Nature Dependent Exporters

What do they have in common?

Planet Tracker

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CONTENTS

WHY READ THIS PAPER

More than half of global output - around USD 44 trillion per year - is moderately or highly dependent on nature.[i,ii] As the natural environment is facing several challenges, so too is our built environment which relies on it. No country is immune to the unprecedented challenges that nature is now facing.

A substantial share of the impact on the environment - up to 70 per cent - is associated with international trade.[iii] Trade has allowed many countries to enjoy levels of consumption that are well above what could be reached based on their natural endowments alone - see Figure 1. Imports to European countries and higher GDP countries in general, unfortunately, tend to be the driver of a great deal of biodiversity losses around the world.[iv] Exporting environmental damages, as we might describe this by-product of trade, means the damages are often inflicted in areas with less oversight. Pressures on our world's ecosystems - and the risks to society associated with them - are often out of sight, out of mind and, as a result, underregulated.

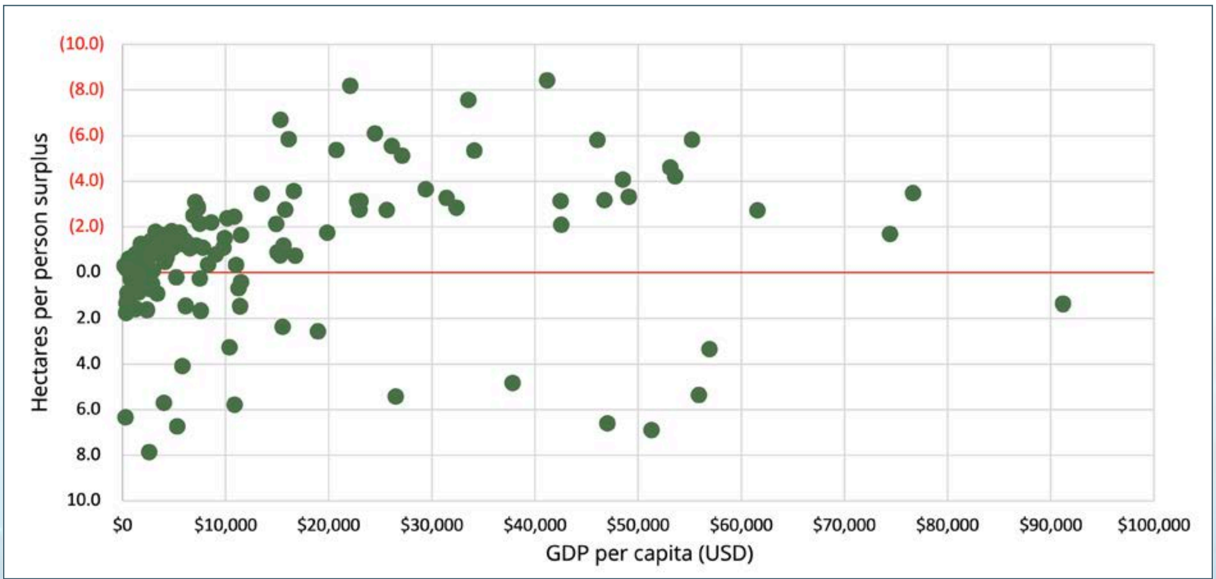


Figure 1: National-level ecological surpluses.

Notes: Mean ecological surplus or (deficit) measured in standardized "global" hectares of land per person needed to meet current consumption levels minus the number actually available in each nation. This is plotted against mean GDP per capita in each nation. It is clear that many nations at all income levels consume beyond their natural bounds. Based on 177 nations in the York University Ecological Footprint Initiative & Global Footprint Network (2021) dataset.[v]

More than half of GLOBAL OUTPUT - around

$44 TRILLION per year - is moderately or highly

DEPENDENT ON NATURE

Humankind is for BETTER or WORSE ultimately dependent on nature even as we INFLICT unprecedented levels of damage on it

Humankind is, for better or worse, ultimately dependent on nature even as we inflict unprecedented levels of damage on it.[vi] In response to the increasing levels of risk to society that such damages are creating, this paper examines those countries which are more heavily dependent on nature and the natural world in terms of what is produced and exported. This effort helps address the nature-trade information gap and inform on where growing trade risks might be observed as global climate change increases[1].

To the financial markets, nature and the natural world may better be understood as natural capital - i.e. those parts of the natural world which can be valued in monetary terms alongside financial, productive, human and social capital. This is in line with the World Forum of Natural Capital's definition of natural capital as "the world's stocks of natural assets which include geology, soil, air, water and all living things".[vii] The World Bank also recognises the importance of examining a country's wealth and assets that underlie gross domestic product (GDP) as one of the focuses in their report "The Changing Wealth of Nations".[viii]

Specifically, Planet Tracker assesses several countries' and territories' export-side exposure to environmental risks. This is their dependency on natural resources as a basis for trade revenue and some of the threats to those resources. To do so, we use the United Nations Commodity Trade statistics database (UN COMTRADE), a repository of official international trade statistics, as distributed by the *Centre d'Etudes Prospectives et d'Informations Internationale* (CEPII) in the BACI dataset.[ix] As published by Planet Tracker in our recent blog 'The Politics of Nature Dependent Trade', between 2010 and 2019, Nature Dependent Exports accounted for 40% of annual world trade.

[1] In this paper we use nature and the natural world synonymously - i.e. all of the flora, fauna, and other things existing in nature

This report:

Classifies exports into those dependent on nature - both renewable and non-renewable resources - and those which are not.

Divides the world into three Nature Dependent Exporter (NDE) groups: those with high (H), medium (M) and low (L) dependency on nature as their basis for exports.

Examines countries classified into HNDE, MNDE, and LNDE groups and which common characteristics they share based on a few broad measures. These range from GDP per-capita and economic inequality, to food security, soil erosion and climate resilience.

We find that HNDEs are often, but not always, characterised as poorer, developing countries. In terms of exports, they tend not to have highly diversified production, and instead rely more heavily on their natural resource endowments. Our analysis suggests that broadly, as economic, political, financial and technological metrics improve, nations tend to transition away from natural resource dependency toward production- or service-centric economies. This perspective falls on the side of the gradually building body of evidence that the causality involved in the so-called “resource curse” or the “paradox of the plenty” is reversed. Rather than the view that resource-rich economies do not thrive, we find at least some evidence that as resource-rich economies do begin to thrive, they transition out of natural resource dependency and the harsher lifestyles it tends to involve. We are of course not the first to refute the resource curse proposition.[x] But, we were surprised to find that it is not as robust as some have proposed.[xi]

As there are still several highly resource dependent nations, this paper attempts to bring to investors’ attention the particular scale of dependency of some countries’ economies on nature - whether renewable or non-renewable resources - and the results of such dependency. We identify these countries, what they have in common, and why this is relevant to financial markets. For those readers who wish to examine the data in further detail please visit the **Planet Tracker NDE Dashboard**.

KEY TAKEAWAYS

Planet Tracker's analysis of Nature Dependent Exporters (NDEs) revealed the following findings:

On renewable resource exporters:

- While there are many countries or territories that are highly dependent on nature, for six countries over 90% of their exports value comes from renewable resources.
- Many small island states, which are comparatively poorer and more susceptible to global climate change, are heavily invested in renewable resources for export.
- There is likely little-to-no relationship between population size or density and renewable exports for many countries. Factors such as urbanisation trends effectively disconnect populations from the natural environment.
- Food security and political stability improvements are likely to result in reduced renewable resource dependence. As stability improves, individuals as well as nations are more likely to invest in production and service-based activities instead of more difficult natural resource production.
- Less inequality and greater GDP per capita levels potentially lead to decreasing renewable exports. The causality between GDP per capita and renewable NDE levels probably goes both ways to some extent, but the concept of the "resource curse" is perhaps not the driving force.
- Renewable resource exporters tend to have worse soil erosion and less water stress. The former is a result of more intensive land use to produce renewables to export, while the latter is a necessary condition for renewable resource production.
- The credit ratings of both renewable and non-renewable HNDEs are poorer on average than their MNDE and LNDE counterparts. However, access to well-established oil wealth and good governance can offset the effect.
- Renewable resource exports are negatively related to patent applications and climate resilience. HNDEs are focused on resource production and harvest rather than more patent-intensive fields.

For **6** COUNTRIES **over 90%** of their exports value comes from RENEWABLE RESOURCES

On non-renewable resource exporters:

- In general, levels of non-renewable resource extraction are less connected to domestic affairs as non-renewables tend to be more often point-source, controlled by a smaller segment of the population, and extracted in co-operation with multinationals.
- The ranking of countries based on non-renewable exports is dominated by oil and gas producers, including those countries with relatively low total volumes of production (e.g. Algeria, Chad, South Sudan), as well as mineral and ore exporters (e.g. Burkina Faso, DR Congo, Mauritania) or a mixture of the two (e.g. Papua New Guinea).
- There is an apparent relationship between the size of a nation and the odds that it discovers and can subsequently exploit non-renewable resources. Due to historical patterns of extraction and population, this also leads to a spurious relationship between non-renewables and population density.
- Political instability is a likely result of non-renewable resource extraction. The literature suggests that point-source resource capture and corresponding state capture by interested parties drives this result.
- There is no significant relationship between non-renewable exports and GDP per capita nor equality levels in many nations. Exceptions are the subset of a few wealthy, low population oil-dependent gulf states.
- Non-renewable export levels have little relationship with soil erosion and water stress indices – the statistical relationships that do occur are likely to be the result of historical trends in when non-renewable resources were first discovered and extracted across the globe.
- Patent application rates also have little relationship to non-renewable exports, and climate resilience has much weaker explanatory power than it does for renewable exports.

NON-RENEWABLE exports are DOMINATED by oil and gas

In support of our conclusions, Table 1 reports a set of correlation coefficients between the national characteristics explored in this report and their level of renewable and non-renewable exports.

Table 1: Summary of correlation coefficients. Source: Planet Tracker.

Metric	Renewable export share	Non-renewable export share
Population size	-0.09ns	-0.08ns
Higher population density	-0.05ns	-0.12*
Larger land area	-0.14*	0.14**
Higher levels of food security	-0.26***	-0.13*
Higher levels of political stability	-0.31***	-0.24***
Higher levels of GDP per capita	-0.38***	-0.06ns
Lower levels of income inequality	-0.25***	-0.08ns
Lower levels of soil erosion	-0.33***	0.19**
Lower levels of water stress	0.29***	-0.17**
Higher credit rating	-0.46***	-0.18**
More frequent patent applications	-0.18***	-0.16*
More climate change resilient	-0.40***	-0.20***

*Notes : Indications of the level of statistical significance follow common convention : ns $P \geq 0.10$; * $P < 0.10$; ** $P < 0.05$; *** $P < 0.01$*

EXECUTIVE SUMMARY

Planet Tracker set out to identify those territories and countries which are dependent on nature for export trade revenues. To do so, natural resource-based exports are defined rather narrowly, excluding ecotourism and similar non-physical contributions to a nation's wealth and trade.

This is not to say that experiential values from the environment do not have value. In fact, for some nations, ecotourism is a substantial source of foreign currency. Rather, we are interested in the dependency of nations specifically on physical goods traded in the international market. These are goods which are often inputs to other production processes and any shocks to global markets will be experienced by their producers first and then reverberate through the rest of the global supply chain.

The forms of natural capital are then further divided into renewables such as agricultural, forestry and seafood products, and non-renewables such as oil and gas, minerals, metals and ores. This division occurs because the dynamics of renewable versus non-renewable resources - the decision-making processes involved - tend to be different in many respects.

The definition of export dependency on nature is based on trade data covering 5,000 different product categories which are then sorted into whether they are directly dependent on natural capital. We recognize that all goods are at least partially dependent on nature. To make the approach actionable, we establish cut-off points. A product which is processed but remains almost entirely made of materials that are harvested from nature, e.g. soybean oil extracted from the seeds of the soybean, is classified as nature dependent. Where a product is changed physically or chemically in a way that makes the product significantly different from its original form, e.g. limestone, marl and clay which are converted into cement, it is excluded.

Following this logic, all complex manufactured goods coming from, for example, the chemical, plastic or machinery industries are excluded. The results are then aggregated to arrive at the percentage by value of each nation's total exported goods that are directly dependent on nature. Their production and export and the relationship to a nation's stability are of primary interest in this study. As all nations' exports are at least in part dependent on nature, we use the term Nature Dependency of Exporters, alternatively Nature Dependent Exporters (NDEs) based on their level of natural resource exports and classify countries into high (HNDE), medium (MNDE) and low (LNDE) groups.

Having established NDE groups, for both renewable and non-renewable resources, Planet Tracker then compares the data using a set of common characteristics. Of primary interest, we explore whether there is a typical profile of HNDEs, exploring what characteristics they may have in common, using twelve metrics and a holistic, exploratory method to discover similarities.

These identify countries in terms of their demography, political, economic, financial, environmental and technological development as noted in Table 2 alongside the data sources.

Table 2: Characteristics used to assess nature-dependent exporters.

Category	Measures used	Data source
Population-resource dynamics	Population size	Population total (World Bank)[xii]
	Population density	Population density (World Bank)[xiii]
	National land area	Land area (World Bank)[xiv]
Social stability	Food security[2]	INFORM Risk (European Commission)[xv]
	Political stability	Fragile State Index (Fund for Peace)[xvi]
Domestic income	GDP per capita	GDP per capita (World Bank)[xvii]
	Income inequality	Gini index (World Bank)[xviii]
Land tenure	Soil erosion	Global Soil Erosion – ESDAC (European Commission)[xix]
	Water stress	Aqueduct Water Stress Score (World Resources Institute)[xx]
Financial access	National credit rating[3]	Sovereign Credit ratings (Standard & Poor's via Bloomberg)[xxi]
Long-term influences	Patent applications	Patent applications of residents (World Bank)[xxii]
	Climate change resilience composite	Notre Dame Global Adaptation Initiative, ND-GAIN, (Notre Dame)[xxiii]

The trade data spans the most recent 25 years available in many cases. This report does not make forecasts – that is reserved for further research – but the indicators are useful for identifying possible trends. For example, if NDEs are using unsustainable agricultural practices, soil erosion is likely to be substantially worse and crop exports might therefore decline in the future.

In addition, an **Interactive Dashboard** permits users to change the definition of nature dependency or rank countries based on different criteria - e.g. marine or agricultural natural capital. Users can also examine individual territories, countries, or regions, or change time periods under investigation.

[2] The INFORM Risk Index is a composite, open-source index. Planet Tracker selected the "Food Security" component of such index.
[3] Credit ratings are converted to a numerical scale using the conversion table presented in Table 7 in the Appendix.

IDENTIFYING NATURE DEPENDENT EXPORTERS (NDEs)

This section outlines Planet Tracker's methodology to identify territories and countries which are more heavily dependent on nature in terms of the value of their renewable and non-renewable exports as a percentage share of total exports.[4] These shares are based on trade data covering 5,000 different product categories, sorted into whether they are directly dependent on natural capital.

If a product is still fairly raw - similar in composition to when it was harvested from nature, e.g. soybean oil extracted from the seeds of the soybean, it is classified as contributing to nature dependent. However, when it is changed physically or chemically in a way that makes the product significantly different from its original form, e.g. limestone, marl and clay which is converted into cement, it is excluded. Following this logic, all complex manufactured goods coming from, for example, the chemical, plastic or machinery industries are excluded.

The aggregate values are converted to percentages of a nation's total export value that is primarily directly dependent on nature. As all nation's exports are at least partially based on nature, we have used the term Nature Dependency of Exporters, alternatively Nature Dependent Exporters (NDEs) based on their level of natural resource exports, and classify countries into high (HNDE), medium (MNDE), and low (LNDE) groups.

Table 3 ranks countries based on the percentage share of renewable products in their exports between 2015 and 2019 inclusive. It is interesting to note the appearance of a number of small island territories and states such as the Falkland Islands, Micronesia, Kiribati, Solomon Islands (discussed above), the Comoros and French Southern Territories, comprising Terre Adélie, French Antarctica, Îles Crozet, Archipel des Kerguelen, Îles Saint Paul et Amsterdam and other scattered islands (Îles Éparses). In terms of total global supply, these nations are not of substantial concern. But in terms of national stability in the face of climate change or other drivers of market instability, their high levels of renewable exports may be concerning.

Among other issues, many of these islands are dependent on seafood exports and therefore distant water fleets (DWF) of larger nations harvesting in their waters, particularly unsustainably, pose a serious threat.

[5] The list of territories is provided by UN Comtrade. Planet Tracker standardised names are used throughout the report..

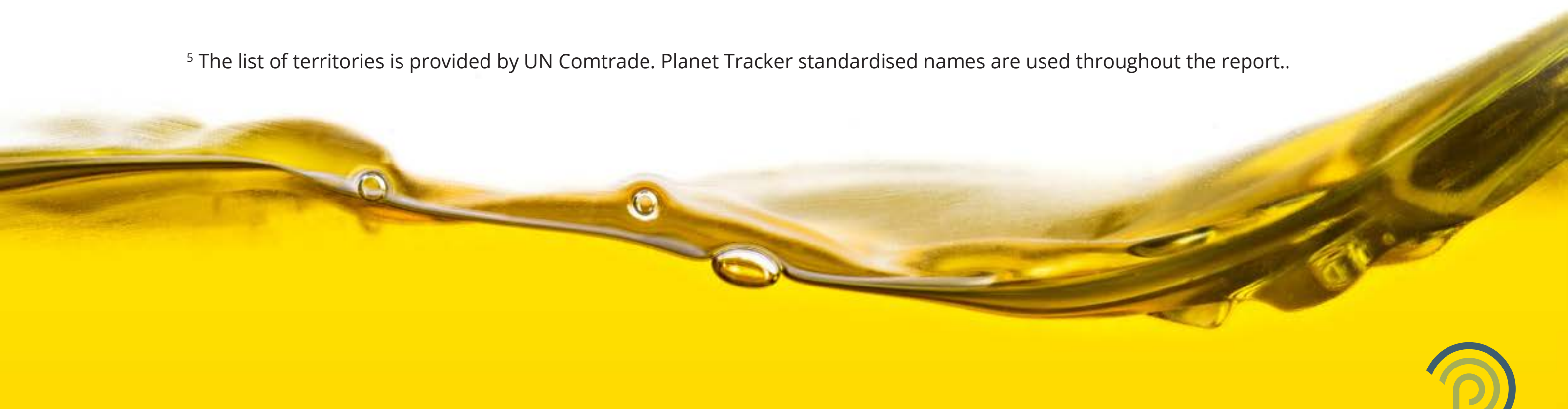


Table 3: Renewable Nature Dependent Exports. % Total Exports, average 2015-2019.

Country Name	Continent	Largest Export ($)	NDE share
Falkland Islands	South America	Preserved Other Molluscs	98.4%
Micronesia	Oceania	Frozen Tuna	97.9%
Kiribati	Oceania	Frozen Tuna	96.3%
Greenland	Europe	Frozen Prawns	96.2%
Guinea-Bissau	Africa	Nuts	93.1%
Solomon Islands	Oceania	Other Wood	92.5%
Malawi	Africa	Tobacco	88.8%
Comoros	Africa	Spices	84.0%
French Southern Territories		Frozen Toothfish	83.6%
Uruguay	South America	Non-Coniferous	82.6%
Tonga	Oceania	Fresh Other Vegetables	81.4%
Gambia	Africa	Nuts	80.4%
Cape Verde	Africa	Frozen Tuna	80.2%
Grenada	North America	Spices	79.6%
Saint Pierre and Miquelon	North America	Frozen Other Molluscs	78.5%
New Zealand	Oceania	Milk and Cream	78.3%
Belize	North America	Sugar	76.3%
Maldives	Asia	Frozen Tuna	74.0%
Syria	Asia	Spices	73.3%
Seychelles	Africa	Prepared Tuna	70.5%
Cuba	North America	Sugar	69.1%
Côte d'Ivoire	Africa	Cocoa Beans	68.6%
Bangladesh	Asia	Cotton	68.5%
Djibouti	Africa	Live Sheep and Goats	67.8%

Table 4 shows territories ranked by non-renewable resource export shares between 2015 and 2019, inclusive. The presence of the large oil exporters will surprise few, as evidenced by Iraq and Libya in the top three. South Sudan, although dwarfed by the oil and gas production of many other countries, has over 99% of its exports accounted for by oil. It's a similar picture for Chad, which is also highly dependent on petroleum exports, followed by gold. Indeed, several smaller nations are almost entirely reliant on oil exports for foreign currency.

Table 4: Renewable and Non-Renewable Nature Dependent Exports. % total exports, average 2015-2019.

