/.
[143] Ibid
[144] Ibid.
[145] Ibid.
[146] Greenland Minerals, "Kvanefjeld Project," accessed April 10, 2023, https://ggg.gl/project/.
[147] Ibid.

– is a Chinese partially state owned mining conglomerate, Shenghe Resources.[148] This nine percent has the potential to take over the entire Kvanefjeld operation, as Shenghe signed a non-binding agreement with Greenland Minerals in 2018 which included a clause that stipulated Shenghe could eventually buy the total output of rare earths from Kvanefjeld.[149] This implies that Shenghe could dictate where all products from Kvanefjeld are dispersed throughout the globe. Following this agreement, Shenghe signed another deal in 2019 with the China National Nuclear Corporation, a state-owned enterprise, that would ensure the China National Nuclear Corporation access to products coming out of Kvanefjeld.[150] The China National Nuclear Corporation is thought to be involved in developing nuclear power and nuclear weapons in China. In 2013, the European Union requested Greenland restrict China's access to its REMs. But Greenland's premier at the time rejected this request, stating, "Greenland is open for investments from the whole world."[151] The Kvanefjeld Project would also produce uranium as a by-product of its rare earth production.[152] This is a major problem for Greenland Minerals because of a law that passed in Greenland in November 2021, which banned the exploitation of any ore body that has more than 100 parts per million of uranium in Greenland.[153] The passing of this law halted the Kvanefjeld Project out of concern for its potential environmental effects.[154] Greenland Minerals has continued to fight the Government of Greenland's decision to move forward with the Kvanefjeld Project, but has been unsuccessful thus far.[155]

There are, however, other rare earth projects in Greenland. Aside Kvanefjeld, Tanbreez is the Greenlandic rare earth project that has received the most attention from external state actors. Unlike Kvanefjeld, the Tanbreez project will not produce excess uranium and is privately owned without known ties to China. The US first expressed interest in the Tanbreez project in 2019. Just days before President Trump had proposed purchasing Greenland, Tanbreez CEO Greg Barnes was invited to the White House to discuss the potential of his project.[156] The Ivigtût Project is another rare earth mining project currently in the works in Greenland that is wholly owned by an Australian Company, Eclipse Metals. [157] Lastly, Canadians too have made their stake in Greenland rare earths. In August 2022, a Canadian Company called Neo Performance Materials purchased

[148] Martin Breum, "Controversial mine in Greenland enters decisive phase," *Martin Breum*, January 14, 2021, https://www.martinbreum.dk/controversial-mine-in-greenland-enters-decisive-phase/.
[149] Ibid.
[150] Ibid.
[151] Chuan Chen, "China's Engagement in Greenland: Mutual Economic Benefits and Political Non-Interference," Polar research 41 (2022): 3, http://dx.doi.org/10.33265/polar.v41.7706.
[152] Greenland Minerals, "Kvanefjeld Project," accessed April 10, 2023 https://ggg.gl/project/.
[153] "Greenland bans uranium mining, halting rare earths projects," *Reuters*, November 10, 2021, https://www.reuters.com/world/americas/greenland-bans-uranium-mining-halting-rare-earths-project-2021-11-10/.
[154] Ibid.
[155] "Greenland Minerals' Kvanefjeld rare-earths project hits roadblock." *Mining Technology*, September 27, 2022. https://www.mining-technology.com/news/greenland-minerals-kvanefjeld-snag/.
[156] Jacob Greber, "How a Perth geologist convinced Trump to buy Greenland," *Financial Review*, April 1, 2021, https://www.afr.com/world/north-america/how-a-perth-geologist-convinced-trump-to-buy-greenland-20210330-p57f96.
[157] Eclipse Metals, "Ivigtût Project," accessed April 10, 2023, https://www.eclipsemetals.com.au/projects/ivittuut-project/.

the Sarfartoq Rare Earth Mining Project in Greenland.[158] While all three of these projects are under development, none are at the stage where they are ready to begin mining production.

Above all, the objective of Greenland's rare earth development strategy is economic growth. Greenland's Mineral Strategy 2020-2024 and the various rare earth projects that are underway in Greenland provide Greenland with the significant economic benefits without notable financial costs to the Government of Greenland. While existing projects in Greenland with the greatest potential to be developed in the near future are owned by US allied countries, Greenland has yet to take a clear stance against Chinese investments in its rare earth industry. There is also a notable environmental element to Greenland's rare earth development strategy. A clear threshold was displayed in which Greenland would not compromise environmental degradation for economic growth with the development of uranium, which consequently impacted Greenland's rare earth development.

Explanatory Model

The rare earth development strategies of Canada and Greenland are both economic in that their first and foremost goals are to bring jobs and wealth to each country through rare earth development. But the approach to rare earth development taken by each country is distinct. From the previous sections, which describe the rare earth development strategies of Canada and Greenland, three features distinguish each strategy from the other. First is domestic government spending. The Government of Canada has already put tens of millions of dollars towards its domestic rare earth development and could be investing billions more. Conversely, while the Government of Greenland is providing regulatory support and encouragement for domestic rare earth development, it has yet to put any of its own funds directly into supporting rare earth development. Second, both countries have formed alliances on rare earth development with countries that are seeking independence from Chinese rare earth supply chains – Canada with the US, Japan, and South Korea, and Greenland with the EU and the US. However, Canada has excluded China from becoming involved in its rare earth industry whereas Greenland has allowed China to become involved in its rare earth industry. Last are environmental attitudes. While concerns for the environment are integrated into the strategies of both countries, Canada uses concerns for the environment to justify a more pro-development stance since rare earths can be used to manufacture renewable energy sources that can replace fossil fuels. On the other hand, Greenland uses concerns for the environment to justify a more anti-development stance due to the environmental problems associated with mining.