Country Name	Continent	Largest Export ($)	NDE share (% total exports)
Iraq	Asia	Petroleum Oil	99.9%
South Sudan	Africa	Petroleum Oil	99.8%
Libya	Africa	Petroleum Oil	99.5%
Papua New Guinea	Oceania	Petroleum Gas	99.4%
Algeria	Africa	Petroleum Oil	99.3%
Chad	Africa	Petroleum Oil	99.3%
DRC	Africa	Copper	99.2%
Mauritania	Africa	Iron	99.2%
Burkina Faso	Africa	Gold	98.3%
Guinea	Africa	Gold	98.1%
Sudan	Africa	Gold	98.0%
Mongolia	Asia	Copper	98.0%
Suriname	South America	Gold	98.0%
New Caledonia	Oceania	Iron	97.9%
Angola	Africa	Petroleum Oil	97.8%
Venezuela	South America	Petroleum Oil	97.7%
Turkmenistan	Asia	Petroleum Gas	97.6%
Gabon	Africa	Petroleum Oil	97.5%
Mali	Africa	Gold	97.4%
Timor-Leste	Asia	Petroleum Oil	97.3%

If readers wish to examine individual countries in further detail please visit the Planet Tracker **Interactive Dashboard**.

TRENDS IN RENEWABLE NATURE DEPENDENT EXPORTS

Overall, the average dependency on renewable resource exports for trade revenues is in decline, particularly in the period 1995-2005. The average dependency across countries in 1995 was 43%, compared to 29% by 2019 - see Figure 2.

Figure 2: Renewable nature dependency for the world. Average across all countries and territories, 1995-2019.

The distribution of nature dependency on renewable exports has also changed. Fewer countries are extremely reliant on renewable exports in the present - see Figure 3.

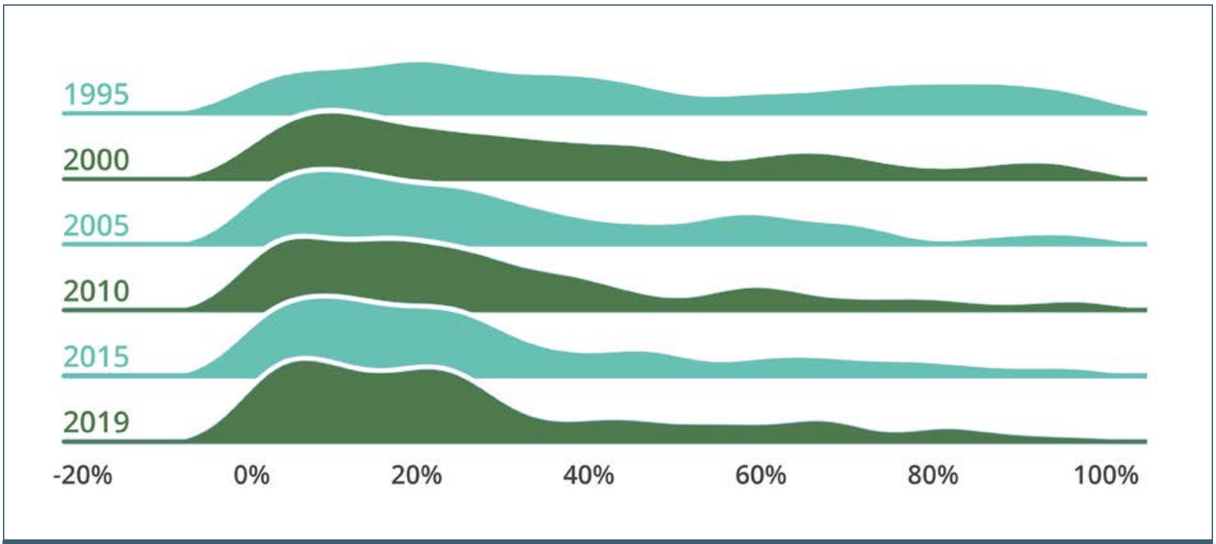


Figure 3: Renewable nature dependency for the world. Distribution for all countries and territories, 1995-2019.

The change in the average of nations' dependency on renewable exports has followed similar trends across continents, at least through 2005, as shown in Figure 4. However, recently the trends have begun to diverge.

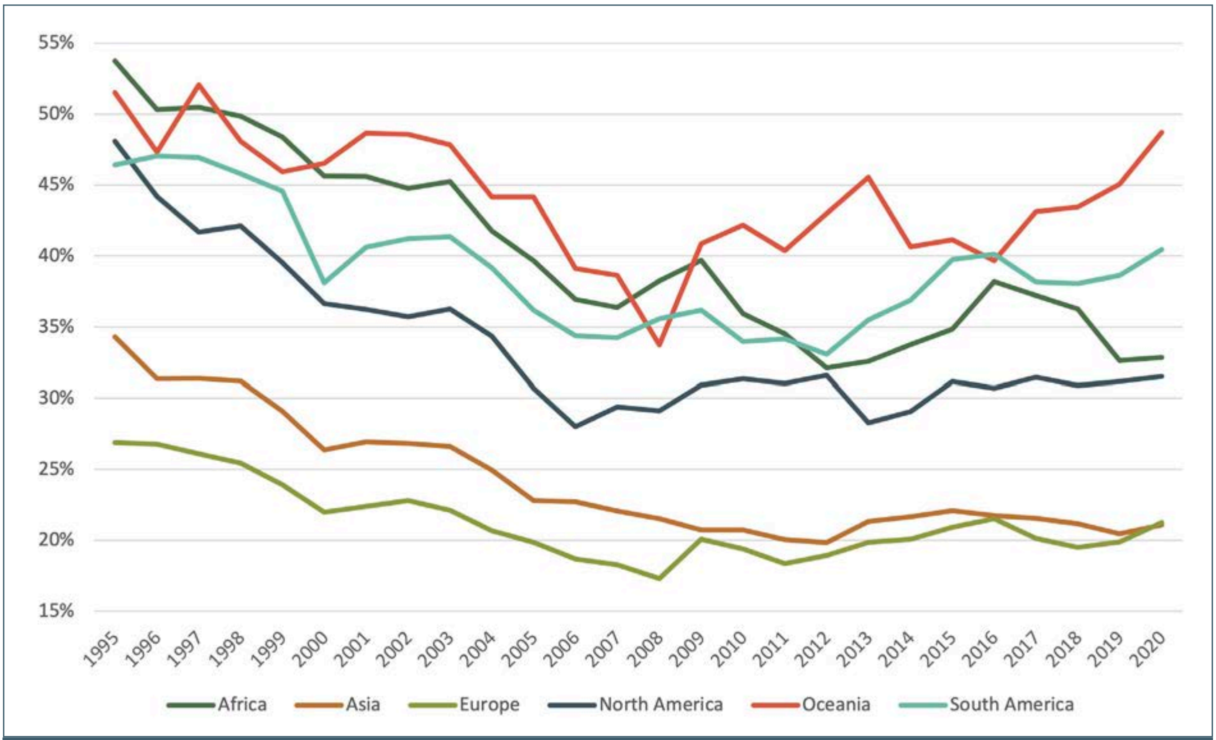


Figure 4: Renewable nature dependency by continent, 1995-2019.

Figure 5 shows that nature dependency for the G8 countries is markedly lower than for the rest of the world. This supports the premise that nations transition away from renewable resource production toward intermediary and finished goods production as well as service-oriented economies over time. Basic resource production tends to be comparatively more difficult work in many cases, so this is not surprising.

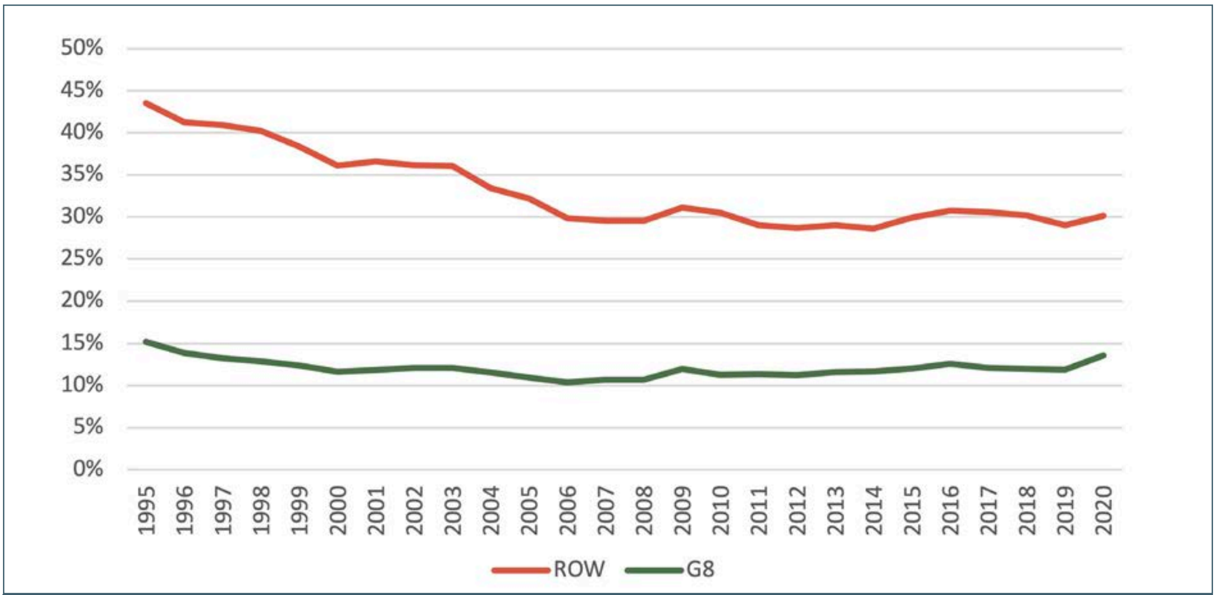


Figure 5: Renewable nature dependency for the G8 and rest of the world, 1995-2019. ROW = Rest of the World. G8 countries: Canada, France, Germany, Italy, Japan, Russia, United Kingdom, United States.

By comparing differences in renewable dependency between two decades, comparing 2000-2009 to 2010-2019, at the country level, it is clear that, in contrast to global trends, for some countries - particularly smaller ones - renewable resource export dependency has instead increased - see Figure 6. Obviously, as the largest increases in renewables dependency are among primarily smaller nations, these changes have little impact on global supply levels in most cases. But in terms of country exposure to environmental risks, these changes are significant.

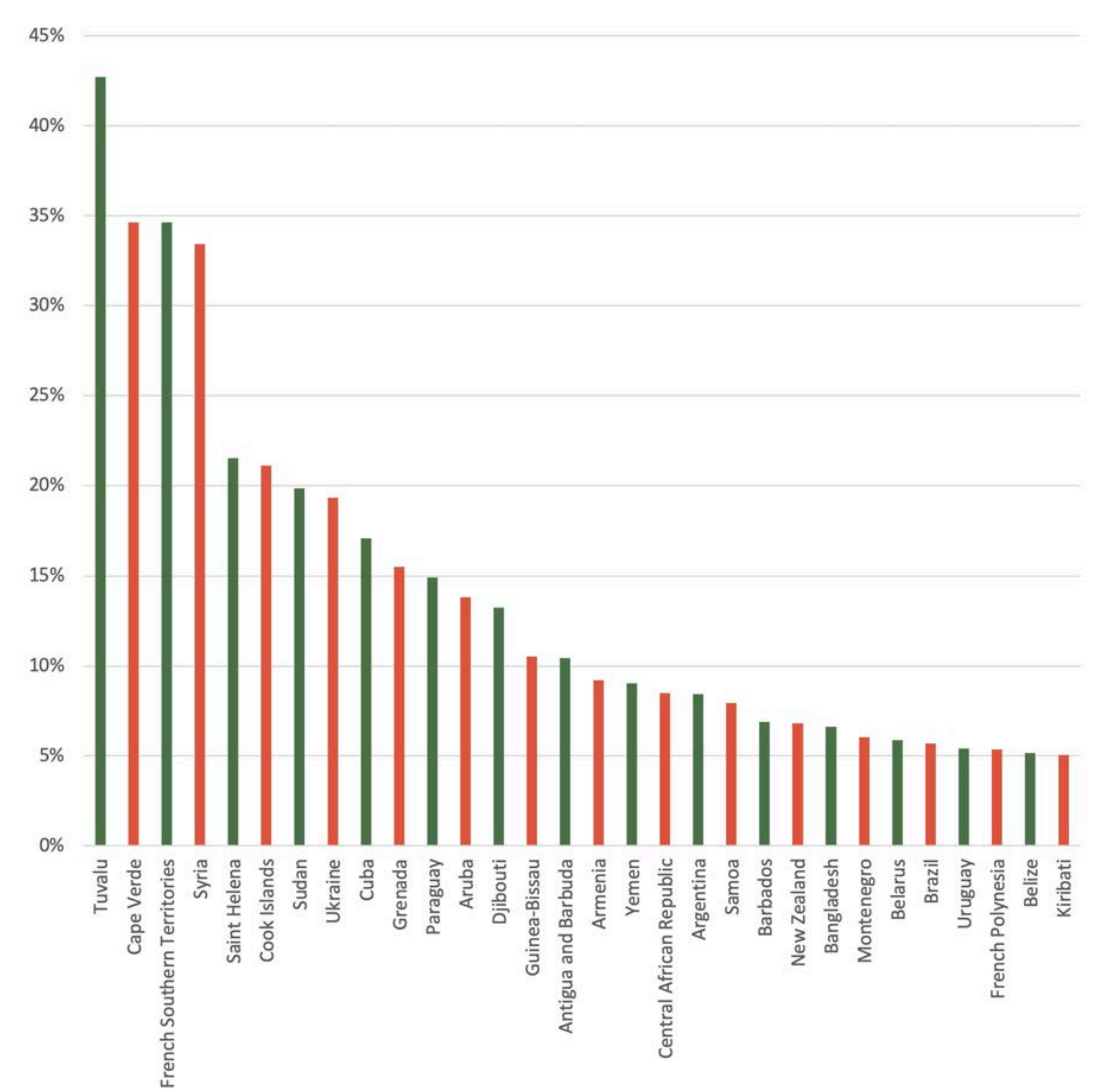


Figure 6: Countries with large increases in nature dependent export shares. Comparing average of the decade 2010-2019 to the previous decade.

DISTINGUISHING RENEWABLE VERSUS NON-RENEWABLE RESOURCES

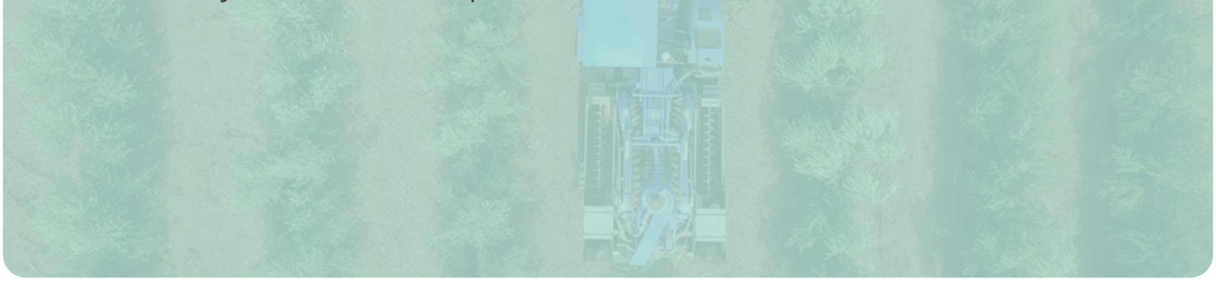
This section outlines why renewable and non-renewable resources must be assessed separately rather than in combination. The dynamics of the two very general categories of natural resource are such that their harvest and extraction decisions, respectively, tend to be entirely different. Both are potentially exhaustible in a sense - renewables through inadequate management and non-renewables as their defining characteristic. Renewable resources recharge, become replenished, or can be grown again in a comparatively short period of time, at least within a harvester’s lifetime.

Non-renewables certainly may regenerate, but the timescale tends to be orders of magnitude longer - several decades at a minimum. This difference then impacts how we think about the resources. Effectively, if something has to be harvested or extracted today, will the resource be scarcer tomorrow?

Qualities of renewable resources

Modern perspectives on the renewable harvest decision can be traced to the 1950’s and the emergence of the Gordon-Schaefer model[5].[xxiv,xxv] The core decision in renewable resource harvesting tends to be about comparing the rate of regeneration of the stock - the resource and its flows and the value derived from it - versus alternative uses of time and other resources which can be summarised as capital for convenience. Another important characteristic in renewables is how open access they are. In many cases, renewable resources are produced or grow across vast tracts of land or sea. In such cases, it is quite difficult to enforce exclusivity on resources, nor does an extractor necessarily have the right to do so. As a result, harvesters must also consider the risk of leaving a renewable resource unharvested - will it still be there in the future, or will another harvester collect it?

Yet another quality of renewables is that they are dynamic - rarely do they exist in their steady state. They are part of the interconnected world which experiences shocks of various magnitudes nearly all the time. This can make otherwise mundane decisions riskier for a resource owner as well as impact harvest decisions. Renewable resource harvesting tends to be difficult work compared to intermediate and finished goods production or the service sector. It is more harshly impacted by global supply shocks and geographically closer substitutes tend to exist on international markets. Therefore, when people have opportunities to do so, they can often be expected to transition away from renewable production.



[5] The Gordon–Schaefer model is a bioeconomic comparative static fishery model based on logistic biological growth, constant harvest price, constant unit cost of effort, and harvest linear in stock biomass and fishing effort.

Qualities of non-renewable resources

The basic model underpinning thought on non-renewable resource extraction can be traced to the 1930's but remains highly relevant today. In some ways, the decision of a non-renewable resource extractor is similar to that of a renewable harvester.

Resource extractors also compare the advantage of leaving the stock alone – the resource in the ground or otherwise not extracted - versus the returns as the flow of value they would receive from extracting it.

However, there is generally no recharge rate to consider, only whether extracting another unit of the resource today versus tomorrow will result in more profit. Another difference is that non-renewables are more often point-source in nature and easier to make excludable. They also tend to be more difficult to extract. Excludability and barriers to entry tend to mean that an extractor does not have to worry about competition on a particular stock, but must instead contend with substantial upfront costs. They must still often compete on the world markets to sell their raw materials, however, and are still at the mercy of global trends and shocks.

Another difference from renewables is that non-renewable stocks can, in many cases, be thought of as riskless when left in the ground - they are isolated from environmental shocks when left alone, but they are by no means immune to changes in their expected worth as determined on the global market. Because of these differences, non-renewables are more likely to be extracted by larger, multinational firms rather than by within-country extractors and we expect that non-renewable trends will be less connected to national events.

THE EXPLORATORY NATURE OF OUR ANALYTICAL APPROACH

It is worth noting that the perspective taken in this analysis, international trade - particularly in basic commodities like natural resources - is the result of complex decision processes. Global as well as national and local events all exert influence over both the supply and demand for resources. This includes both what is produced for local consumption and export. While this report focuses on the export side of each nation's natural resource production, the business environment is no less complex.

Such complexity means that the causal relationships involved - which event or activity leads to another and through what sort of mechanisms - can be difficult to ascertain. It is possible to identify four general types of relationships between export shares and the characteristics in this paper:

1. Changes in a characteristic of interest eventually leads to changes in natural resource export shares. In these cases, it can be assumed that changes in the characteristic of interest lead to changes in trade activity.
2. Changes in natural resource export shares, perhaps through stochastic shocks or global trends, lead to changes in the characteristics of interest. In these cases, it is generally changes in trade activity that are leading to changes in national characteristics.
3. Both changes in export shares and the characteristics of interest originate in a third factor generally outside anyone's capacity to measure well. In these cases, the characteristics operate as a more salient proxy for the underlying driver of change.
4. Export shares and the characteristics of interest can also be nearly or wholly unrelated. It can also be the case that a characteristic is related to renewable or non-renewable exports only, as the nature of the two general categories is quite different in important ways.

In light of the four types of causal linkages between national characteristics and natural resource export shares, a substantial portion of this study is devoted to developing an intuition for causality. We might also think of this as the direction of flow through the linkages in the economies of interest. In fact, we might say that a couple of the primary contributions of this report are to postulate such linkages and then explore them in an approachable empirical manner.

The exploratory nature of this report and our postulations are not without firm foundations nor predecessors in style, however.[xxvii] For every characteristic in this report, the discussion is grounded in the literature available including a wide variety of academic, non-profit, non-governmental and government research reports. In some cases, the discussions that we build on go back several decades. In short, we both conduct an exploratory analysis of the linkages that we are interested in and firmly ground them in the most up-to-date theoretical and empirical information available.