Economic Capabilities

Arguably the most important factor when considering the differences in government spending between the two countries is each country's capacity to spend. Canada has a population just shy of

[158] Reuters, "Neo agrees to buy Greenland rare earth project from Hudson Resources," *Mining*, August 22, 2022, https://www.mining.com/web/neo-agrees-to-buy-greenland-rare-earth-project-from-hudson-resources/.

40 million.[159] Greenland's comparatively insignificant population is estimated to be around 56,500.[160] The two countries are similar in terms of GDP per capita, which allows similar levels of development. However, Greenland's vastly smaller population means that it's economy dwarfs in comparison to Canada's. Canada's GDP per capita currently sits at 51,987.9 (current USD) whereas Greenland's GDP per capita currently sits at 54,571.2 (current USD).[161] Canada's most recently recorded GDP by the World Bank in 2021 was 1.99 trillion (current USD).[162] Greenland's most recently recorded GDP by the World Bank in 2020 was 3.08 billion (current USD).[163] This allows Canada to have a much higher budget than Greenland, from which funds for rare earth development can be allocated. Canada's Budget 2022 allocated 190.3 billion CAD for budgetary expenditures, which is equal to roughly 141.2 billion USD.[164] Conversely, Greenland doesn't even fund much of its own budget. Denmark provides Greenland with an annual block grant of roughly 511 million USD, which amounts just more than half of Greenland's public budget and about a fifth of Greenland's GDP.[165] Greenland also receives an annual subsidy from the EU of over 30 million euros for reasons related to Greenland giving EU fisheries rights in Greenland waters.[166] The EU has also allocated 225 million euros to Greenland from 2021-2027 through a bilateral program grant for the long-term development of Greenland.[167] 90% of the grant will target the education sector while the remaining 10% targets "Green Growth," which includes energy, production of hydrogen, biodiversity, climate, and research.[168] For context, the Canadian Critical Minerals Strategy alone is set to have 3.8 billion CAD allocated towards it, which is comparable to Greenland's entire GDP and multiple times greater than Greenland's annual budget.[169]

Based on this information, it would not be reasonable to expect both countries to have comparable spending on their rare earth development due to capacity alone. For Greenland to make

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[159] Statistics Canada, "Canada's population clock (real-time model)," last modified March 22, 2023, https://www150.statcan.gc.ca/n1/pub/71-607-x/71-607-x2018005-eng.htm.

[160] Greenland Travel, "Facts about Greenland," accessed May 6, 2023, https://www.greenland-travel.com/inspiration/articles/facts-about-greenland/.

[161] World Bank. "GDP per capita (Current US$)." Accessed May 6, 2023. https://data.worldbank.org/indicator/NY.GDP.PCAP.CD.

[162] World Bank, "Current GDP (US$) – Canada," accessed March 4, 2023, https://data.worldbank.org/indicator/NY.GDP.MKTP.CD?locations=CA.

[163] World Bank, "Current GDP (US$) – Greenland," accessed March 4, 2023, https://data.worldbank.org/indicator/NY.GDP.MKTP.CD?locations=GL.

[164] Government of Canada, "2022-23 Estimates," last modified July 12, 2022, https://www.canada.ca/en/treasury-board-secretariat/services/planned-government-spending/government-expenditure-plan-main-estimates/2022-23-estimates.html.

[165] International Trade Administration, "Denmark – Country Commercial Guide," last modified November 30, 2022, https://www.trade.gov/country-commercial-guides/denmark-other-areas-kingdom-denmark.

[166] "Greenland's Modern Path To Independence," Visit Greenland, accessed May 6, 2023, https://visitgreenland.com/articles/greenlands-modern-path-to-independence/#:~:text=While%20it%20is%20recognised%20that,of%20responsibility%20for%20its%20budget.

[167] Ibid.

[168] Ibid.

[169] "The Canadian Critical Minerals Strategy," Government of Canada, last modified February 15, 2023. https://www.canada.ca/en/campaign/critical-minerals-in-canada/canadian-critical-minerals-strategy.html.

contributions to its rare earth industry that are comparable to what Canada has funded for its own industry relative to its own GDP, Greenland would be giving an amount of money that would be inconsequential in relation the amount of money needed to develop a rare earth mine. This can also help explain why Canada has blocked Chinese SOE investment and Greenland has not. Foreign investment is needed to fund Greenland's rare earth development, since Greenland lacks the capacity to fund its rare earth development domestically. China is an investor with deep pockets that can provide a lot of opportunity to Greenland. Conversely, Canada is capable of funding its rare earth development domestically which affords Canada a greater ability to reject potential investors such as China.

Independent Policy-Making Capabilities

Despite the economic benefits Greenland receives as a country within the Kingdom of Denmark, there is a widespread belief among the general population of Greenland and Greenlandic officials that Greenland should eventually seek independence. In 2020, Kim Kielsen who was then Prime Minister of Greenland stated:

> "The mandate we have from our people says that we must work towards independence. There should be no doubt that everything we do is part of this preparatory process. More than 70 percent of our population want us to move towards independence, and it is stipulated in the law on Greenland's Self Rule how this must happen. That is the mandate we have been given and it has been with us for a very long time."[170]

At an event hosted by the Wilson Center in June 2022, Thomas Lauridsen, the Government of Greenland's Chief Advisor for the Ministry of Mineral Resources and Justice, stated:

> "The Green Transition applies to demand for many minerals. Therefore, in the years to come, and now maybe more than ever before, Greenland has an opportunity to develop its mineral resource sector. By developing the mineral resource sector, Greenland can diversify its economy and skills through the new types of job offers in the industry and through the possibility for contracts to existing and new businesses. The mining sector can contribute to the treasury, and make Greenland… become more economically independent."[171]

Beyond the statements of public officials, independence is widely supported amongst Greenland's general population. According to a 2017 poll, most Greenlanders favor eventual independence.[172]

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[170] Martin Breum, "Greenland's premier does not foresee a US take-over and remains committed to Greenland's quest for independence," High North News, January 20, 2020, https://www.highnorthnews.com/en/greenlands-premier-we-must-work-towards-independence.

[171] "Trade, Minerals, and the Green Transition in Greenland: A Conversation with Prime Minister Múte B. Egede," *Wilson Center*, June 15, 2022, https://www.wilsoncenter.org/event/trade-green-transition-greenland-prime-minister-mute-b-egede.

[172] "Greenland: from Danish autonomy to Chinese supervision?" *A Revu Parlementaire* at https://www.larevueparlementaire.fr/index.php?option=com_k2&view=item&id=1465:groenland-de-l-autonomie-danoise-a-la-tutelle-chinoise&Itemid=1524.

However, 78% of the population is against independence if it means a drop in living standards and social security benefits.[173] The key to Greenland's independence movement is that it is to be gradual. Greenlanders understand that premature independence could be disastrous for the country since it currently lacks the economic capability to stand on its own two feet. Greenland has been cautious around independence talks as pre-mature independence could have disastrous consequences for the country; recall that Denmark pays for half of all of Greenland's budget. Thus, for Greenland, economic independence is the necessary precursor to achieving political independence.[174]

Greenland has been on a trajectory towards independence for decades now. Greenland established its first government in 1979 with the introduction of Home Rule. which gave Greenland's Provincial Council the title of Parliament and the power to legislate and manage almost all parts of Greenland's government administration.[175] After 1979, Greenland's Home Rule gradually adopted the administration of areas that had previously been administered by the Danish state, such as health, education, taxation, infrastructure, business affairs, domestic affairs, spatial planning, social affairs, and housing.[176] Then, in a November 2008 referendum, 75% of voters were in favour of the Self-Government Act, which recognised Greenlanders as their own nation entitled to the right of self-determination, that has the option of independence.[177] The Self-Government Act and the inauguration of Greenlandic Self Rule then took place in 2009.[178] This led to the inauguration of Greenlandic Self Rule from June 21st 2009.[179] Through Self Governance and Self Rule, Greenland seized control over its mining and natural resource sectors as well as several other sectors.[180]

Currently, Greenland controls most of its own policy and administration, with the greatest exceptions which remain in Danish control being foreign policy, defence and national security, the judicial system, and the monetary system.[181] However, Greenland still has some influence over its foreign policy – the Itilleq Declaration of 2003 states that Greenland must be heard in cases that relate to its interests. Therefore, Greenland can take over certain negotiations and Greenland may enter into agreements with nations other than Denmark.[182] There is an apparent issue within this constitution when it comes to the administration and governance of rare earth development in Greenland. Rare earths are a mineral resource, and therefore should be governed by Greenland. They are also key to critical defense supply chains, and so could arguably fall under Copenhagen's

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[173] Ibid.
[174] Dubois, Kenty. "The Security Implications of China-Greenland Relations." *The Polar Connection*, July 10, 2018. https://polarconnection.org/security-china-greenland-relations/.
[175] "Greenland's Modern Path To Independence," Visit Greenland, accessed May 6, 2023, https://visitgreenland.com/articles/greenlands-modern-path-to-independence/#:~:text=While%20it%20is%20recognised%20that,of%20responsibility%20for%20its%20budget.
[176] Ibid.
[177] Ibid.
[178] Ibid.
[179] Ibid.
[180] Ibid.
[181] Ibid.
[182] Ibid.

authority. In practice, Greenland's rare earth policy has been shaped entirely in Nuuk, as Copenhagen has yet to override any decisions made by the Government of Greenland. As such, Greenland is designing its own rare earth policy but without consideration for its security implications, since security is the concern of Denmark. Thus, it is easier for Greenland to ignore the security risks of having China involved in its rare earth industry, making Chinese SOE investment far more attractive to Greenland.

Greenland and China

Mining presents one of the most feasible options for Greenland's economic independence. This is a necessary precondition to political independence because of Greenland's dependence on Denmark for financial aid.[183] Existing research suggests that Greenland could achieve economic independence in a relatively short period of time through the mining industry.[184] However, it is thought to require as many as 20 large-scale projects to operate simultaneously within the country to achieve such economic gains, which presents a challenge to Greenland in terms of labour and financing.[185] The total number of employed persons in Greenland is about 25,000 of their total population of 56,000, so mining projects could, in theory, substantially boost employment.[186] However, the issue with Greenland's domestic labour force is that it is underqualified and undereducated to independently manage mining operations. To build a mining industry sufficient for Greenland's independence would require an inflow of foreign labour.[187] With that inflow comes the risk that the current Greenlandic population would become a minority in Greenland, making this an unpopular plan amongst pro-independence Greenlandic nationalists.[188] The need for education in Greenland could have helped motivate the aid packages provided by the US to Greenland in 2020 and 2021. For reasons related to rare earth development, these aid packages provided funding for education, and mining and tourism in Greenland.[189] The US may have been hoping that an educated population capable of operating rare earth mines independently could help incentivize Greenland to pursue rare earth development.