NDE COUNTRY GROUPS AND NATIONAL CHARACTERISTICS

This section highlights the division of renewable and non-renewable export data into equally sized HNDE, MNDE and LNDE country groups as displayed in Figure 7 and Figure 8 for renewable and non-renewable exports respectively. Since an NDE group could change over time, as evidenced by Figure 3, the basis for categorisation into an NDE group is from their 20-year average, from 2000-2019. Another reason for this approach is that the country characteristic data is not consistently available across countries - it began as an unbalanced panel dataset.

Because of the particular way it is unbalanced, with more frequent observations on comparatively wealthier countries in many cases, keeping it in that form would bias any statistical results toward the conditions of wealthier nations. As we want to compare nations on a more equal footing, we take 2000 to 2019 country averages, not just for the purpose of NDE export shares and subsequently groups, but also for other statistics. Figure 7 and Figure 8 give an idea of which countries and geographic regions tend to produce a higher share of renewables or non-renewables as shares of their exports.

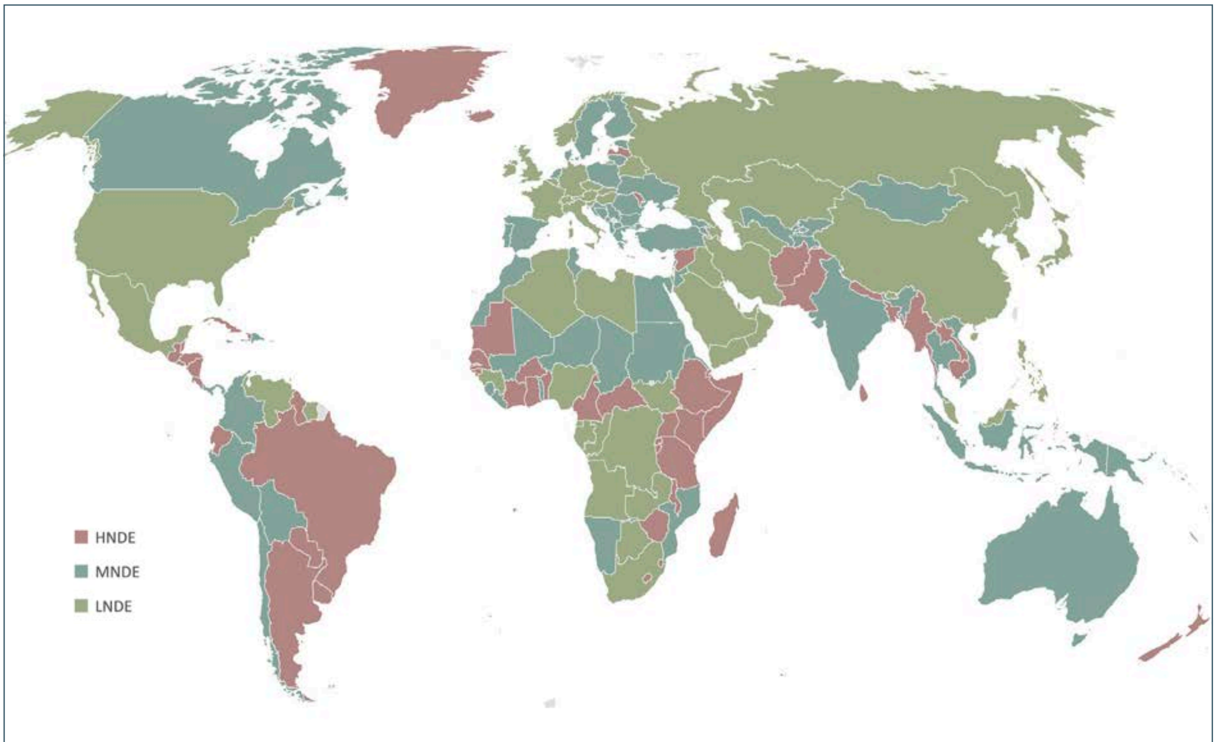


Figure 7: Renewable nature dependent exports; high, medium, low.

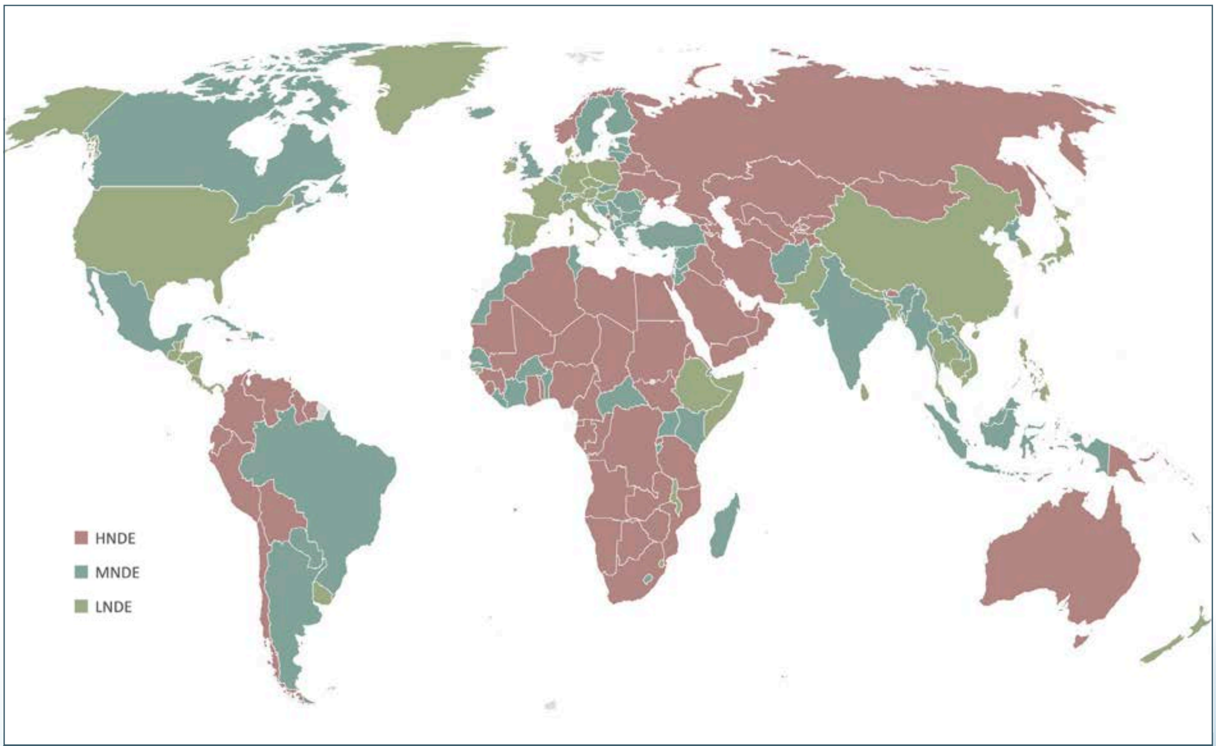


Figure 8: Non-renewable nature dependent exports; high, medium, low.

FOCUS SMALL ISLAND DEVELOPING STATES

The small island developing states are worthy of a particular focus, as not all appear as dependent on nature-based exports as suggested above. To examine this further, we have used World Bank country groupings such as "Pacific Islands", "Caribbean Small States" and "Other Small States".

Figure 9 shows a box plot of regions and their percentages of renewable nature-based exports. It shows that Pacific islands are comparatively more dependent on nature for their exports, with a median for the group approaching 60%. The Caribbean Small States have a median close to 20%, with Other Small States (e.g. Bhutan, Seychelles) are slightly higher at close to 25%. However, this comparison can also reveal the limitations of the data. Tourism, which is classified as an export, is often highly reliant on nature, but is excluded as it is a service, not a good. Many of the Caribbean countries are likely more reliant on natural resources when defined more widely. We also note that there are substantial differences in scale involved here - while having exports at 60% versus 20% based on renewable resources is important at the country level, Pacific Island and Caribbean small states contribute comparatively small quantities to the global total of most resources.

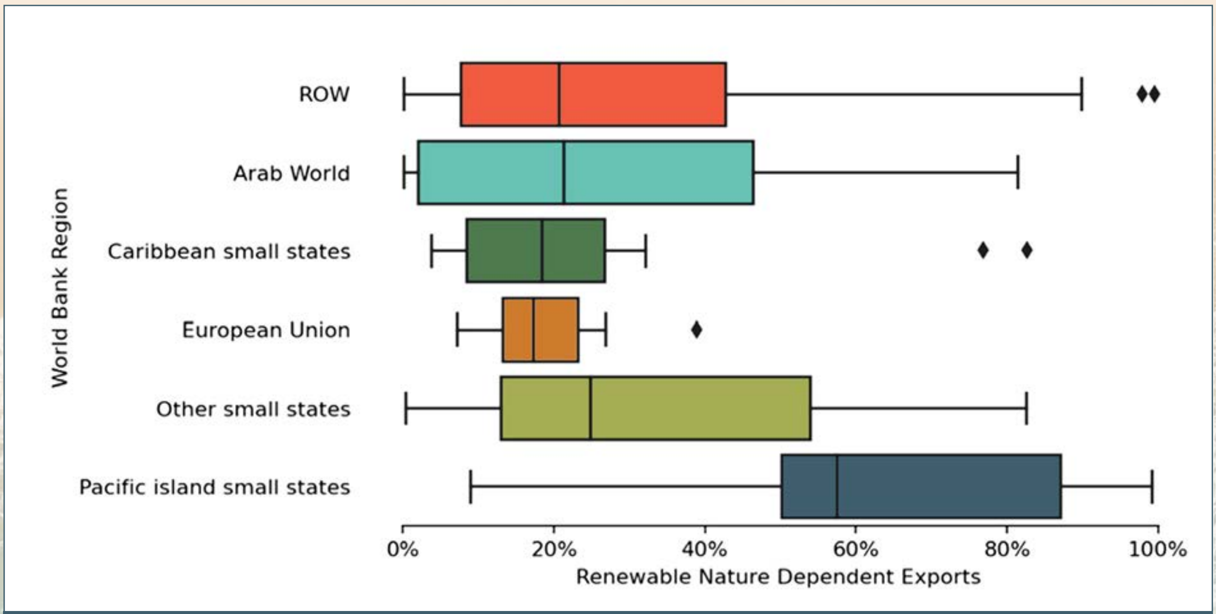


Figure 9: Comparing Small Islands' Nature Dependency. The UK is included in EU in this classification (as per 2019). Classifications as 'Small States' and 'Arab World' follow World Bank usage.

To explore the qualities that might identify nature dependency in exports, Planet Tracker has developed a dataset containing several attributes grouped into categories of what they tell us about nations. These include important subjects such as how stable society is likely to be and the treatment of natural resources.

They are intended to provide a broad view of nations and territories by including values on demography, politics, economy, environmental, technological development and credit rating. The categories and characteristics assessed are:

1. **Population-resource dynamics**
   - Population size
   - Population density
   - Land area
2. **Social stability**
   - Food security
   - Political stability
3. **Domestic income**
   - GDP per capita
   - Income inequality
4. **Land tenure**
   - Soil erosion
   - Water stress
5. **Financial access**
   - Credit rating
6. **Long-term influences**
   - Patent applications
   - Climate resilience

The characteristics are then composed as a cross-sectional dataset at the national level, where each datapoint contains the average of a nation's values over the period 2000 to 2019. This is a compromise approach to address the considerably unbalanced nature of the data which would otherwise be biased toward the conditions of wealthier nations which have historically been more intensively monitored. A downside of this approach is that we cannot, in the current application, account for precision. That is, wealthier nations with more frequent observations are probably measured more precisely than, say, a poorer nation that is only observed, say, once in the two decades of data collection. The source of variation when we do statistical analyses on the characteristics separately are differences in an independent variable at the national level; for example, differences in population sizes between countries, versus differences in the natural resource share of a nation's exports.

Each NDE characteristic is next studied separately so that we gain a firm footing in what each characteristic potentially tells us about societies and their susceptibility to resource market shocks.

The statistics used in the analyses are:

- **Correlation coefficient, ρ**

- **Single linear regression coefficient, β, from estimating on equation**
$\textit{Export share}_i = \alpha + \beta \textit{charactistic}_i + \varepsilon_i$ where, in turn, *export share*$_i$ is the renewable and non-renewable shares, and *charactistic*$_i$ is the characteristics of interest in this report. Both are first expressed on a 100-point scale such that β indicates the percentage point change in *export share*$_i$ with a one-percentage point change in *charactistic*$_i$.

- **Standard error, σ, on the estimated coefficient β**
When the Breusch-Pagan test for heteroskedasticity - whether the variance of the data is systematically related to its levels - found a statistically significant relationship, heteroskedasticity-consistent (Hubert-White) standard errors were used.

- **Coefficient of determination, R^2**
This may be more familiar to some readers than ρ though it contains the same information.

For each characteristic we present boxplots divided by NDE group - HNDE, MNDE, and LNDE and scatterplots with fitted lines from OLS single linear regression. This provides a more holistic view of the characteristics involved than using either approach alone. We can, for instance, observe whether the source of variation originates within groups, or if the groups themselves are distinctly different from each other. To begin, we study population-resource dynamics. It is a discussion of how land area and population density may be related to resource extraction possibilities and choices.

1 POPULATION-RESOURCE DYNAMICS

Measures assessed: population size, density and country size

Summary

There is probably little relationship between population size or density and renewable exports for many countries. However, **many smaller, ocean-dependent nations are reliant on renewable exports**.

In terms of non-renewable exports, there is likely to be a **relationship between the land area of a nation and the odds that it discovers and can subsequently exploit non-renewable resources**. Due to historical patterns of extraction and population, this may also lead to a spurious relationship between non-renewables and population density as well as other factors.

Background

Population size and density

Concern over the relationship between population size or density and environmental impact is, at its core, about scarcity. Population growth-induced scarcity is a concern that we often trace back to Malthus' arguments starting in 1798.[xxviii] In essence Malthusianism - as the perspective has come to be called - argues that exponential population growth and subsequently consumption would eventually exceed more linear growth in the provisioning services of the environment, in particular agricultural production. Consumption pressure exceeding supply would subsequently result in widespread famine and death in the not too distant future. The failure of the predictive power of Malthusianism has been heavily criticised.

It was quite obvious well over a century ago that the basic premise of Malthus' argument - that humans are merely subject to their environment and do not adapt in the face of adversity – is not accurate.[xxix] Yet, fear of a Malthusian catastrophe, of famine-driven population collapse, persists. This is not for nothing, of course, as subsets of humanity have experienced famine many times.

In recent decades, the prospect of a Malthusian dystopia has been conjectured as now possible on a global scale. Among academics - in particular natural scientists - probably the first reference that comes to mind is the work of the Club of Rome. This was a committee of primarily natural scientists who received substantial notoriety as well as criticism for sounding the Malthusian alarm in the early 1970's.[xxx] Among the general public, the upscaling from national-to-global concern can be traced to the 1960's concept of a "spaceship earth".[xxxi] In its simplest interpretation, "spaceship earth" is meant to summarise a concern that the world is no longer best described as an open set of economies all able to attain scarce resources beyond national capacities through trade.

Rather, the world is becoming a globally closed economy - we're reaching certain limitations on a global scale - and critically no longer able to meet the extensive demands placed on it by a growing global population. Since the 1960's, the concept of global austerity, of harshly constrained global resources, has been taken quite seriously by many. Several popular works not worth highlighting here have since predicted the imminent end of civilization through resource-based conflict. Fortunately, such predictions have thus far also adhered to the Malthus' tradition of failing to have predictive power.

An interesting result of Malthusian concerns and their rebuttal has been the development of the modern sustainability movement. By the end of the 1960's, programmmes supporting technological innovation in particular were being advocated for by the public as part of the larger global green movement. Industry interest in recycling and conserving resources also began to increase at that time. Eventually, the movement led to substantial government interest in environmental conservation, including the establishment of the U.S. Environmental Protection Agency in 1970.[xxxii] By the 1990's, several agencies around the world were involved in researching and encouraging sustainability practices, including in the UK.[xxxiii,xxxiv] This clearly muddies the picture - that nations responded to pressing environmental concerns independent of their population size or density.

It is extremely difficult to predict how dense a population must be, or how large in general, before it begins to impact the environment. We cannot even be sure what scale of humanity the Earth can sustainably support. A survey of 65 expert estimates had a modal value of 8 billion people or less. However, estimates also ranged from less than 2 billion, to tens of billions more people than are alive today.[xxxv]

This wide range is a direct result of the complex relationship we have with the environment and our ability to often innovate our way out of trouble. In short, scarcity has frequently led to innovation, which in turn increases Earth's estimated carrying capacity. At the national level this is even more difficult because the capacity to import from abroad means that a geographically small nation may support a substantial population by relying on imports. We should therefore be sceptical of strong links between population size or density and environmental impacts. But we should also be wary of trusting whole-heartedly in human ingenuity - not all causes of scarcity may be easily addressed.

But to the point at hand, we cannot be sure of the carrying capacity of the only truly closed economy - the global-scale one. So, we certainly should not expect a clear picture to emerge at the open economy national level. The impact of a nation's population size or density on the environment will almost certainly be clouded by several confounding factors.[xxxvi]

For one, population growth is not likely to be correlated with land use due to urbanisation trends. Another reason is that open trade means that a nation needn't rely on its own resources. How the population is distributed - particularly trends toward urbanisation, the real income level of the population and therefore capacity to purchase from abroad, and potentially several other factors, are confounders.[xxxvii] A population that is growing but also transitioning toward urban living in dense cities could actually lower its impact on its domestic environment. But not all cities are alike - it has also been noted that some cities develop as centres for industrial production - as "industrial cities" - while others develop as centres of services-focused domestic consumption - as "consumption cities".[xxxviii] In terms of income, the environmental Kuznets curve hypothesis - that environmental degradation first increases with income and then decreases - finds mixed empirical support (though we might also observe this relationship in Figure 1 of this report). Compounding the identification issue - and necessitating this report - nearly every nation of the world is open to trade.

Land area

While we might not expect a relationship between renewables and population size or density, we should expect that non-renewables are related to the total area of a nation for quite different reasons. Think of discovering non-renewable resources as the pay-out from playing a global lottery. Then, think of the share of the earth that each nation controls as their odds of winning that lottery, of discovering natural resources. It should then be immediately clear that a larger nation has higher odds of striking it rich - of discovering a non-renewable resource supply. The reason that we might think of non-renewable resource discovery this way is that they both predate the vast majority of nations and until comparatively recently were difficult to discover.

The result is that non-renewable resources are distributed independently of the boundaries of nations in many (but not all) cases. This independence then allows a lottery interpretation of resource discovery. The scale of non-renewables reserves worth exploiting tend to be quite large in many cases, for example an oil field. It is then almost certain that winning the non-renewable lottery will lead to increased non-renewable exports, not just increased domestic consumption.

Figure 10 summarizes the expected linkages between population-resource dynamics and natural resource exports. As noted, the confounding factor of urbanization makes the predictive power for renewable resources weak at best. Meanwhile, non-renewable resource discovery is basically a numbers game - the larger the area a nation controls, the higher the odds that a nation is sitting atop of extractable resources.

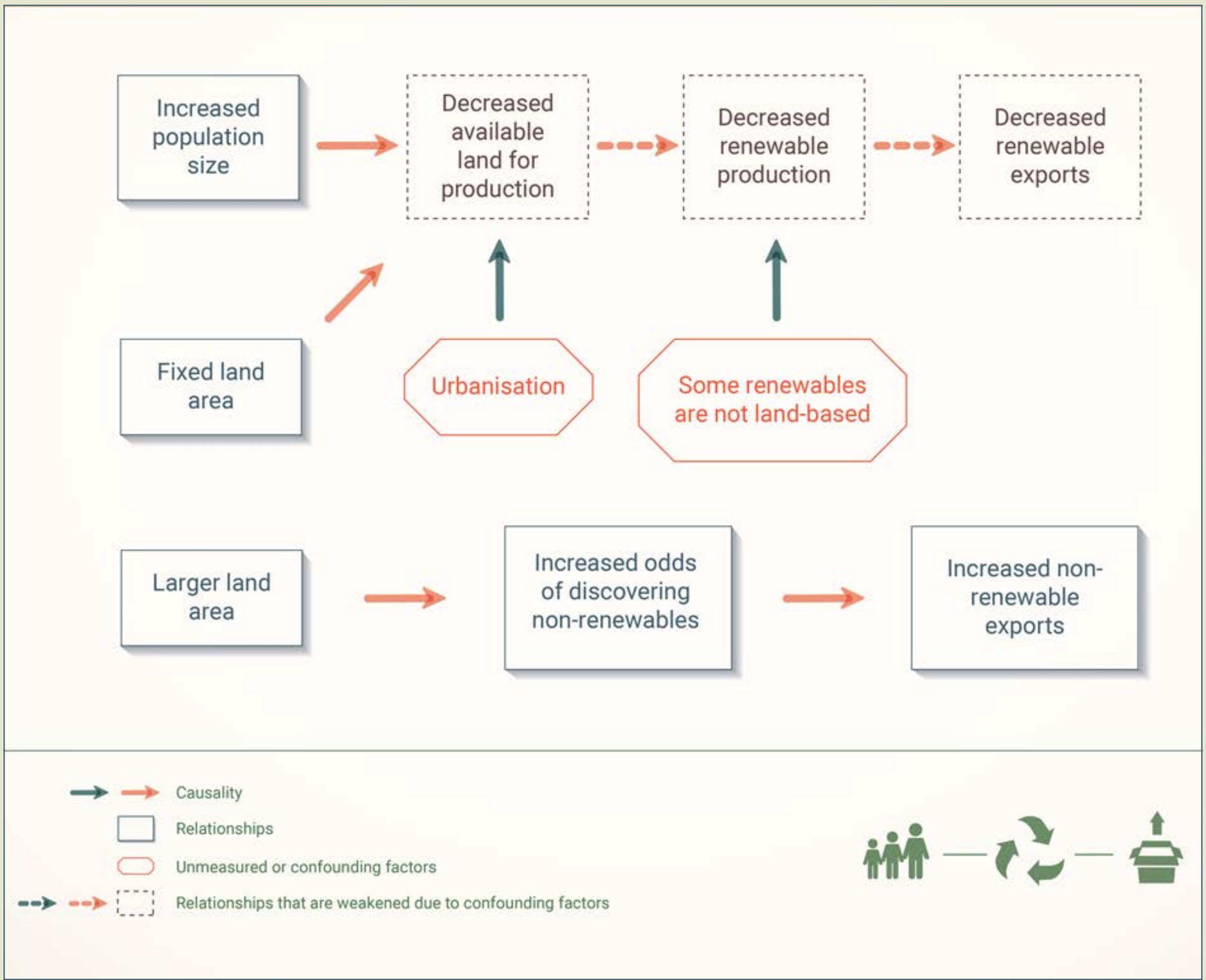


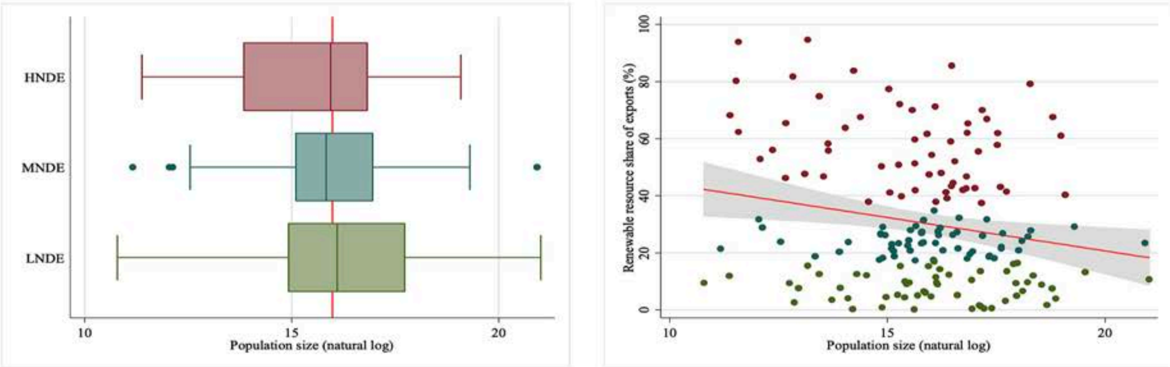
Figure 10: Proposed Linkages between Population-Resource Dynamics and NDEs.
Arrows suggest causality, boxes suggest relationships, octagons suggest unmeasured or confounding factors. Dashed arrows or boxes suggest relationships that are weakened due to confounding factors.

Analysis

In this section, the relationships between population-land dynamics and natural resource exports are explored empirically. The results are displayed in Figure 11 - a set of six graphics comparing renewable resource exports to population size, density and land area and Figure 12 - a set of six graphics comparing non-renewable resource exports to population size, density and land area.

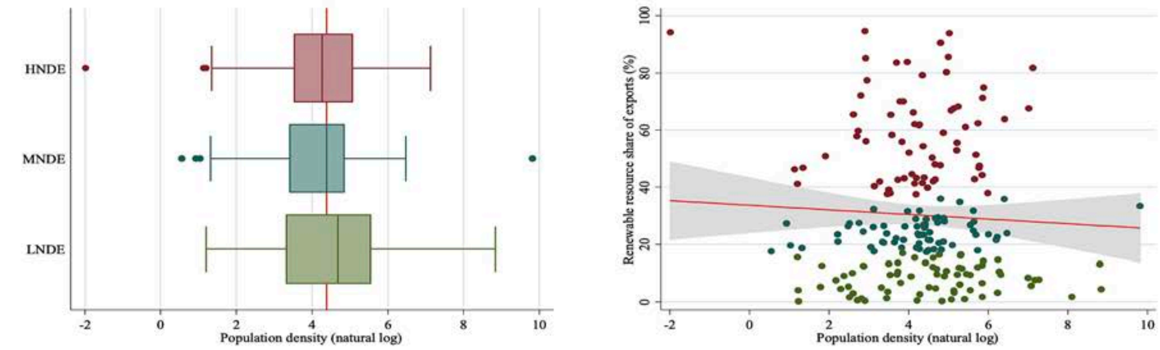
Whether we are discussing population size or land area, a cross-section of nations suggests a great deal of diversity. There are nations of more than a billion people discussed alongside nations a fraction of that size. It is helpful then to visualise the results on a natural-log scale. The natural-log scale also allows a convenient interpretation as a percentage change. Since the dependent variable is on a 100-point scale, changes in the graphics suggest the percentage point change in natural resource export shares with a percentage change in the characteristics of interest. An example of the natural log relationship is in Figure 11, top row, where a 1% change in total population is related to a 2.3 percentage point decrease in the renewable resource share of exports. This is a complementary interpretation to that of the β coefficients - where both sides of the equation are on a 100-point scale - which are interpreted as the percentage point change in renewable resource exports resulting from a percentage point change in a characteristic.

In terms of renewable resources, it was suggested that there would be at most a weak linkage between population size, density, total land area and renewable resource exports. This should be particularly true as NDE levels are in percentage shares rather than total volume. Land area should have little relationship to NDEs, as we observe in Figure 11, bottom row. Because of the confounding effect of changing geographical distributions of populations - in particular the trend toward urbanisation - we also expect little identifiable relationship between NDEs and population density. Total population size as well as population density is found to be statistically insignificant at all reasonable levels as in Figure 11, middle and top rows, respectively. The weak negative relationship with total population on the natural log scale may be more spurious than useful. The majority of the relationship observed is due to changes within the HNDE group. This result can be attributed to a number of low-population, primarily island nations exporting a substantial amount of sea-based NDEs. Once this is controlled for, as in population density, it is clear that there is no independent relationship between population size and NDE share of total renewable exports.



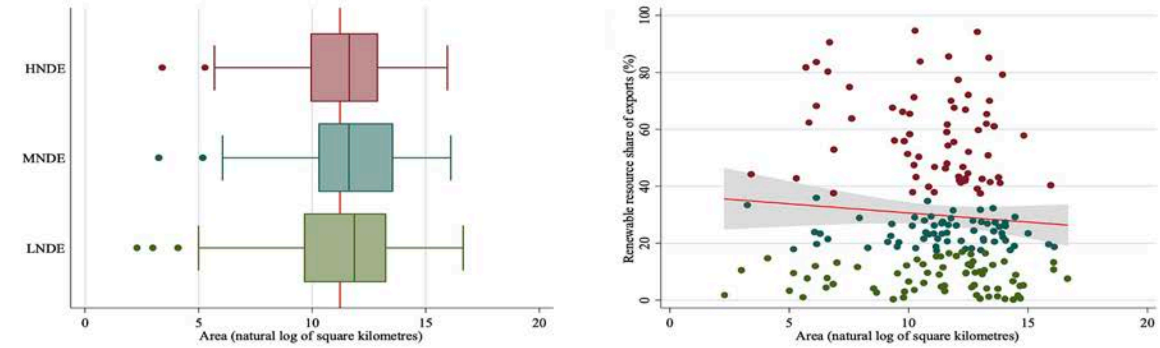
$$\rho = -0.09, \;\; \beta = -0.20^{ns}, \;\; \sigma = 0.17, \;\; R^2 = 0.01, \;\; N = 174$$

TOTAL POPULATION



$$\rho = -0.05, \;\; \beta = -0.15^{ns}, \;\; \sigma = 0.21, \;\; \mathrm{R}^2 = 0.002, \;\; \mathrm{N} = 208$$

POPULATION DENSITY



AREA

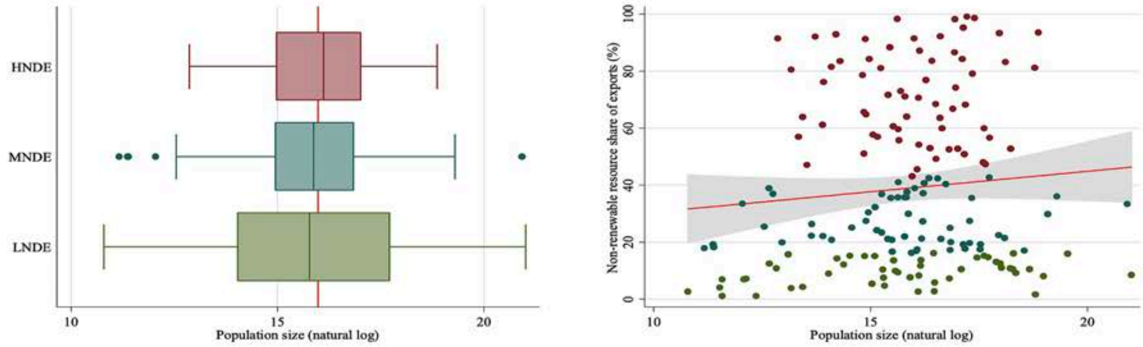
$$\rho = -0.14, \;\; \beta = -0.29^{*}, \;\; \sigma = 0.15, \;\; R^2 = 0.02, \;\; N = 199$$

Figure 11: Renewable Resource Exports and Population-Land Dynamic. Shading represents 95% confidence interval.

P-value: ns = P > 0.05, * = P ≤ 0.05, ** = P ≤ 0.01, *** = P ≤ 0.001

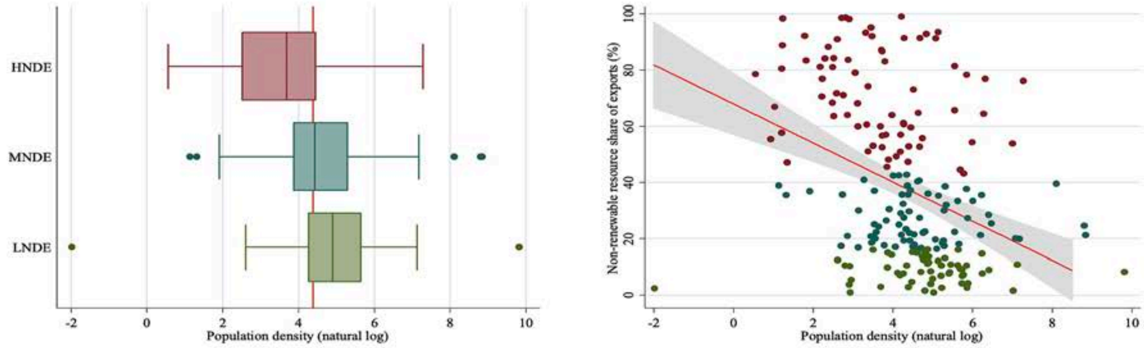
The relationship between non-renewable exports and population-resource dynamics are explored next. As discussed, total population is not expected to have any meaningful relationship with generally point-source, non-renewable exports.

However, total land area - improving the odds in the non-renewable resource lottery - is expected to have a strong relationship. This relationship, in turn, is also detected spuriously in population density. Figure 12, top row, confirms the lack of direct relationship between total population and NDE level, while the bottom row confirms the strong relationship between a nation's area and non-renewable exports. We can visually observe that the relationship is driven by significant differences between the three NDE groups rather than within-group variation. In particular, the HNDE group contains several nations that are much larger than the combined average. This creates an interesting statistic - a 10 percentage point increase in a nation's land area approximately results in a 3.8 percentage point increase in the non-renewable export share. This is, roughly speaking, the increase in the odds of striking it rich in terms of non-renewable exports. In terms of population density, we instead see a strong negative relationship between density and non-renewable resource exports. This is likely a historical artefact - on average more densely populated nations discovered and capitalised on their non-renewable resources a few decades early, preceding the scope of the current analysis. They have since transitioned away from non-renewable resource extraction as sites were exhausted. Less densely populated and less hospitable countries now dominate non-renewable resource suppliers as extractors sought new sources. In short, the relationship between land area has a plausibly more meaningful relationship with non-renewable exports in the long-run than does population density. Yet, because of the combination of land area and history, the density relationship at first appears stronger.



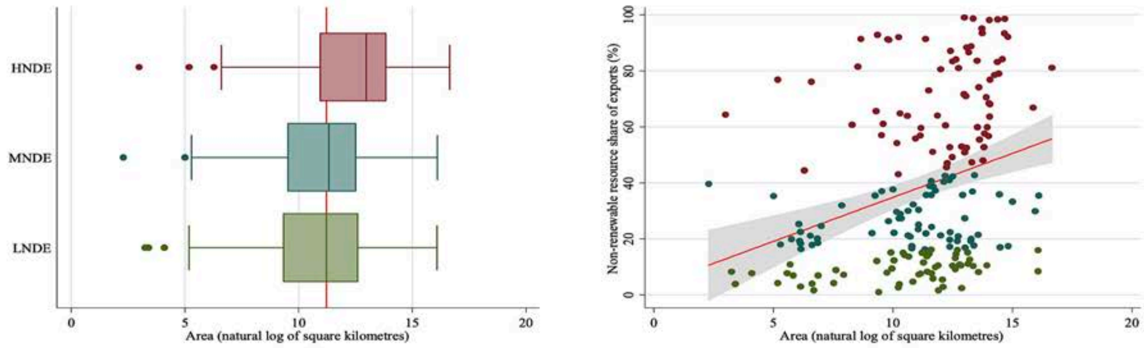
$$\rho = -0.08,\ \ \beta = -0.23^{ns},\ \ \sigma = 0.21,\ \ R^2 = 0.01,\ \ N = 174$$

TOTAL POPULATION



$$\rho = -0.12,\ \ \beta = -0.42^{*},\ \ \sigma = 0.25,\ \ R^2 = 0.01,\ \ N = 208$$

POPULATION DENSITY



AREA

$$\rho = 0.14,\ \ \beta = 0.38^{**},\ \ \sigma = 0.18,\ \ R^2 = 0.02,\ \ N = 199$$

Figure 12: Non-renewable resource exports and population dynamics. Shading represents 95% confidence interval.

P-value: ns = P > 0.05, * = P ≤ 0.05, ** = P ≤ 0.01, *** = P ≤ 0.001

2 SOCIAL STABILITY

Measures assessed: food security and political/state stability

Summary

Food security and political stability improvements could result in reduced renewable resource dependence. As stability improves, individuals and nations are likely to invest in production and service-based activities instead of more difficult basic resource production.

Political instability, however, likely follows from non-renewable resource extraction. The literature suggests that point-source resource capture and state capture by interested parties drives this result.

Background

Food security

As noted in the discussion of the NDE population category, famines and scarcity are unfortunately not new concerns. However, the modern perspective on food insecurity - and in its extreme, famine - originates in Amartya Sen's observations.[xxxix] From first-hand experience as well as careful study, Sen found that unequal access to food, rather than specifically a lack of food, leads to famine. One horror that results from unequal access as the driver of famine is that areas undergoing famine can also be food exporters to markets where there is no food insecurity at all. The prevalent modern perspective on food insecurity has subsequently become that it is often the result of policy choices. The policy choices originate within countries but are also forced upon them by other powers acting in their own interest.

Naturally, the idea that public policy is the true driver of famine in many cases precedes Sen. We might observe an early story of the power of public policy over famine in the biblical telling of Joseph's management of Egypt's grain production, in that aggressive collection during seven years of plenty then averted seven years of extreme hardship.[xl] Egypt, unfortunately, cannot save us today - it is now almost entirely reliant on grain imports and the public on bread and flour subsidies.[xli] Agriculture-relevant policies can certainly have long-reaching consequences beyond collection and storage. Sen's first-hand observation of famine - triggered by extended extreme drought - can also be traced back to changes in the structure and quantity of India's grain storage and the reorientation of the market for exports under British rule.[xlii] Global integration may bring us cheaper products, but has had a potentially large, negative impact on food security in some countries.

As a perhaps uniquely modern concern, global grain reserves have become increasingly concentrated in one nation. China supposedly stores more than half of our world's reserves and is a source of flour and related products across the globe.[xliii] But there is increasing concern that the grain store figures for China - whose stores, like all nations, are disbursed across the country - are substantially inflated in addition to concerns that in a crisis, China will care for China first.[xliv] Should the world ever need to rely on those reserves, we may find that mice and the principal-agent problem have beat us to it.

Political stability

Trade is generally associated with political stability. One reason is that it requires some minimal level of competence to negotiate the several trade agreements required for extensive trade relations. Another reason is that international trade is a means for societies to gather the resources they need. A society engaged in extensive trade is, all else equal, also likely one that is striving to meet its needs at a lower cost than it could in isolation. However, the story of political stability and trade have not always been so clear. We can follow the development of trade theory as a story of moving toward trade that improves a wider swathe of society's lives:

- In the pre-modern trade era, European trade in particular was described as a zero-sum game - every nation was expected to compete against each other for the upper hand. The core objective of so-called Mercantilism was to develop the largest trade imbalance possible through policies to maximise exports while minimising imports.[xlv] One can imagine that describing and treating your trade partners as also your enemies is not conducive to trade, economic development or stable relations. Yet, one finds parallels in modern nationalist interventionism.

- Adam Smith's most famous contribution in the 18th century was to break with the zero-sum world view by introducing the concept of absolute advantage in trade. In short, some nations are positioned to be able to produce certain goods and services more cheaply than anyone else. It is then to everyone else's advantage to purchase goods from that nation and instead use their own endowments to produce goods where they have an absolute advantage instead.[xlvi] Smith's work remains thought-provoking to this day. However, the problem with an absolute advantage-based description of trade is that it isn't particularly predictive - nations trade in a variety of goods where they do not appear to have a particular absolute advantage at all and may even import and export similar - substitutable - goods.

- David Ricardo followed Smith by instead noting that it is comparative advantage that is key.

To Ricardo, it was not just a matter of what a nation can produce best, but rather what can it produce relative to its other options, compared to what its trade partners can produce best versus their other options. That is, one country could have an absolute advantage in every production process, but we might rank these - surely a nation is better at producing one good than another. So, anytime it steps away from producing the good where it has the greatest advantage, they must ask whether the trade-off is worth it or would it instead be better to purchase the good from another country? The comparative advantage basis for understanding trade is comparatively quite predictive and the general concept forms the basis for much of modern marginalist economic thought. The problem with comparative advantage is that it doesn't quite get at why a nation would have a comparative advantage. A natural resource endowment is one reason that seems at first obvious. But natural resources require development before they can be sold. And what about nations that have advantages in other areas that are neither natural resources nor the skill of their labour?

- Eli Heckscher and Bertil Ohlin's theory of factor endowments then explores where Ricardo's work ends by asking why a nation has a comparative advantage and what policies should subsequently be adopted to leverage said advantages? In short, a nation with more abundancy in particular inputs to production can likely develop them at lower cost. Their comparative advantage is likely derived from a cost-minimising decision.[xlvii,xlix]

- Paul Krugman's new trade theory (NTT) - building on work by Dixit and Stiglitz on monopolistic competition - instead explores other bases for a cost advantage, focusing foremost on the power of economies of scale.[l] If instead of constant returns to scale, we expect increasing returns to scale, a nation that specializes sufficiently in the production of a particular good or service may gain a trade advantage specifically through the costs savings that follow from scale.[li] A nation can then produce a competitive advantage that did not exist before with sufficient effort - it need not be bound by nature and chance.