Greenland also simply lacks the domestic capital to fund the large-scale mining projects necessary for its independence.[190] For this reason, Greenlandic politicians widely agree that

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[183] Chuan Chen, "China's Engagement in Greenland: Mutual Economic Benefits and Political Non-Interference," *Polar Research* 41 (2022): 2, http://dx.doi.org/10.33265/polar.v41.7706.
[184] Ibid.
[185] Kenty Dubois, "The Security Implications of China-Greenland Relations," *The Polar Connection*, July 10, 2018, https://polarconnection.org/security-china-greenland-relations/.
[186] Chuan Chen, "China's Engagement in Greenland: Mutual Economic Benefits and Political Non-Interference," Polar research 41 (2022): 2, http://dx.doi.org/10.33265/polar.v41.7706.
[187] Kenty Dubois, "The Security Implications of China-Greenland Relations," *The Polar Connection*, July 10, 2018, https://polarconnection.org/security-china-greenland-relations/.
[188] Ibid.
[189] Jacob Gronholt-pederson, "In Arctic push, US extends new economic aid package to Greenland," *Reuters*, September 15, 2021, https://www.reuters.com/world/europe/arctic-push-us-extends-new-economic-aid-package-greenland-2021-09-15/.
[190] Chuan Chen, "China's Engagement in Greenland: Mutual Economic Benefits and Political Non-Interference," Polar research 41 (2022): 2, http://dx.doi.org/10.33265/polar.v41.7706.

attracting foreign investment is the way forward for developing Greenland's mining industry.[191] Greenland can gain from both western and Chinese investment. Investment bids from Chinese companies and SOE's in Greenland's rare earth projects provide Greenland with greater economic benefits by giving investors from western countries additional competition.[192] Chinese investment also gives Greenland a bargaining chip to incentivize countries that oppose Chinese investment, such as the United States and Denmark. This provides Greenland with greater benefits to replace those Greenland would otherwise be receiving from China.[193]

Greenland and China began developing bilateral relations after Greenland's adoption of the Self-Government Act in 2009, when the Government of Greenland first started looking at China as a potential investor for its mining industry.[194] Then, in November 2011, Ove Karl Berthelsen, who was Greenland's Minister for Industry and Natural Resources, visited the China Mining Conference and Expo and met with China's then Vice-Minister for Land and Resources Wang Min as well as several Chinese companies.[195] China's then Minister for Land and Resources, Xu Shaoshi, later visited Nuuk on a diplomatic mission in April 2012 and a large Chinese investor delegation visited Greenland in 2013.[196] Recall that a Chinese partially state-owned mining conglomerate called Shenghe is the largest stakeholder in the company that owns Greenland's largest rare earth project, Kvanefjeld.[197] In 2018, Shenghe signed a non-binding agreement with Greenland Minerals which included a clause that stipulated Shenghe could eventually buy the total output of rare earths from Kvanefjeld.[198] This implies that Shenghe could eventually dictate where the entirety of Kvanefjeld's production is directed.[199] Most recently, in November 2021, the Government of Greenland established a more permanent presence in China via a representative office in Beijing, with the goal of the office for Greenland being to promote trade as well as foster economic and cultural relations with China and the rest of East Asia.[200]

China and Greenland have both been coy not to frame their relationship as anything strategic. In 2018, the state-owned China Communications Construction Company was close to landing a contract that would aid the extension of airport runways in Greenland.[201] However, the Danish Government intervened and instead volunteered to fund half of the estimated cost, in an effort that was widely perceived as an attempt to keep China out of Greenland.[202] This triggered the populist pro-independence Partii Naleraq to withdraw from the Greenlandic Parliament's

[191] Ibid.
[192] Ibid., 3.
[193] Ibid.
[194] Patrik Andersson, "Greenland," *The People's Map*, March 3, 2022, https://thepeoplesmap.net/country/greenland/.
[195] Ibid.
[196] Ibid.
[197] Martin Breum, "Controversial mine in Greenland enters decisive phase," *Martin Breum*, January 14, 2021, https://www.martinbreum.dk/controversial-mine-in-greenland-enters-decisive-phase/.
[198] Ibid.
[199] Ibid.
[200] Patrik Andersson, "Greenland," *The People's Map*, March 3, 2022, https://thepeoplesmap.net/country/greenland/.
[201] Ibid.
[202] Ibid.

governing coalition in protest of receiving Danish assistance.[203] Although some Chinese academics have made the argument that Greenland could play a key role in China's Polar Silk Road, Chinese officials have been cautious when it comes to statements regarding Greenland's strategic importance to China. Recall that Greenland's defense and security is governed by Denmark.[204] Thus, any alliance between Greenland and China that can be interpreted as strategic could be challenged by Denmark, which itself is engaged with several defense cooperation initiatives with the US. These initiatives include NATO, the Euro-Atlantic Partnership Council, the Organization for Security and Cooperation in Europe, and the Arctic Council.[205]

Canada and China

Unlike Greenland, Canada's relationship with China outside of rare earth development has been soured by a few events. In December 2018, the Chief Financial Officer of Chinese Technologies company Huawei, Meng Wanzhou, was arrested by Canadian police in Vancouver on behalf of an American court.[206] Days after Meng's arrest, the Chinese government arrested and detained two Canadian citizens in China.[207] These citizens were kept as prisoners in China for over 1000 days and were eventually freed on the same day as Meng in September 2021.[208] Recent reports from Canada's intelligence agencies showed that China had interfered with Canadian federal elections in 2019 and 2020.[209] In February 2023, a Chinese spy balloon was shot down by a US fighter aircraft after being caught flying over western Canada.[210] Canada's antagonistic attitudes towards China are not unique to critical minerals and rare earth development; rather, Canada's antagonistic attitudes towards China with critical minerals and rare earth development are a reflection of Canada's overall approach to China.