The development of international trade theory and the general perspective is hardly bound to the preceding list. We can also observe the underlying power of national policies at play – each model of trade is based on a perhaps long history of policy decisions that led to the modern state. Even in the case of natural resources, a state had to at one point explore for them, catalogue the wealth at their disposal and decide whether to invest in its development. We must then ask, is what a nation trades related to stability?

Does a less stable society rely less on developing manufacturing capacity and human resources and instead rely more heavily on natural resource exploitation? Or perhaps, does a greater reliance on natural resources for export revenues somehow weaken a state's stability? Does a nation addicted to natural resources (see the discussion of the "resource curse" elsewhere in this report) not develop a wider set of stabilizing institutions?

It has been widely and forcefully argued that the exceptional resource rents that can be captured - particularly from mineral and oil resources - lead to widespread corruption, private capture of public wealth and kleptocracy.[lii] Part of the reason for this is that mineral and oil resources in particular are point sources - sites that are easier to control and monopolise on by a smaller elite of society.[liii] Such groups are generally not focused on leading their nations and instead generally respond insufficiently to economic shocks. This results in less growth, more consumption volatility and subsequently greater political instability. Simultaneously, it has been argued that policy and industry experts tend to continue to focus on assisting resource extraction even in such poorly governed environments.[liv] We might imagine that they remain faithful to what is known as the Kaldor-Hicks compensation criteria.[lv,lvi] The basic premise of it is to make the economic "pie" as large as possible and then figure out how to distribute it later. Yet, it has been argued that such a basis for effectively looking the other way is entirely indefensible if there is no mechanism and intent for the gainers in society – the resource-owning elite - to compensate the public.[lvii] In short, there appears to be every opportunity for resource extraction-based trade - particularly from minerals and oils - to be related to political instability, at least if strong institutions to ensure accountability and redistribution are not present. Figure 13 incorporates these concerns into a schematic of the linkages between social stability and NDEs proposed in this section.

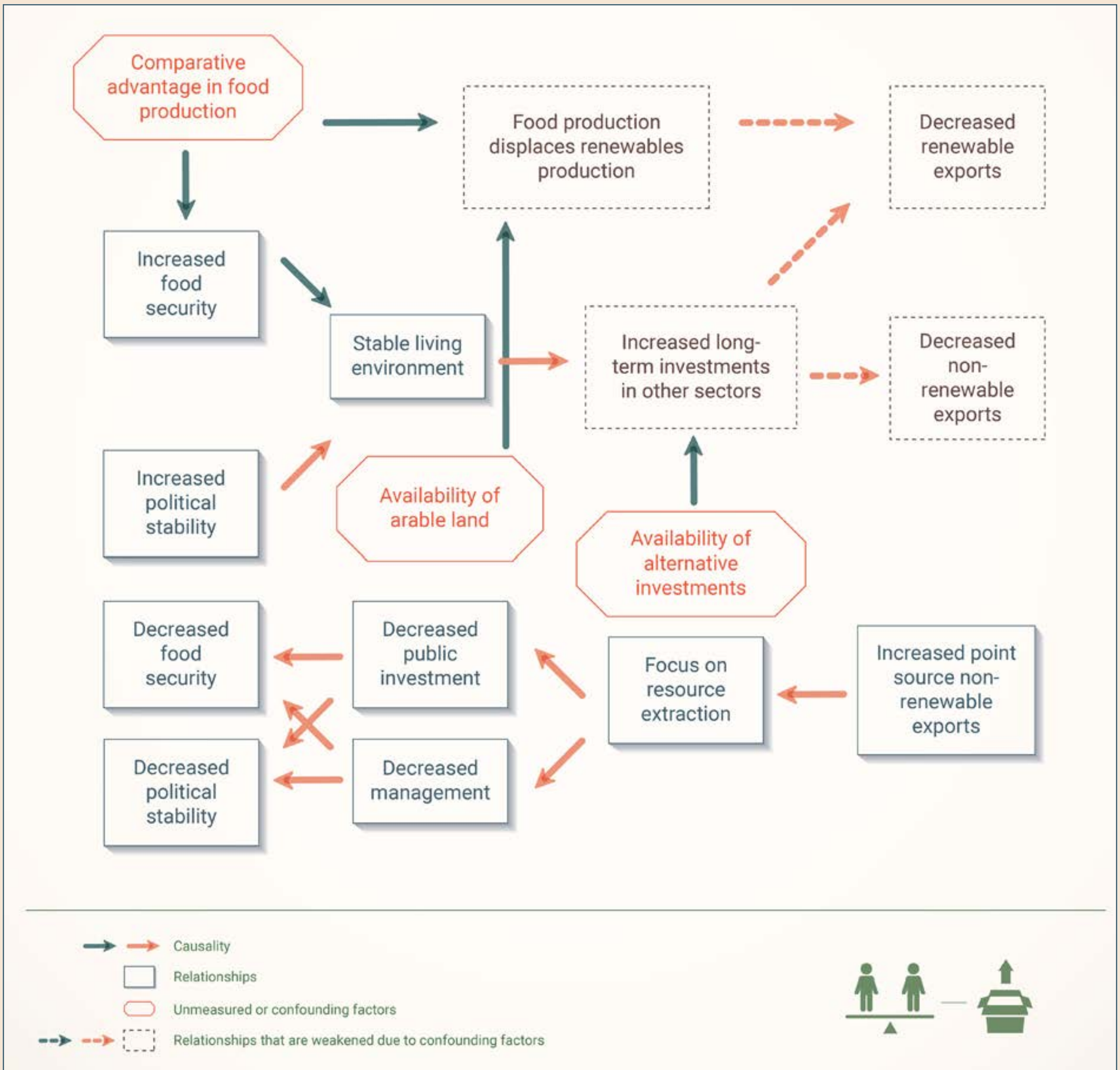


Figure 13: Proposed linkages between social stability and NDEs
Arrows suggest causality, boxes suggest relationships, octagons suggest unmeasured or confounding factors. Dashed arrows or boxes suggest relationships that are weakened due to confounding factors.

FOCUS POLITICALLY STABLE HNDE OUTLIERS

We highlight a couple countries with high dependency on renewable natural resources and low Fragile Index Scores: Iceland and New Zealand. Some HNDEs exhibit considerable diversity in their exports which may reduce export volatility.

In Figure 14 we demonstrate the diversity of exports from New Zealand.

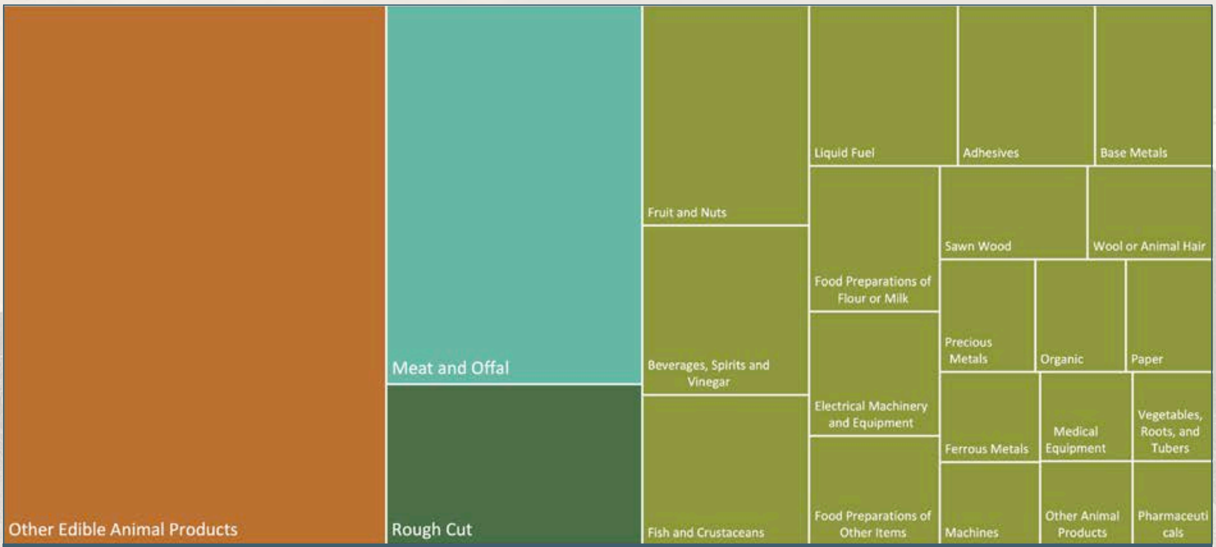


Figure 14: New Zealand's Exports by Value (2010-2019)

Another outlier, Iceland, is considerably less diverse as noted in Figure 15. During economic booms this may not matter, but during economic busts Iceland may be more seriously impacted.

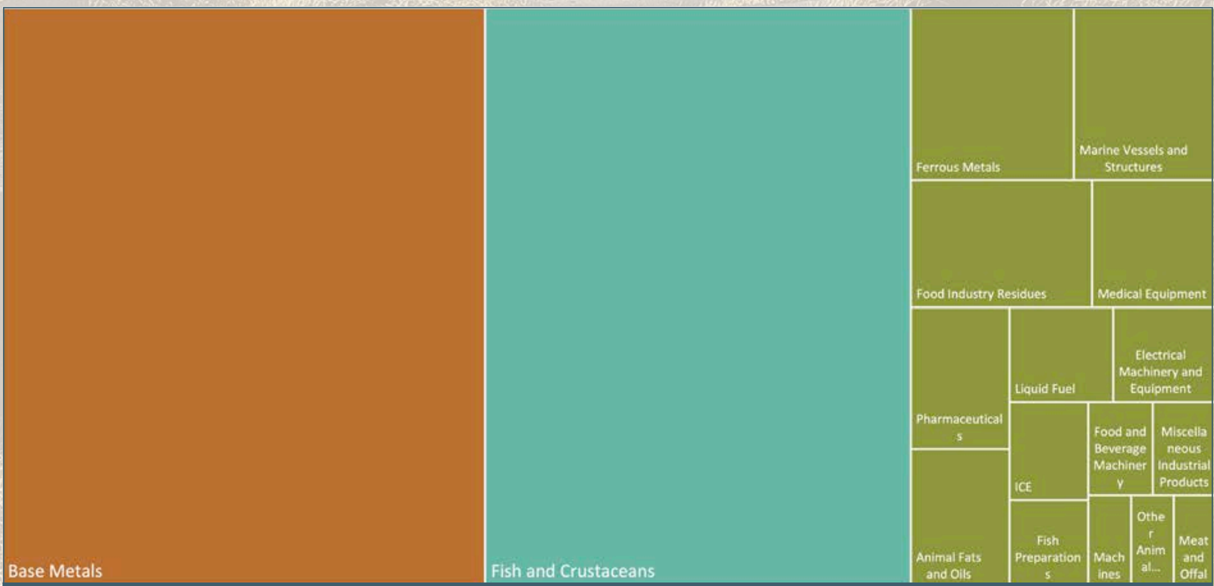


Figure 15: Iceland's Exports by Value (2010-2019)

Analysis

If Sen's premise that food is foremost a policy choice is correct, it is entirely possible that we find a correlation with NDE social stability measures - given land constraints, a nation can guide production towards some combination of agricultural and renewable resource production. When arable land is particularly limited, this trade-off is clearly more binding. However, without accounting for that constraint, the data includes observations where the land constraint is more or less binding. Food security as well as political stability also likely have longer-term effects - people living in a more stable environment are likely to be more able and willing to invest in the future. As renewable resource extraction tends to involve harsher conditions, greater long-term investments are likely to be made in other fields such that a nation moves away from renewable resource-based trade. In Figure 16, top row, we observe that nations with the best levels of food security are overwhelmingly in the LNDE and MNDE groups. Figure 16, bottom row, has a slightly different interpretation - countries in the HNDE group are rarely ever highly politically stable. We might speculate an interpretation that food security allows and encourages a nation to transition away from renewable resource extraction, while political instability can prevent such a transition.

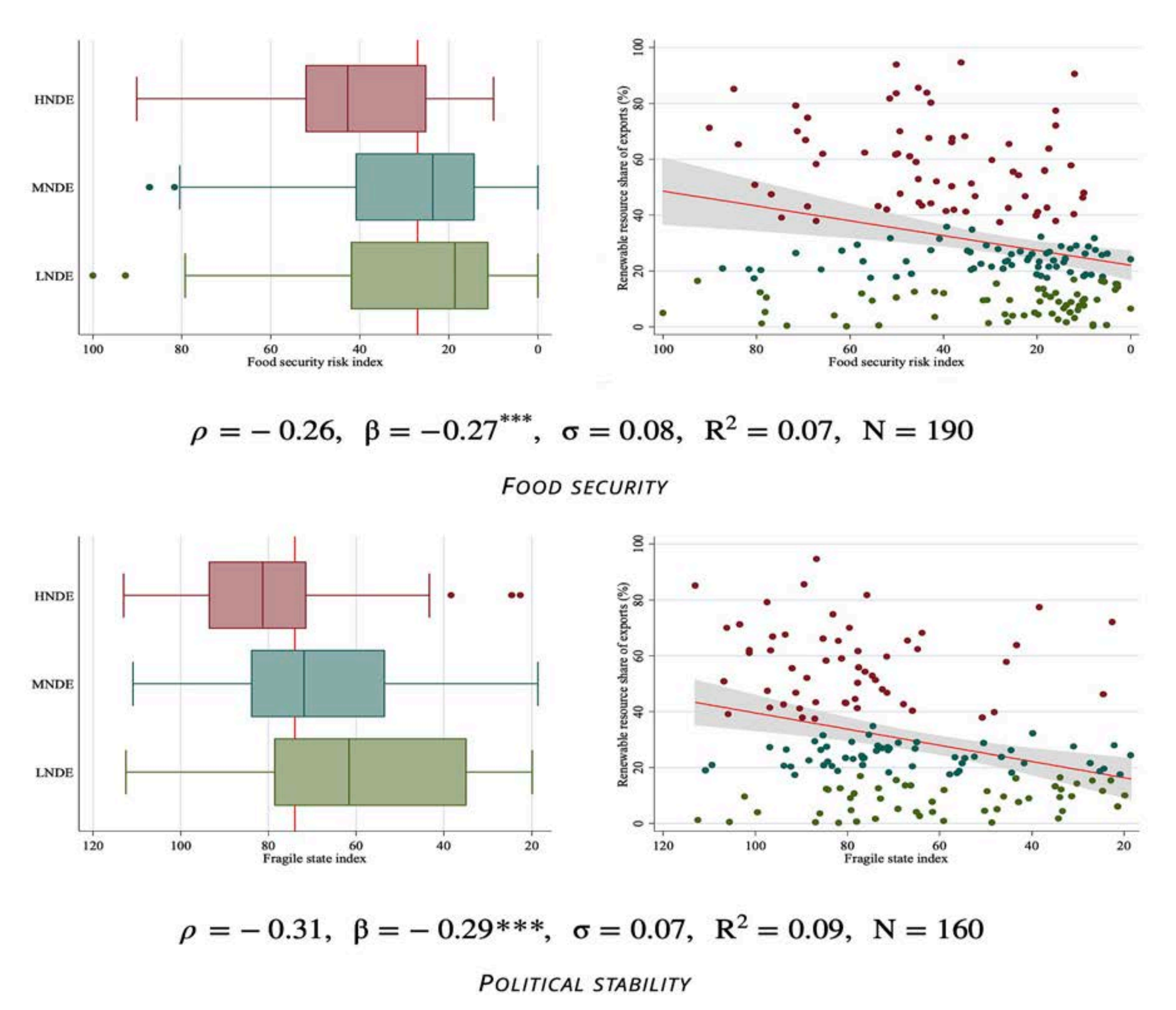


Figure 16: Renewable resource exports and social stability measures. Shading represents 95% confidence interval.

P-value: ns = P > 0.05, * = P ≤ 0.05, ** = P ≤ 0.01, *** = P ≤ 0.001

In terms of non-renewable resources, we generally expect a negative relationship with food security and political stability. However, as in Figure 17, top row, the relationship with food security is weaker. The premise was that a nation focused on point source, non-renewable resource extraction would be poorly focused on other matters such as developing a strong agricultural basis. Yet many nations according to the non-renewable resource metric are also food secure. Basically, there is little difference between the three groups in terms of food security. The empirical evidence generally, but not entirely, favours the perspective that nature-focused exporters - particularly mineral and oil exporters - have greater political instability. We see a relationship between non-renewable exports and political stability that is about the same as with renewable exports: a 10 percentage point improvement in the political stability index is correlated with about a 2.9 percentage point decline in non-renewable NDEs.[6] However, the background discussion suggested a reverse causality - point-source resource extraction results in decreased political stability. It is also interesting that there may be a minimal level of state stability necessary for point-source resource extraction - we observe that many HNDEs appear to exist along an instability bound of around 75 points as observed in Figure 17, bottom right plot.

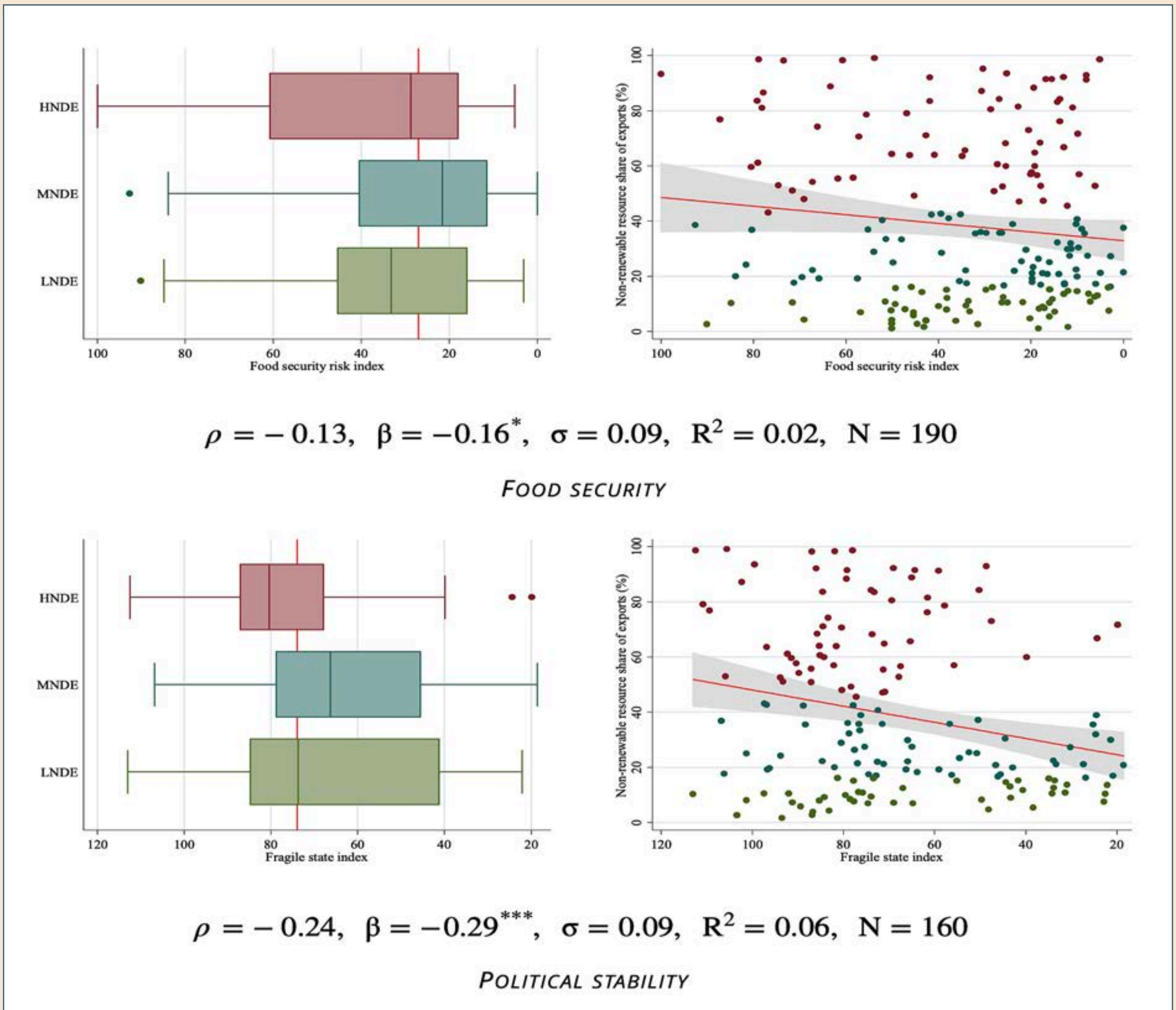


Figure 17: Non-renewable resource exports and social stability measures. Shading represents 95% confidence interval.