The main document that outlines Canada's approach to China is the Canadian Indo-Pacific pacific strategy which was released in late 2022. Within this strategy, China is described as an adversary to the status quo rules-based international order which Canada supports:

> "China has benefitted from the rules-based international order to grow and prosper, but it is now actively seeking to reinterpret these rules to gain greater advantage. China's assertive pursuit of its economic and security interests, advancement of

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[203] Ibid.
[204] Ibid.
[205] "U.S. Security Cooperation with Denmark," U.S. Department of State, February 14, 2023, https://www.state.gov/u-s-security-cooperation-with-denmark/#:~:text=Denmark's%20Partnership%20with%20NATO&text=Denmark%20led%20NATO%20Mission%20Iraq,a%20U.S.%20Space%20Force%20Command.
[206] John Boyko, "Meng Wanzhou Affair (Two Michaels Case)," *The Canadian Encyclopedia*, December 15, 2022, https://www.thecanadianencyclopedia.ca/en/article/meng-wanzhou-affair#:~:text=The%20two%20Michaels%20were%20imprisoned,options%20as%20a%20middle%20power.
[207] Ibid.
[208] Ibid.
[209] Crispin Thorold, "Canada claims China interfered in its elections," *NPR*, March 19, 2023, https://www.npr.org/2023/03/19/1164585528/canada-claims-china-interfered-in-its-elections.
[210] Vincent Rigby, "Up in the Air: The Spy Balloon and What it Means for Canada," *Center for Strategic and International Studies*, https://www.csis.org/analysis/air-spy-balloon-and-what-it-means-canada.

> unilateral claims, foreign interference and increasingly coercive treatment of other countries and economies have significant implications in the region, in Canada and around the world."[211]

Canada's Indo-Pacific Strategy makes specific note of China's challenges to the status quo rules-based international order, including China's disregard for UN rulings on disputes in the South China Sea and its actions to further militarize that region. China refused to accept a ruling against it by an international tribunal in the Hague in a key 2016 legal case over strategic reefs and atolls, which Beijing claimed would give it control over disputed waters in the South China Sea.[212] According to US military sources, China has now militarized as many as three islands in the South China Sea.[213] The Indo-Pacific Strategy also makes note of the forced labour problems occurring in China.[214] In the Xinjiang region of China, the Chinese government has been retraining and relocating unemployed workers as part of a broader pattern of the Uyghur Muslim population.[215] Products for which the Government of Canada considers there to be a high probability of being produced wholly or in part by non-voluntary Uyghur workers include polysilicon and downstream electronic and photovoltaic products, which require REEs to manufacture.[216] Canada's Indo-Pacific Strategy further opposes China's treatment of Uyghurs in noting, "China's increasing reluctance to comply with the mandates of UN institutions, such as its efforts to block the UN High Commissioner for Human Rights' report on the situation of Uyghurs in Xinjiang, China, from consideration by the UN Human Rights Council."[217] In late 2022, a UN report on the situation of Uyghurs in Xinjiang detailed how the rights abuses against the Uyghur minority group in China may amount to crimes against humanity.[218]

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[211] "Canada's Indo-Pacific Strategy," Government of Canada, last modified January 10, 2023, https://www.international.gc.ca/transparency-transparence/indo-pacific-indo-pacifique/index.aspx?lang=eng.
[212] Tom Phillips, Oliver Holmes, and Owen Bowcott, "Beijing rejects tribunals ruling in South China Sea Case," *The Guardian*, July 12, 2016, https://www.theguardian.com/world/2016/jul/12/philippines-wins-south-china-sea-case-against-china.
[213] "China has fully militarized three islands in South China Sea, US admiral says," *The Guardian*, March 21, 2022, https://www.theguardian.com/world/2022/mar/21/china-has-fully-militarized-three-islands-in-south-china-sea-us-admiral-says.
[214] Canada's Indo-Pacific Strategy," Government of Canada, last modified January 10, 2023, https://www.international.gc.ca/transparency-transparence/indo-pacific-indo-pacifique/index.aspx?lang=eng.
[215] "Study of Supply Chain Risks related to Xinjiang forced labour," Government of Canada, last modified March 6, 2022, https://www.international.gc.ca/transparency-transparence/study_forced_labouretude_travail_force.aspx?lang=eng.
[216] Ibid.
[217] "Canada's Indo-Pacific Strategy," Government of Canada, last modified January 10, 2023, https://www.international.gc.ca/transparency-transparence/indo-pacific-indo-pacifique/index.aspx?lang=eng.
[218] "UN, China present opposed reports on Uighurs in Xinjiang," *Aljazeera*, September 1, 2022, https://www.aljazeera.com/news/2022/9/1/un-china-present-diametrically-opposed-views-on-xinjiang#:~:text=The%2045%2Dpage%20report%20released,report%20as%20a%20%E2%80%9Cfarce%E2%80%9D.

Satisfaction with International Order

Following the previous analysis, the question that must be posed is why Canada has chosen to adopt this approach to international order, and consequently, why Greenland has decided to adopt a different approach. These different approaches to international order can be explained by the differences in each country's size and capabilities relative to other countries in the international system.[219] The middle power approach to Canadian foreign policy analysis would suggest that middle powers who are traditional allies of the US, such as Canada, share a preference for the status quo rules-based order and multilateralism. [220] The reason for this is that international rules, norms, and institutions help provide international stability, ensure free and open global commerce, and protect smaller powers from being coerced by great powers.[221] By opposing China's challenges to the rules-based international order, Canada has joined US allies and other middle powers in the Indo-Pacific region (including Japan, Australia, and South Korea) in supporting the status quo rules-based international order.[222] In other words, Canada's rare earth development strategy is shaped by Canada's satisfaction with the status quo rules-based international order since the status quo rules-based international order places Canada in a position of relative strength that Canada is satisfied with.

Greenland and China are both dissatisfied with their rankings within the international system. Though Greenland has economically benefitted from Denmark, Greenland's policy-making capabilities have been hindered by Greenland's position as a country within the Kingdom of Denmark. Greenland wants to change its rank within the international order by gaining independent policy-making capabilities. This, however, can only be achieved through economic independence – which China can help provide. Greenland is not opposed to working with China, since, like China, Greenland is seeking to make changes to the international order by gaining its independence. China wants a more permissive international environment so it can pursue its interests without regard for international law and norms. Canada is satisfied with its rank in the international order, so Canada wants to preserve the international order and its rank within it. Greenland, however, is attempting to change its rank within the international order, so it is more willing to make the international order more permissive to do so. In a less permissive international environment, Greenland would not be able to receive investment from rule breakers like China. Hence, the less permissive international order Canada favours is one that limits Greenland's ability to increase its ranking through independence.

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[219] David B. Dewitt and John J. Kirton, "Three Theoretical Perspectives," in *Readings in Canadian Foreign Policy: Classic Debates & New Ideas, Third Edition*, ed. Duane Bratt and Christopher J. Kukucha (Ontario: Oxford University Press, 2015), 68.

[220] Erik Brattberg, "Middle Power Diplomacy in an Age of US-China Tensions," *The Washington quarterly* 44, no. 1 (2021): 221, https://doi.org/10.1080/0163660X.2021.1896136.

[221] Ibid.

[222] Kenneth Holland, "Canada and the Indo-Pacific Strategy," *Canadian Foreign Policy Journal* 27, no. 2 (2021): 243, https://doi.org/10.1080/11926422.2021.1880949.

Types of Environmental Concerns

Recall that Greenland halted the completion of its largest rare earth project, Kvanefjeld, due to environmental concerns with the uranium byproducts of rare earth mining.[223] Meanwhile, the Government of Canada has used environmental concerns to justify the development of its rare earth mining industry. Rare earths can be used to build renewable energy technologies to replace fossil fuels and limit climate change, which is a global issue.[224] As such, Canada used environmental concerns which impact the international system as a whole to justify increasing rare earth development, whereas Greenland used domestic enviromental concerns associated with rare earth development to justify limiting rare earth development. Thus, there are two types of environmental concerns which have shaped the differences in rare earth development in each country.

Understanding the differing approaches to international order of Canada and Greenland can shed new light on the differing environmental attitudes of Canada and Greenland reflected in each country's rare earth development strategy. Canada benefits greatly from the status quo rules-based international order, and its position in the international order wants to uphold the present order. Thus, Canada is more inclined to voluntarily cooperate on issues like the environment and climate change, since this cooperation further enforces the status quo rules-based order over a more permissive system, in which countries can act in their own self interest more often rather than in the interest of the system as a whole. Cooperating on climate change is a reflection of Canada's overall commitment to multilateralism and the international order. Conversely, Greenland is more concerned about its own domestic environment for the same reasons Greenland welcomed Chinese investments into its rare earth industry: its approach to international order. Greenland is dissatisfied with its inability to pursue its own interests in the current international order, and is not interested in voluntarily cooperating with other countries out of collective interests. Rather, Greenland's greatest concern is its own environment and the immediate local damage it might see from exploitative mining practices.

[223] "Greenland bans uranium mining, halting rare earths projects," *Reuters*, November 10, 2021, https://www.reuters.com/world/americas/greenland-bans-uranium-mining-halting-rare-earths-project-2021-11-10/.
[224] Government of Canada, "The Canadian Critical Minerals Strategy," last modified February 15, 2023, https://www.canada.ca/en/campaign/critical-minerals-in-canada/canadian-critical-minerals-strategy.html.