P-value: ns = P > 0.05, * = P ≤ 0.05, ** = P ≤ 0.01, *** = P ≤ 0.001

[6] Note that the political instability index is not strictly on a 100-point scale but rather ranges from Finland with a score of 14, to Yemen with a score of 112. This is then approximately interpretable as percentage point changes.

3 DOMESTIC INCOME

Measures assessed: GDP per capita and income inequality

Summary

Less inequality and greater GDP per capita levels are related to decreasing renewable exports. However, the causality between GDP per capita and renewable NDE level probably goes both ways.

There is unlikely **to be a significant relationship between non-renewable exports and GDP per capita and inequality levels in most nations.** The exceptions are a few wealthy, particularly low-population oil-dependent Gulf States.

Background

GDP per capita

Gross domestic product (GDP) - and subsequently GDP per capita - is quite old as a concept, originating in the 1600's.[lix] However, the modern structure of GDP originates in the 1930's as a basis on which the US Congress could manage an increasingly complex national economy during a substantial crisis. Even at its modern inception, it was acknowledged that GDP has substantial limitations as it is not equivalent to a measure of a population's actual welfare - it only includes a particular subset of measurable contributors to national output and as a result is not value free.[lx] Despite such concerns, GDP, GDP per capita and similar national accounts-based measures such as Gross National Product quickly became the primary metrics through which to note nation's success. By the 1960's it was clear that reliance on GDP measures was affecting all aspects of society, as what we measure is subsequently the basis for policy development.[lxi] The need for alternatives to GDP and GDP per capita – or at least additions - has intensified in recent years.[lxii,lxiii] Several measures have been proposed recently.[lxiv,lxv] But while GDP has repeatedly been found wanting, it has also been found necessary - it measures the magnitude of growth and, as such, *"whether the capacity for better lives is increasing."* [lxvi] By contrasting the alternative proposed against the necessity of GDP, we might observe that GDP itself is not the problem, but rather what we have done with it. By not reporting on how the returns to economic progress are disbursed, we cannot know whether an increase in GDP is benefitting the many or the few in society.[lxvii] As such, we should expect that satisfaction with GDP as a measure of economic progress differs substantially between societies - those with more transparency and traditions of inclusion of wider swaths of society in development are probably better represented by it.

It is particularly noteworthy in the present context that exports are one of the primary categories included in the GDP calculation via the expenditure approach[7]:

$$GDP = Consumption + Investment + Government + Exports - Imports$$

So, we immediately see that GDP and subsequently GDP per capita increase when exports increase, all else being equal. Whether the relationship between GDP per capita and exports is dependent on natural resource extraction is, however, not so clear. As previously noted, as nations become richer, their population tends to transition toward methods of earning a living that are not as difficult as renewable resource extraction. The issue doesn't just occur at the individual level - what a nation chooses to do with the revenues generated through resource extraction and exports can differ substantially.

An important difference between renewable and non-renewable natural resources as well as versus produced goods is also the level of exclusivity involved. Many natural resources of interest - particularly among non-renewables - are in short supply relative to demand as not everyone can simply acquire them through production. That is, at any moment there is a limited global supply available[8]. Subsequently, exclusivity-driven scarcity tends to result in positive long-run profits from natural resources. How such long-run profits are spent tends to matter a great deal. Does a nation invest in the future? Or does it expend natural resource-based profits in the present on consumption? The former leads to long-run development while the latter effectively wastes an opportunity.

This difference is still a matter of substantial debate - on whether a nation's ownership of natural resources, particularly non-renewables, is a "resource curse" as the phenomenon has come to be known. Or does access to basic resources help kickstart economic growth and social development?[lxviii] The concept of the resource curse itself is quite old - Machiavelli cautioned against running afoul of the idea in the year 1517.[lxix] It finds further historical reference in the works of Jean Bodin (16th century), Montesquieu (17th c.), Adam Smith (18th c.), and John Stuart Mill (19th c.).[lxx] However, modern debate on the resource curse - and the related phenomenon of the "Dutch disease" - can be traced to efforts in the 1950's to identify bases for the phenomenon.[lxxi,lxxii] The bases identified at that time - that resource exporters will end up with substantial trade imbalances and subsequently weakening terms of trade, that international commodities markets are fairly volatile and thus public spending will be volatile and that the profits from resource extraction by multinational corporations are unlikely to be spent in the local economy, continue to be explored in academic circles.[lxxiii,lxxiv,lxxv] But there is little doubt that, among the general public and in some circles in academia, the resource curse was popularised by the work of economists Jeffrey Sachs, Andrew Warner and their close colleagues from the 1990's onwards.[lxxvi,lxxvii,lxxviii] Unfortunately, evidence continues to be collected both supporting and refuting the existence of a resource curse in various cases.[lxxix]

[7] A couple of alternatives are the production approach based on the value added throughout the production chain, and the income approach based on which groups earn income from production. The expenditure approach makes most explicit the role of exports.

[8] Though, as we have seen repeatedly, scarcity often leads to exploration as well as innovation.

Income inequality

Economic inequality itself appears to be at least as old as humankind's transition to a sedentary, agricultural lifestyle. It appears to have existed since the earliest opportunities for man to extract rents from restricting access by others to scarce resources.[lxxx] It has been noted that the most sustained reductions in inequality appear to follow periods of great upheaval when the price of labour has increased due to scarcity.[lxxxi,lxxxii] We can observe the beginning of modern analytical interest in inequality perhaps by Jean-Jacques Rosseau.[lxxxiii] But more generally, we tend to observe that extreme inequality tends to reduce economic growth, particularly in poor countries.[lxxxiv, lxxxv, lxxxvi] In relation to trade, we can observe that inequality shows up in the discussions of Adam Smith and David Ricardo - in works famous for their discussions of trade.[lxxxvii, lxxxviii] The impact of trade itself on economic inequality may be quite case specific. However, it does appear that natural resource exporters have higher wealth inequality, particularly among poorer nations.[lxxxix, xc] One reason for this relationship is the infamous Dutch disease phenomenon where other sectors - in particular manufacturing where most jobs are working class-level - tend to decline when an economy's exports become natural resource dependent.[xci] Another reason is that if the items produced for trade are capital intensive, then those who own capital will benefit the most and inequality will increase. In comparison, if items produced for trade are labour intensive, workers benefit more and inequality may decrease.[xcii] This prediction does not bode well for particularly capital-intensive point source resource extractors focused on trading minerals and oil. Compounding the problem, international markets for basic natural resources tend to be quite volatile. This volatility may be a major driver of inequality in HNDEs, as it can be difficult for poorer households in particular to recover from shocks.[xciii, xciv]

Figure 18 summarizes the proposed linkages between GDP per capita, inequality and NDEs.

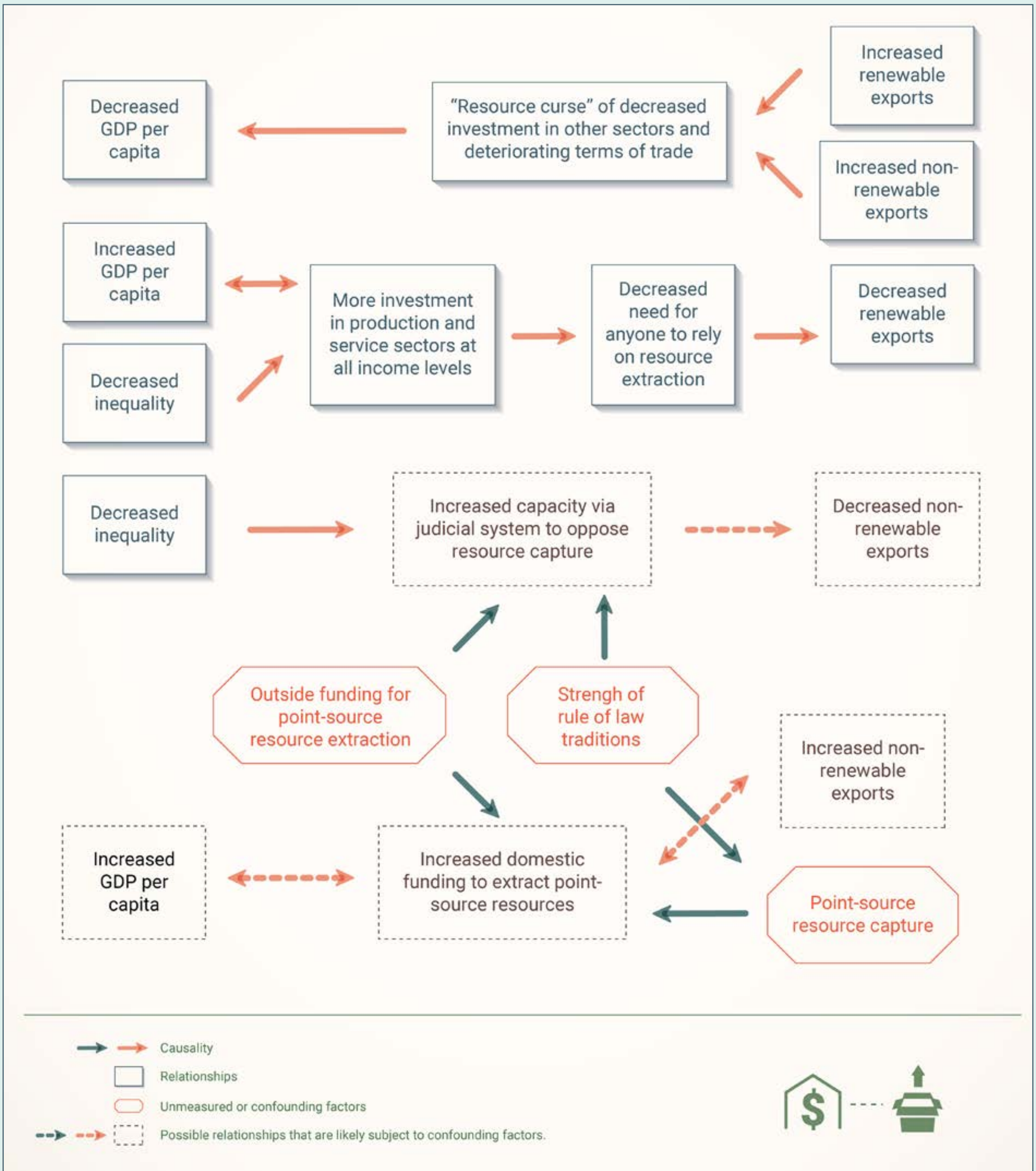


Figure 18: Proposed Linkages between Domestic Income and NDEs
Arrows suggest causality, boxes suggest relationships. Dashed-line arrows or boxes suggest possible relationships that are likely subject to confounding factors.

FOCUS WHY USE THE GINI COEFFICIENT?

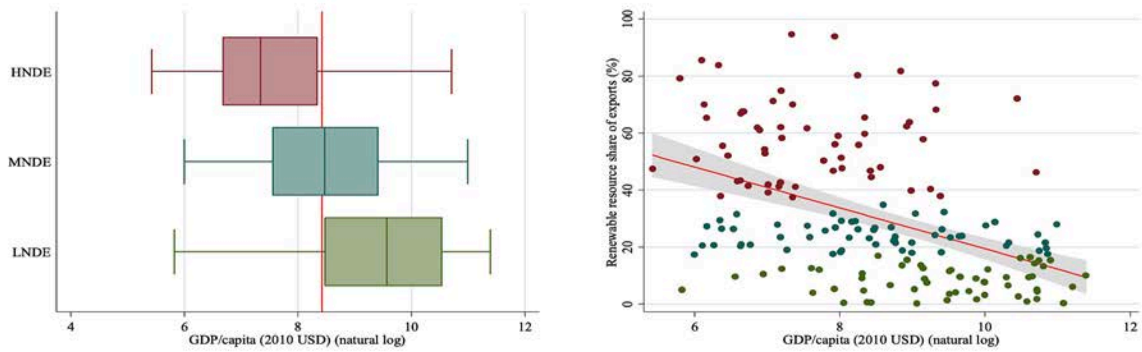
Another consideration is how to measure inequality trends. In this report we utilize the Gini coefficient.[xcv, xcvi] It is a popular distributional measure often based on summing over the Lorenz curve as it is particularly mathematically tractable.[xcvii]

The Lorenz curve is a representation of the distribution of income or wealth, depending on the metric of interest, noting that these two measures imply different things about society[xcviii] The basic functioning of the curve is to imagine ordering everyone in society from poorest to richest and then adding their wealth to the national coffers person-by-person as we progress up the social order. In an entirely equal society, each person's addition would be the same. At the other extreme, if one person owned all income or wealth, the rest of society would contribute nothing. The Gini score results from the difference between the entirely equal society case versus reality - the Gini is mathematically a measure of the area between such curves. So, when society is entirely equal, the Gini is zero - there is no difference and the Gini then increases with inequality. While it is true that the same Gini coefficient can be arrived at by different distributions, they are in general fairly consistent as most income distributions follow an approximately lognormal distribution pattern. Another issue with the Gini coefficient is that it only provides a snapshot in time, while inequality is almost always growing or shrinking in society (so the growth rate of the Gini coefficient is sometimes more appropriate).[xcix] The Gini coefficient is also making an implicit assumption that zero inequality is optimal - that a lower Gini coefficient is better, while some of the literature on economic growth suggests that low-to-moderate inequality may instead aid growth.[c, cl. cli]

Despite the preceding criticisms of the Gini coefficient, like GDP per capita it is difficult to beat. If poverty alleviation were the goal, the headcount ratio, poverty gap index, Watts index, Sen-Shorrocks-Thon index, or Foster-Greer-Thorbecke indices are all perhaps more applicable, particularly the latter as they incorporate the intensity of poverty.[ciii, civ, cv, cvi, cvii] One cannot seriously argue that mass poverty is ever socially optimal nor that its impact on trade would make any improvements in trade worth it. However, what about cases where the issue is not extreme and pervasive poverty? That is, there would be very little informative variation in poverty measures amongst advanced economies. Other measures, such as the Multidimensional Poverty Index (MPI), take a more general perspective on wellbeing.[cviii] However, the MPI is based on the Human Development Index through applying a set of subjective weights to its composite measure of welfare and so is immediately open to criticism.[cix, cx] Others have derived measures of inequality that are dynamic and grounded in social preferences, but less intuitive for the public.[cxi] In short, many have lamented the state of inequality and subsequently its measurement, but no statistic has emerged to represent the state of inequality with as much intuitive appeal as the Gini coefficient.

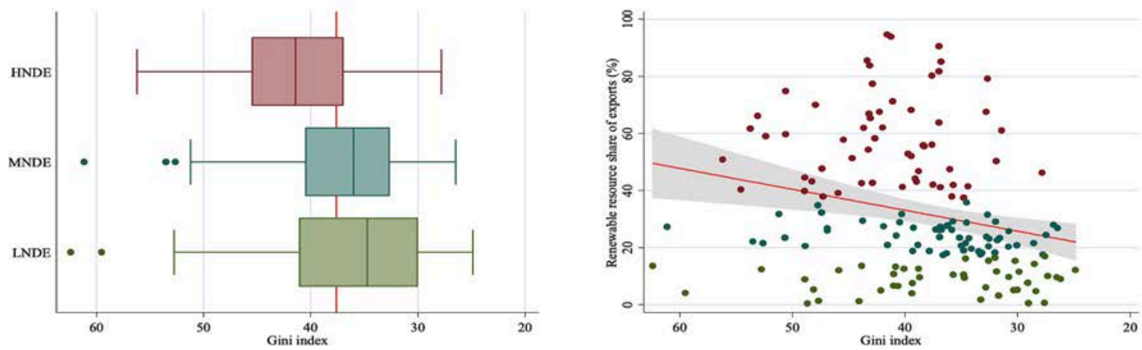
Analysis

Five-centuries of belief in the resource curse as well as several empirical studies from the 1990's onwards encourages us to include GDP per capita in our report. From the resource curse discussion, we might expect that a higher level of NDE is related to lower GDP per capita levels because export-based revenues were not effectively re-invested over past decades. Yet an alternative explanation has already been posited - as income increases, the people in society transition toward production and service jobs that yield comparatively more comfortable lifestyles. We cannot in this section distinguish between these causes - they likely have a synergistic effect anyway - but measure the strength of the combined relationship. Figure 19, top row, shows the relationship between GDP per capita and renewable exports, where a 10 percentage point increase in GDP per capita is related to about a 4.5 percentage point decrease in renewable exports. We can observe that this difference is driven by differences between the groups - that HNDE and LNDE groups are particularly different in terms of GDP per capita. We can also note in terms of inequality - as measured by the Gini coefficient transformed to a 100-point scale - substantial differences between the HNDE and LNDE groups. A 10 percentage point decrease in inequality as measure by the Gini index is related to a 7.3 percentage point decline in renewable exports.



$$\rho = -0.38,\ \ \beta = -0.45^{***},\ \ \sigma = 0.07,\ \ R^2 = 0.14,\ \ N = 173$$

GDP PER CAPITA



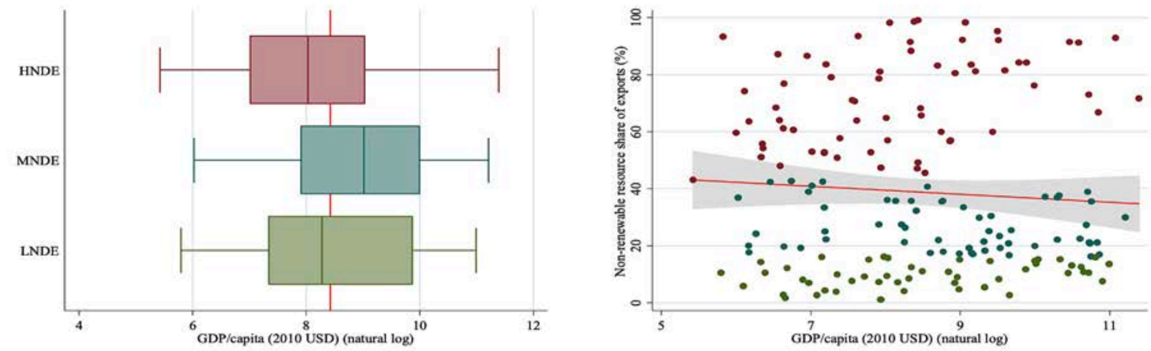
$$\rho = -0.25,\ \ \beta = -0.73^{***},\ \ \sigma = 0.23,\ \ R^2 = 0.06,\ \ N = 161$$

INCOME INEQUALITY

Figure 19: Renewable Resource Exports and Domestic Income Measures. Shading represents 95% confidence interval.

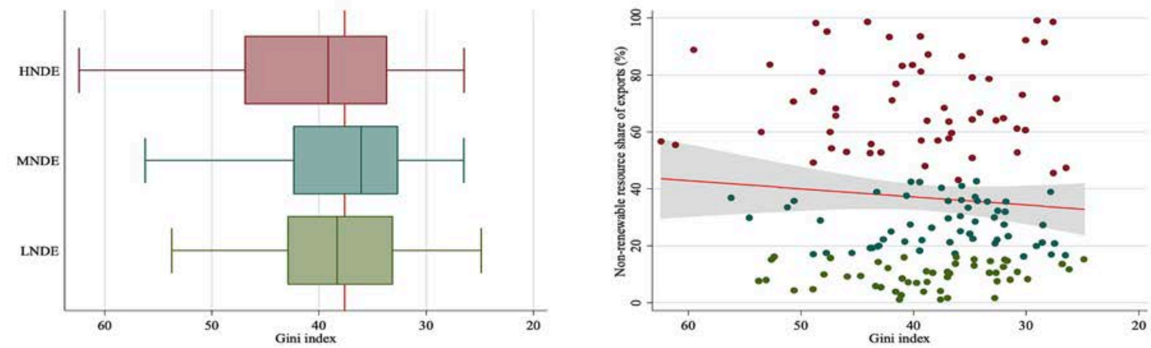
P-value: ns = P > 0.05, * = P ≤ 0.05, ** = P ≤ 0.01, *** = P ≤ 0.001

The resource curse explanation for GDP per capita differences often does not distinguish between renewable and non-renewable resources. However, the alternative of a transition away from difficult renewable production as incomes increase does not apply equally to non-renewables. Non-renewables are more often point-source in nature and often require a great deal of capital to exploit. They are likely to be controlled by a few elite members of society, according to the literature, and invested in by large, often multinational firms rather than by contributions from the public. In short, non-renewable resource extraction should be statistically independent of GDP per capita and income inequality measures, which is what we find in Figure 20. The exceptions are a few particularly wealthy, relatively low-population oil-reliant states in the HNDE group. These exceptions are not enough to influence the general result, however, that GDP per capita and the Gini index have low explanatory power when discussing non-renewable exports.



$$\rho = -0.06,\ \beta = -0.09^{ns},\ \sigma = 0.12,\ R^2 = 0.003,\ N = 173$$

GDP per capita



$$\rho = -0.08,\ \beta = 0.29^{ns},\ \sigma = 0.28,\ R^2 = 0.006,\ N = 161$$

Income inequality

Figure 20: Non-renewable Resource Exports and Domestic Income Measures.
Shading represents 95% confidence interval.