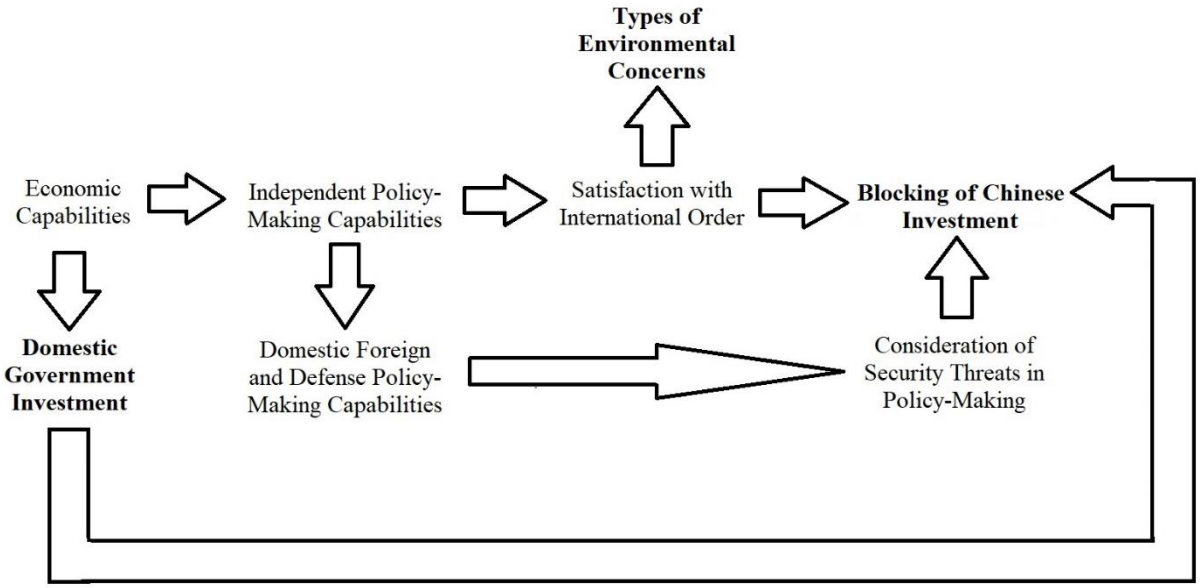

Figure 1: Explanatory Model

Figure 1 illustrates how the differences between each country translate to an explanatory model of why Canada and Greenland have adopted different rare earth development strategies. The independent variable at the root of the differences between each countries' rare earth development strategy is economic capabilities. Economic capabilities determine each country's capacity to independently fund rare earth development through domestic government investment. Canada's decision to block Chinese investment was in part shaped by its capacity to offset Chinese investment with government investments. Conversely, Greenland's decision not to block Chinese investment was in part shaped by its inability to offset Chinese investment with government investments. Economic capabilities are also a precondition for independent political decision-making capabilities. As in the case of Greenland, economic independence is the necessary precursor to political independence since Greenland would need to fund its own budget if it were to become fully independent. Political independence for Greenland would also imply administering its own foreign and defense policy; as such, its policy would need to consider the security ramifications of doing business with China, as Canada has. Greenland's current government does not manage its foreign and defence policy, and Greenland is not considering the security implications of Chinese investment in its rare earth sector since Greenland's security is the responsibility of Denmark. Canada, however, is responsible for its own security, so it is considering the security implications of Chinese investment in its rare earth sector. This has led to Canada's exclusion of China from its rare earth sector.

Greenland's lack of independent political decision-making capabilities has also shaped its view of the international order differently from Canada's. A rules-based international order has enabled Canada to hold a rank high enough in the international order to be a system affecting state, where it can have some foreign policy decision-making powers and avoid being crushed under greater powers. However, the story is completely different for Greenland; under the status quo rules-based international order, Greenland has effectively been made a colony without fully

independent political decision-making capabilities. Greenland is not a dissatisfied power in the same way China is, in that Greenland is not making any challenges to the rules-based international order. Greenland is not breaking any rules or upsetting status quo powers by pursuing independence, so Greenlandic independence still operates within the bounds of the status quo rules-based international order. Recall that the Greenlandic population looks upon independence unfavourably if it means a drop in living standards and social security benefits. So, unlike China, Greenland is unready to challenge the status quo rules-based international order as a whole. However, Greenland's pursuit of independence still challenges its rank within the international order. This is where Greenland and China have something in common strategically: both countries are attempting to change their rank within the international system.

Each country's attitude towards the international order impacts its willingness to work with China. Canada, which benefits from the international order, does not want to work with countries like China who are trying to overturn the status quo rules-based international order. Greenland, through independence, seeks to change its rank within the international order. Thus, Greenland has more in common strategically with China, which is also seeking to reshape the international order and increase its own rank. Greenland's environmental attitudes relative to Canada's also reflect the two countries' differences in attitudes towards the international order. Canada has greatly benefited from the status quo rules-based international order, which encourages global cooperation. Hence, it is more likely to adopt forms of environmentalism that consider environmental impacts globally rather than just locally. Greenland, on the other hand, has seen fewer benefits from multilateralism and the rules-based international order. Hence, Greenland is more skeptical about sacrificing its own environment through exploitative mining operations, which have immediate local damage for the preservation of the global environment.

Conclusion

This research ultimately identified three features that distinguish the rare earth development strategies of Canada and Greenland: (1) the presence of direct government investment; (2) the blocking of Chinese SOE investment, and; (3) the types of environmental concerns. These three features were found to be products of differences in the economic capabilities of each country – specifically, through differences in each country's independence in policy-making capabilities, satisfaction with the status quo rules-based international order, and consideration of security threats in policy making. These findings were produced firstly by creating an overview of the existing literature on explaining mineral development policy, with a particular focus on rare earths and critical minerals. Consequently, differences in rare earth criticality known to shape rare earth development policy could be compared between Canada and Greenland to illustrate the similarities. Rare earths were found to be similarly critical in Canada and Greenland; it was not rare earth criticality that shaped the differences between the rare earth development strategies of Canada and Greenland. Comparing criticality across countries is a way of understanding differences in rare earth development strategy that has yet to be tested in other literature. Future

research that seeks to understand differences between countries' rare earth development strategies could use this research as a model.

Next, the rare earth development strategies of Canada and Greenland were defined so that the differences between each country's strategy could be highlighted and explained. This research has articulated the rare earth development strategies of Greenland and Canada by examining the existing policies of each country. The implication for Canada is that Canada's rare earth development strategy has followed in the footsteps of its other policies on China, the environment, and international order. Canada's rare earth development strategy reflects its position as a middle power in the international system. Greenland's rare earth development strategy is primarily a reflection of its relationship with Denmark, which consequently impacts Greenland's approach to its policies on China, the environment, and international order.

Beyond the implications for Canada and Greenland specifically, the results of this study can be applicable to other countries for understanding rare earth development policy. Regarding the existing literature on rare earth development, this research provides insight on the behaviour of countries that have yet to fully develop their rare earth reserves. Most importantly, these relate to countries' decisions to accept or exclude Chinese investment. Countries like Greenland, with a lack of domestic capital to spend on rare earth development are more likely to take investment opportunities from China than are countries with plenty domestic capital to spend on rare earth development, if rare earths provide them opportunities to increase political decision-making capabilities. Countries that concern themselves with the economic benefits of rare earth development but not the security ramifications are more likely to take investment from whichever countries are offering it. Countries that are more cynical of the rules-based international order can be less likely to develop their rare earth reserves due to skepticism of sacrificing their domestic environment through exploitive mining practices for global efforts in climate change. Countries that are more cynical of the rules-based international order are also more likely to accept Chinese investment due to strategic similarities.

Appendix A: Indicators Modified and Removed from Comparative Criticality Analysis

According to the availability of data and the utility of some indicators in the context of this research, some indicators used by Eheliyagoda, Zeng, and Li (2020) were modified, and others were excluded from the comparison of rare earth criticality in Canada and Greenland. Eheliyagoda, Zeng, and Li (2020) used import dependency to provide a ratio of a country's mineral imports to its total supply. Import reliance can be used to measure a similar concept (the extent to which a country is reliant of foreign sources for its domestic mineral consumption) without some of the data required to calculate import dependency that is not readily available.[225] It should also be noted here that there were some indexes used in this comparison which do not provide data for the country of Greenland. Although circumstances in Denmark and Greenland are not identical, Greenland is still considered a part of the Kingdom of Denmark rather than fully sovereign country like Canada. As such, data for Denmark is used in place of Greenland when it is justifiable and for indicators where data for Greenland is unavailable.

Mineral adequacy, which helps to explain if countries' mine production is meeting it mineral demands, was excluded from the comparison as it requires data for overseas-purchased mine production, which is not readily available.[226] Data for by-product dependency, which measures the amount of total mineral production coming as a by-product of the production of other minerals,[227] could not be located for REMs in Canada and Greenland, so this indicator was not included in the comparison. Eheliyagoda, Zeng, and Li (2020) used the self-sufficiency of minerals to measure countries' capacity to resist a mineral's global supply shortage when such an event occurs.[228] This indicator uses the total demand of a mineral to calculate which could not be found for rare earths in Canada and Greenland, so this indicator was excluded from the comparison.[229]

End of life recycling rate measures the extent to which a metal can be recycled after its initial use.[230] Eheliyagoda, Zeng, and Li (2020) stated that this rate can usually be found in published literature, but this is not the case for rare earths in Canada and Greenland.[231] As such, the end-of-life recycling rate was not discussed in this comparison. Eheliyagoda, Zeng, and Li (2020) used the substitutability of mineral as an indicator for mineral criticality.[232] While inferior substitutes exist for many of the essential purposes of rare earths, there is a lack of existing data

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[225] Dominic Wittmer, Cynthia Latunussa, Gian Andrea Blengini, and David Pennington, "European Innovation Partnership on Raw Materials: Annual Monitoring Report 2017" 29443 (2018).
[226] Disna Eheliyagoda, Xianlai Zeng, and Jinhui Li, "A Method to Assess National Metal Criticality: The Environment as a Foremost Measurement," *Humanities & social sciences communications* 7, no. 1 (2020): S6, https://www.nature.com/articles/s41599-020-00537-4.
[227] Ibid., S7.
[228] Ibid., S16.
[229] Ibid.
[230] Ibid., S18.
[231] Ibid.
[232] Disna Eheliyagoda, Xianlai Zeng, and Jinhui Li, "A Method to Assess National Metal Criticality: The Environment as a Foremost Measurement," *Humanities & social sciences communications* 7, no. 1 (2020): S3, https://www.nature.com/articles/s41599-020-00537-4.

that can show how rare earth substitutes vary in Canada and Greenland.[233] Without the potential for variation between the case countries, utilizing this indicator would not provide valuable information to be compared.

The Environmental Performance Index, which is used by Eheliyagoda, Zeng, and Li (2020) to measure how well countries' policies protect the environment, was excluded from this analysis because this index does not contain data for Greenland and the data it uses for Denmark is not inclusive of Greenland.[234] The Economic Freedom Index was used by Eheliyagoda, Zeng, and Li (2020) as a measure of countries' ability to adapt to supply restrictions.[235] The Economic Freedom Index indicator was excluded from this comparison because this index does publish data for Greenland, and so data for Denmark cannot justifiably used in place of Greenland for this indicator. Eheliyagoda, Zeng, and Li (2020) also used four indicators for social, regulatory, and geopolitical risk, but these indicators were excluded from this analysis since they all lack a causal link to the rare earth development strategies of Canada and Greenland.

[233] U.S. Geological Survey, 2023, Rare Earths Mineral Commodity Summaries, accessed February 25, 2023, https://pubs.usgs.gov/periodicals/mcs2023/mcs2023-rare-earths.pdf.
[234] Yale, "Environmental Performance Index," accessed March 3, 2023, https://epi.yale.edu/epi-results/2022/component/epi.
[235] Disna Eheliyagoda, Xianlai Zeng, and Jinhui Li, "A Method to Assess National Metal Criticality: The Environment as a Foremost Measurement," *Humanities & social sciences communications* 7, no. 1 (2020): 5, https://www.nature.com/articles/s41599-020-00537-4.

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