P-value: ns = P > 0.05, * = P ≤ 0.05, ** = P ≤ 0.01, *** = P ≤ 0.001

4 LAND TENURE

Measures assessed: soil erosion and water stress

Summary

Renewable resource exporters tend to have worse soil erosion and less water stress. The former could be a result of more intensive land use to produce renewable resources for export, and the latter is likely a precursor to effective renewable resource production.

Non-renewable export levels are likely to have little explanatory relationship with soil erosion and water stress indices. The weak statistical relationships found are probably the result of historical trends in where non-renewables were extracted first.

Background

Soil erosion

Compared to socioeconomic factors, the linkages between land tenure and NDEs tend to be more direct. The first linkages that we explore are between soil erosion and production for export. Due to growing global population levels and unequal arable land endowments, the trade in agricultural products has grown substantially in recent decades - sustained at a rate of about 8% per year for several years.[cxiii] Much of this growth has come from low- and middle-income countries. This has led to calls for caution, as much of the environmental impact linked to consumption in developed economies now occurs in less developed ones through international trade.[cxiv] That is, the environmental impacts occur abroad during production and harvesting, often in countries with less rigorous environmental regulations and monitoring. This is not an issue that is easily addressed either - it is often difficult to put numbers to environmental damages occurring abroad due to less access and familiarity.[cxv] Additionally, the form of land tenure can induce a principal-agent problem where the users of land choose production methods that do not preserve the value of a nation's soil assets. As a result of these factors, it is currently assessed that much of the world's agricultural output is being produced unsustainably. Trends in agricultural production are also adding to inequality issues and poverty, as large corporate producers tend to acquire higher quality lands and smallholding farms are increasingly concentrated in marginal areas which may also experience more rapid soil loss.[cxvi]

Water Stress

Approximately 78% of the world's cultivated land is rainfed, accounting for 60% of global crop output. However, as the world experiences global climate change and agricultural producers seek larger yields, they are increasingly turning to surface and groundwater sources in many countries, placing additional, unprecedented strain on systems.[cxvii] The combined pressures on water and soil resources are having a synergy effect as well – threatening the world's food supply and subsequently the stability of society. As nations withdraw more water from their surface and aquifer assets, their ability to cope with future shocks as well as population growth is also reduced as, quite often, the rates of withdrawal exceed recharge rates. Human activity has also negatively impacted recharge rates in many cases, to the extent that several previously recharging aquifers may now be considered closed systems - where effectively no recharge occurs at all.[cxviii] While agriculture accounts for the majority of water use - sometimes using over 90% of a nation's water resources - scarcity also impacts industry and obviously people directly.[cxix] As a result, the number of conflicts over water have risen substantially in recent years.[cxx] Figure 21 outlines the proposed linkages and confounders between land tenure measures and NDEs.

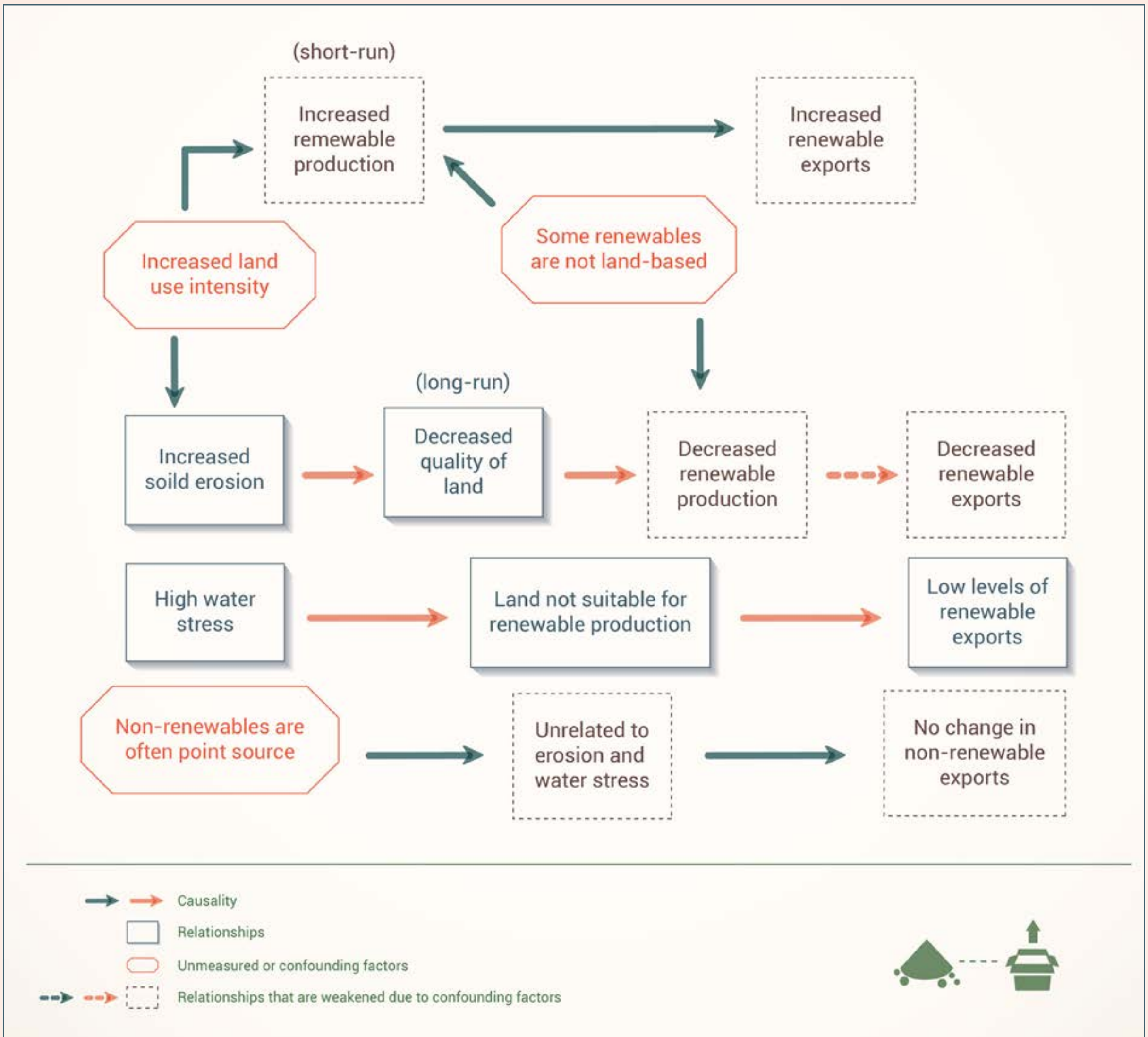
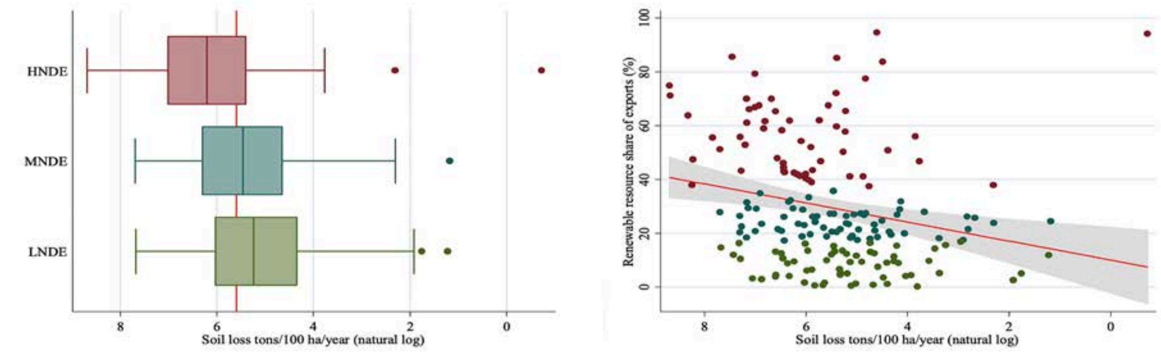


Figure 21: Proposed Linkages between Land Tenure and NDEs
Notes: Arrows suggest causality, boxes suggest relationships, octagons suggest confounding factors. Dashed arrows or boxes suggest relationships that are weakened due to confounding factors.

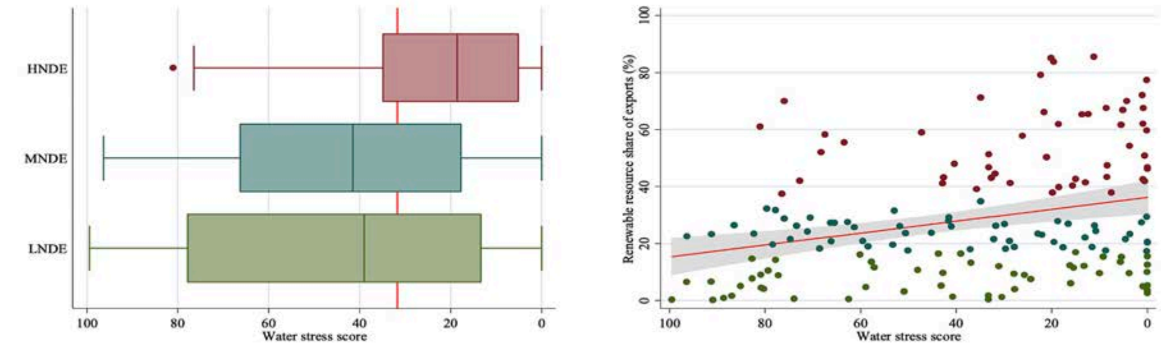
Analysis

While it is difficult to measure the impact of trade on agricultural land and water resources directly, we can assess the export side exposure to the risk created by soil erosion. It is probably abundantly clear that soil erosion degrades the value of land and that, all else being equal, using a parcel of land more intensely is likely to increase production in the short run, but also the rate of soil loss. This occurs to some extent regardless of whether land is used for renewable resource production or other uses. The determining factor, then, is whether soil erosion occurs more intensively during renewable resource production or production of alternatives. Figure 22, top row, suggests a negative relationship, that a 10 percentage point decrease in soil erosion is related to a 4.9 percentage point decline in renewable resource exports. That might suggest that renewable resource production is related to higher rates of soil loss. We also note that the underlying driver in the short-run is unlikely to be soil erosion itself, but a reduction in land use intensity and whether a nation invests in sufficient preventative measures. It is entirely possible that without intervention, agricultural-producing nations in particular may later lose competitive advantage - over the long-run - due to high levels of soil erosion.[cxxi] This also implies that, like inequality and food security, the scale of soil erosion is in part a policy choice.[cxxii] Identification of soil erosion factors is then tied to a nation's institutions as are many of the factors in this report. As an example, between 2001 and 2012, it is estimated that Africa and South America saw a considerable increase in mean soil erosion (+10% for Africa), whereas, primarily due to increased soil conservation practices, North America and Europe decreased their soil erosion in the same time frame.[cxxiii] Water stress has an entirely different interpretation in this study. Staple crops, as well as many cash crops often produced for export, tend to be water intensive. As such, low water stress is a prerequisite for many types of renewable resource production. The result is a positive relationship as in Figure 22, bottom row, where HNDE countries have on average lower water stress. However, the inclusion of states that export sea-based renewable resources muddies the empirical picture somewhat for both soil erosion and water stress indicators.



$$\rho = -0.33,\ \ \beta = -0.49^{***},\ \ \sigma = 0.11,\ \ R^2 = 0.11,\ \ N = 183$$

Soil erosion



$$\rho = 0.29,\ \ \beta = 0.21^{***},\ \ \sigma = 0.05,\ \ R^2 = 0.08,\ \ N = 161$$

Water stress

Figure 22: Renewable resource exports and land tenure measures. Shading represents 95% confidence interval.

P-value: ns = P > 0.05, * = P ≤ 0.05, ** = P ≤ 0.01, *** = P ≤ 0.001

FOCUS RENEWABLE NDEs, SOIL EROSION AND WATER STRESS TOP 10

In this focus, we rank the 10 countries experiencing the highest levels of soil erosion measured by average tons per hectare per year, as well as the 10 countries experiencing the highest levels of water stress.

In terms of soil loss, the majority of the top 10 also have a substantial share of renewables in their exports, approaching 80% in some cases. This adds some support to the argument that intensive renewables production is contributing to soil erosion. In terms of water stress, headed by Qatar, Israel and Lebanon, we note that none of the countries are significant renewable resource exporters. We also interpret this as support for the argument that high levels of water stress prevent renewable resource production for export.

Top 10 countries by soil loss and water stress

Soil loss			Water stress		
Country	**Soil Loss Mean ton/ha/yr**	**Renewable NDE %**	**Country**	**Aqueduct Water Stress Score**	**Renewable NDE %**
Comoros	59.4	73.3	**Qatar**	5.0	0.1
Haiti	59.4	75.7	**Israel**	4.8	6.6
Rwanda	42.0	45.9	**Lebanon**	4.8	24.4
Burundi	37.6	32.3	**Iran**	4.6	8.0
Mauritius	35.3	64.2	**Jordan**	4.6	21.8
Nepal	24.6	50.8	**Libya**	4.5	0.2
Viet Nam	23.6	27.6	**Kuwait**	4.4	1.1
El Salvador	22.0	55.1	**Saudi Arabia**	4.4	1.8
San Marino	21.5	17.4	**United Arab Emirates**	4.3	6.2
Malawi	18.9	77.5	**San Marino**	4.1	15.7

Non-renewable resources, in comparison, are more likely to be point-source in nature, implying they should not require extensive tracts of land, nor is there ex ante reason to believe that they would be substantially impacted by a lack of general water availability. Figure 23, top row, confirms there is little direct relationship on the natural log scale between soil loss and non-renewable resources, while β is statistically significant. This disparity suggests the result is driven by a few outliers. The small relationship between water stress and non-renewable exports suggested by the bottom row is more likely spurious and the result of historical trends. That is, non-renewable resource extraction tends to occur in more inhospitable locations today, after having been exhausted in more convenient and hospitable ones in the past and this likely causes both results.

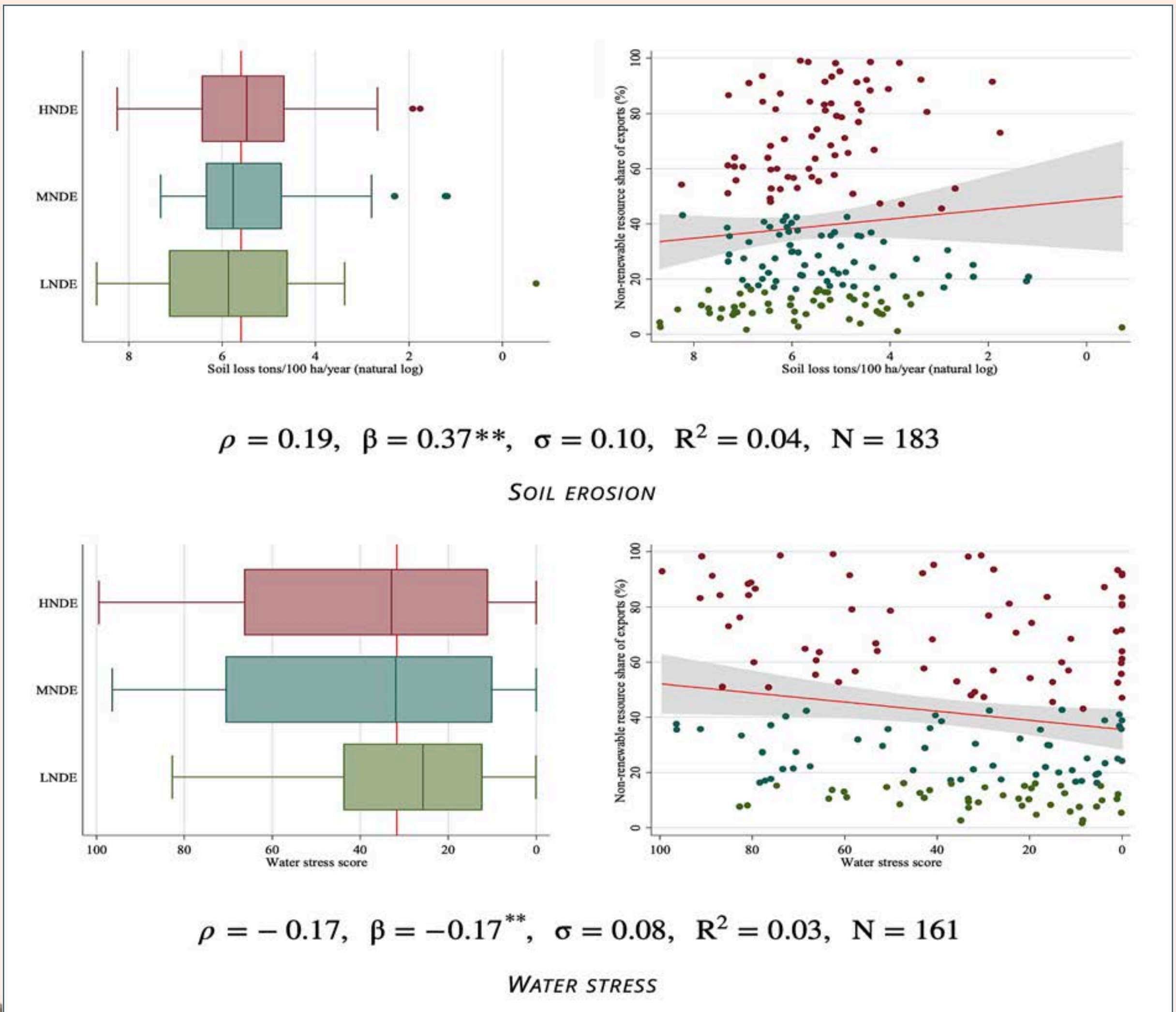
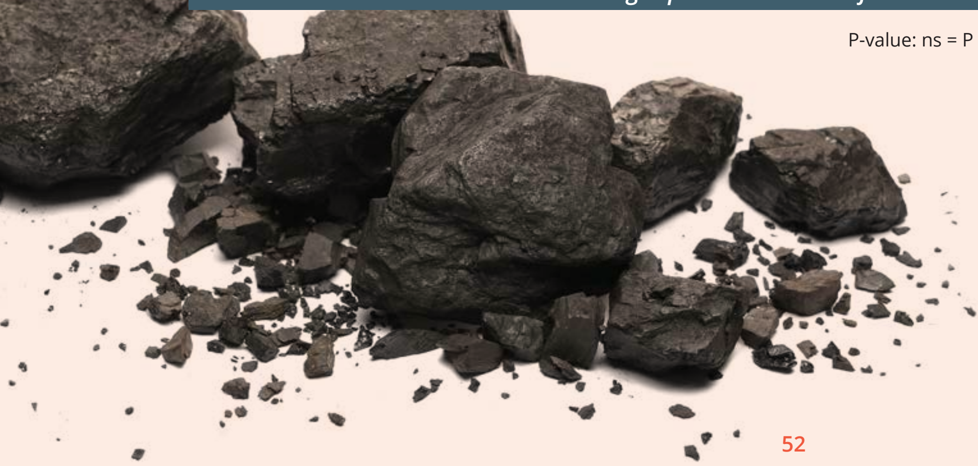


Figure 23: Non-renewable resource exports and land tenure measures. Shading represents 95% confidence interval.

P-value: ns = P > 0.05, * = P ≤ 0.05, ** = P ≤ 0.01, *** = P ≤ 0.001



5 FINANCIAL ACCESS

Measure assessed: Sovereign credit rating

Summary

The credit ratings of both renewable and non-renewable HNDEs are poorer on average than their MNDE and LNDE counterparts. However, access to well-established oil wealth and good governance can offset the effect.

Background

Credit rating

It is perhaps interesting that the modern national-scale credit rating system is a relatively new phenomenon, arising in response to greater global interconnectedness. The origin of modern credit ratings can be traced to at least the early 19th century mercantile credit agencies.[cxxiv] These arose to address the increasing information gap as people and firms began doing business at greater frequency with a greater variety of partners at greater distances. In short, independently it is costly to ascertain the credit worthiness of potential partners which are not known personally. Following the 1837 financial crisis, the mercantile credit agency model was upscaled and consolidated considerably in the United States, eventually leading to today's national-scale rating system.[cxxv]

The credit rating of a country is generally based on its sovereign debt risk, which in turn is based on a nation's willingness plus ability to repay its debts. Willingness to repay is generally a function of the costs and benefits to a nation of repaying versus defaulting and will be particularly difficult to identify. A nation has every reason to signal either willingness to repay or default as suits their agenda. Ability to repay one's debts is perhaps more quantitatively approachable. Common variables used in assessing sovereign debt risk are a nation's debt service ratio (what is due on a debt versus export revenues), import ratio (imports versus foreign reserves), investment ratio (the share of national revenues that are reinvested in productive uses), the variance of export revenues and the growth rate of the domestic money supply.[cxxvi] Clearly then, we should expect a strong relationship between natural resource exports and a nation's credit rating. We have observed in prior sections that national resource commodity markets tend to be more volatile.[cxxvii] This volatility implies to creditors that an HNDE may have difficulty repaying its debt at some point in the future. We have also noted previously that point-source natural resources in particular are more often subject to capture by smaller groups in society. The entire point of such capture is to retain resource rents for private use, negatively impacting the investment ratio. This likely decreases the total magnitude of economic growth as well, reducing the capacity to repay a nation's debts.

Recently, there has also been advocacy for better representation of environmental and natural resource-related risks - both related to renewable and non-renewable resources - into estimates of sovereign debt risk.[cxxviii] In short, substantial stresses on our planet's ecosystems are becoming a biting constraint on output.[cxxix, cxxx] Planet Tracker has previously published on this matter in co-operation with the London School of Economics Grantham Research Institute on Climate Change and the Environment in our 2020 report the **Sovereign Transition to Sustainability**.[9] As a practical matter, rather than waiting for environmental losses to be revealed through international market volatility, one wants to assess changes in risk at the national level - the level that matters for credit ratings.[cxxxi, cxxxii] However, incorporation of environmental risks directly into credit ratings is an ongoing process and not reflected in the data available. Still, there is sufficient evidence to suggest a strong relationship as outlined in Figure 24.

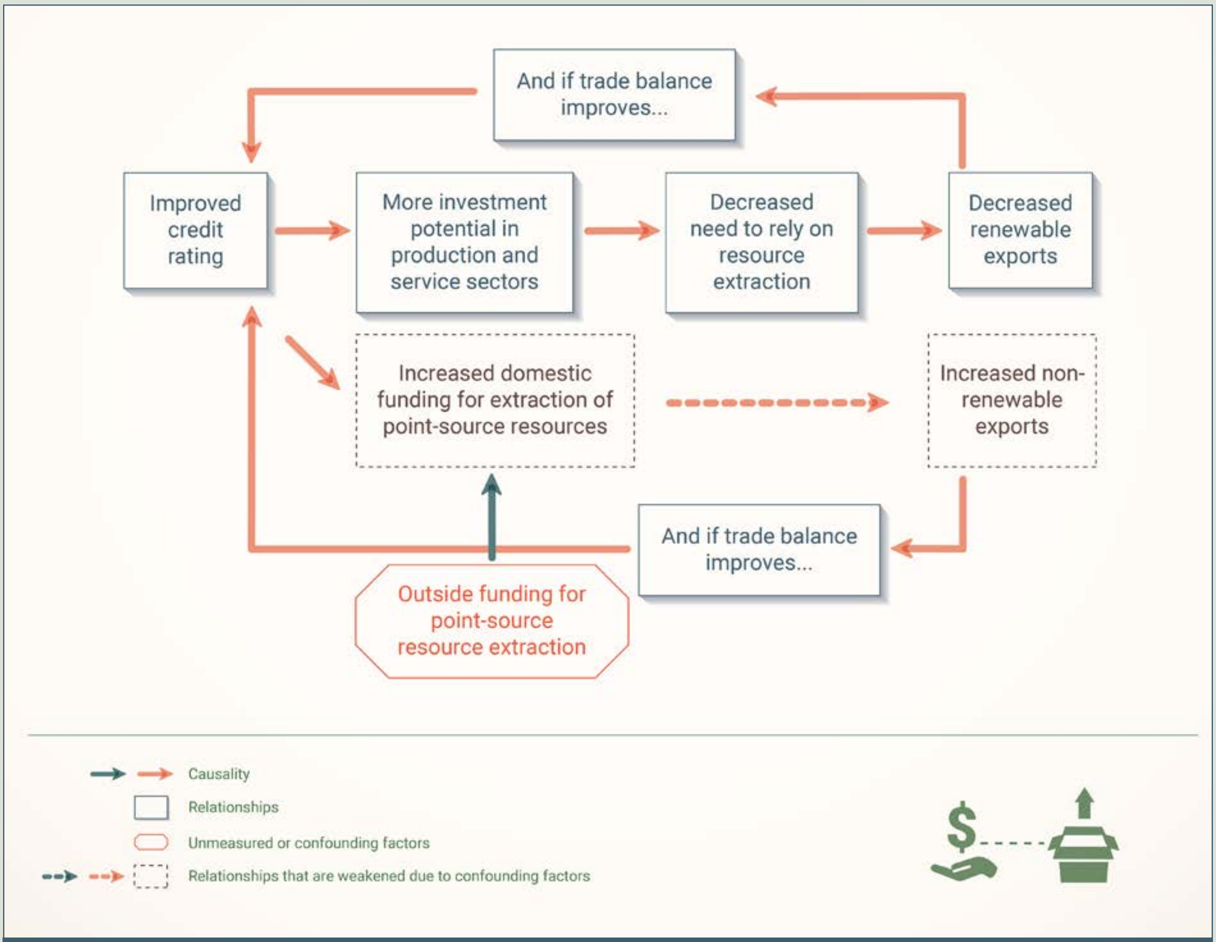
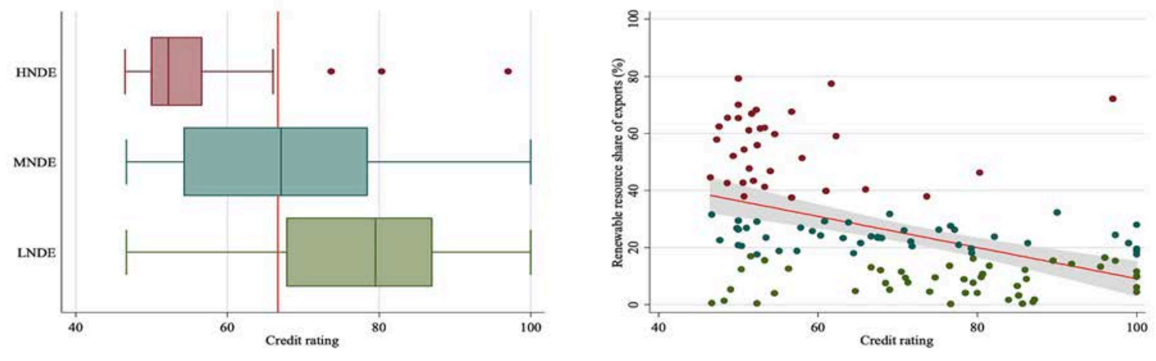


Figure 24: Proposed Linkages between Financial Access and NDEs
Arrows Suggest Causality, Boxes Suggest Relationships, Octagons Suggest Confounding Factors. Dashed Arrows Or Boxes Suggest Relationships That Are Weakened Due To Confounding Factors.

[9] https://www.lse.ac.uk/granthaminstitute/news/countries-must-protect-their-natural-capital-or-face-increased-sovereign-credit-risk-say-london-school-of-economics-and-planet-tracker/

Analysis

As susceptibility to market volatility increases default risk, we expect that nations with higher levels of natural resource exports - which tend to have more volatile markets - will have lower credit ratings. Conversely, as a nation transitions away from NDEs, their credit rating should gradually improve. As their credit rating improves, a nation also has better access to development funds and foreign investment at more favourable rates. In the case of renewable exports, we expect a feedback cycle to then occur as nations transition away from renewable production to intermediate and finished goods production as well as services. The plots in Figure 25 provide some evidence in support of this process as HNDEs have substantially worse credit ratings than other countries in almost all cases. But this result was almost a certainty as the volatility of exports directly impacts a nation's credit rating.



$$\rho = -0.46,\ \ \beta = -0.55^{***},\ \ \sigma = 0.10,\ \ R^2 = 0.21,\ \ N = 124$$

Figure 25: Renewable resource exports and credit rating. Shading represents 95% confidence interval.

P-value: ns = P > 0.05, * = P ≤ 0.05, ** = P ≤ 0.01, *** = P ≤ 0.001

Figure 26 shows that mean credit ratings for each NDE group have fallen in recent decades, but not equally - the gap between HNDE and LNDE countries has widened somewhat. We also observe that HNDE countries receive credit ratings from S&P less often - that the NDE group in this case is less representative of the entire population.

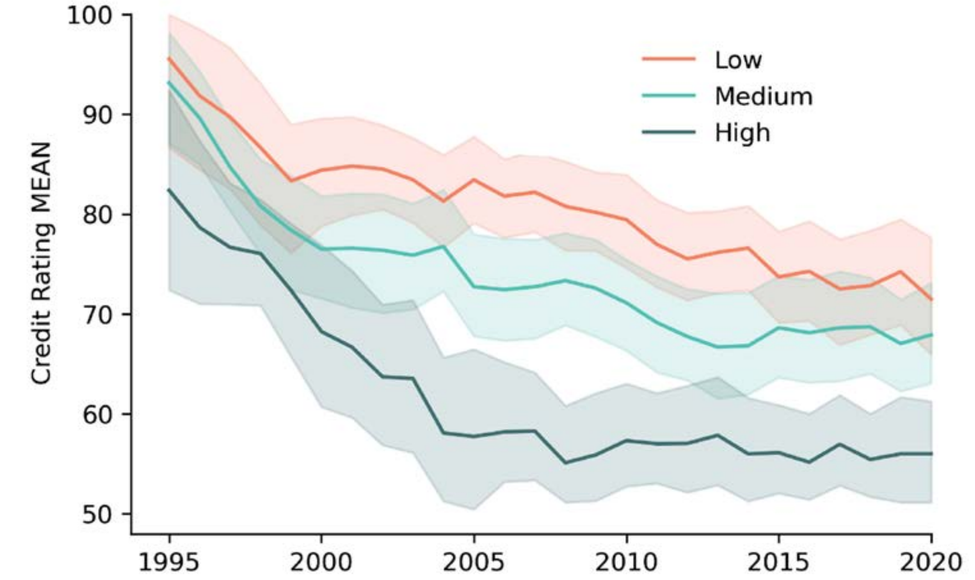
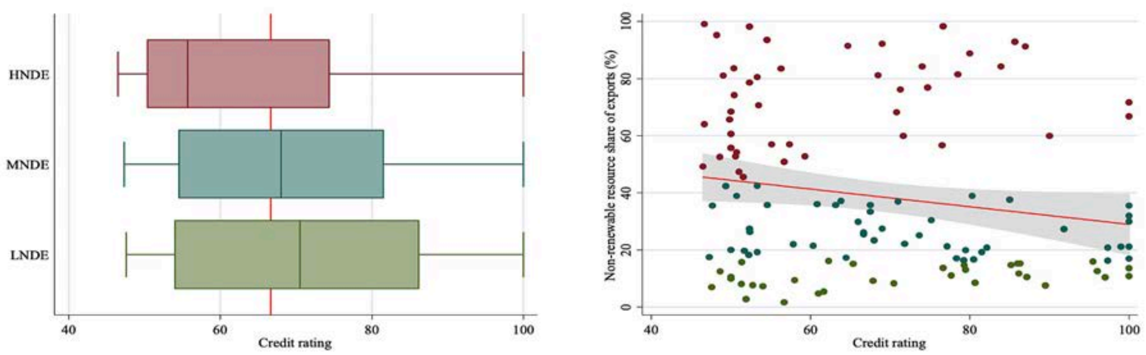


Figure 26: Credit ratings for high, medium and low renewable NDEs, over time. Credit ratings are converted to a 1-100 scale, 100 is the best score. Shading represents 95% confidence interval.

The result differs somewhat for non-renewable exporters due to the nature of non-renewable assets. We can observe in Figure 27 that several HNDEs have substantially worse credit ratings than other nations. However, we also observe that several nations do not fit this pattern and are similar in credit rating to MNDE and LNDE nations and as a result, the explanatory power of the model suffers. The type and certainty of non-renewable assets is an important factor - several oil-producing nations receive higher credit ratings as there is little expectation of unmitigated default. Figure 26 shows that mean credit ratings for each NDE group have fallen in recent decades, but not equally - the gap between HNDE and LNDE countries has widened somewhat. We also observe that HNDE countries receive credit ratings from S&P less often - that the NDE group in this case is less representative of the entire population.



$$\rho = -0.18, \ \beta = -0.31^{**}, \ \sigma = 0.15, \ R^2 = 0.03, \ N = 124$$

Figure 27: Non-renewable resource exports and credit rating. Credit ratings are converted to a 1-100 scale, 100 is the best score. Shading represents 95% confidence interval.

P-value: ns = P > 0.05, * = P ≤ 0.05, ** = P ≤ 0.01, *** = P ≤ 0.001

FOCUS OECD CREDIT RATINGS AND NATURE DEPENDENCY

In this focus, we examined the countries in the 38-member OECD to see whether the relationship between high nature dependency of exports persists. Figure 28 suggests that OECD credit ratings have remained robust while the rest of the world has been degraded.

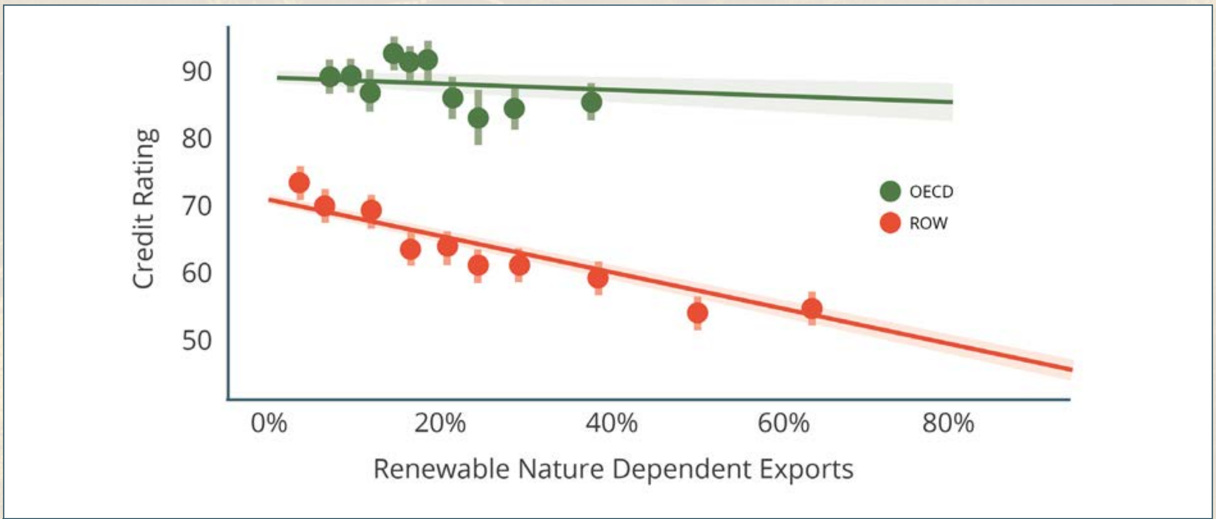


Figure 28: Credit ratings vs renewable nature dependent exports. Credit ratings are converted to a 1-100 scale, 100 is the best score. OECD and rest of the world (ROW).
This plot is made by binning the x variable into 10 discrete evenly-sized (not necessarily spaced) bins and then estimated the central tendency (mean) and a confidence interval. This binning only influences how the scatterplot is drawn; the regression is still fit to the original data.

We note the negative correlation between the credit rating and the dependence on nature-based exports was therefore much stronger for non-OECD countries (-0.46) than for OECD countries (-0.11). This can also be seen in Figure 29, which shows time on the x axis.

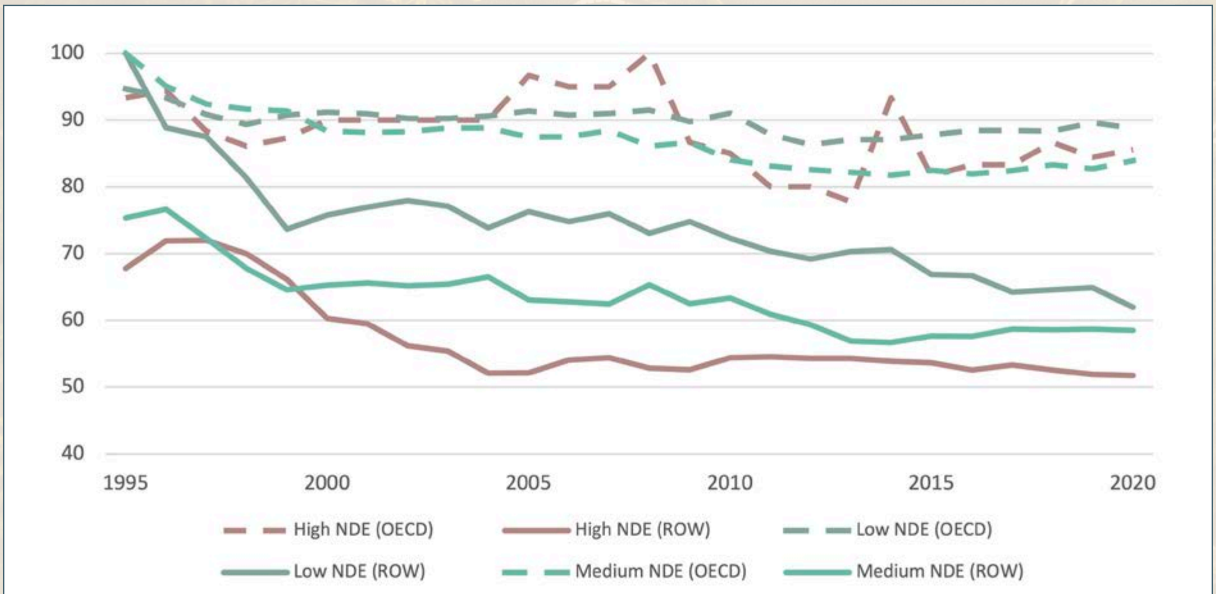


Figure 29: OECD versus rest of the world (ROW) and NDE category credit ratings.
Credit ratings are converted to a 1-100 scale, 100 is the best score.

6 LONG-TERM INFLUENCES

Measures assessed: patent applications and climate resilience

Summary

Renewable resource exports are negatively related to patent applications and climate resilience. HNDEs are focused on resource production and harvest rather than more patent-intensive fields. Meanwhile, climate resilience scores are in part based on natural resource dependency.

Non-renewable resource exports have a weaker but still negative relationship with patents and climate resilience.

Background

Patent applications

While we have noted some factors that have long-term influences, for example soil erosion in the preceding section, this section explores characteristics that have particularly long-term impacts. The first of these is patent activity. Patenting itself is quite old, existing in various forms and societies for millenia.[cxxxiv, cxxxiv] Patents, as is commonly known, grant monopoly power to the holder for some time. For much of patent history, the focus of patent protections was on what they did for the inventor through that power and, in different periods and societies, patents have also been abused to retain monopoly for persons linked to the aristocracy. It is far more recently that patents enter the mainstream discussion of economic growth and trade - of what patents do for society.

One noteworthy strand of the literature begins with endogenous growth theory, which explores the drivers of total factor productivity (TFP) changes in societies.[cxxxv] One of the reasons that innovation is particularly valuable in increasing TFP is that knowledge and some technological improvements can be effectively implemented widely without decreasing in their impact - they are not decreasing in returns to scale.[cxxxvi]

It is also thought that patents have synergistic as well as cumulative effects - that innovation builds atop of innovation. The speed of the distribution of innovations both within and between economies is, however, influenced by many factors.[cxxxvii] It is at least in part a policy choice and countries which embrace innovation - including through establishing the right balance between patent protections versus ease of diffusion - will typically engage in a higher rate of innovation and ultimately patent granting. Patent applications are basically a more salient proxy for the speed of technological development - of innovation - with a higher number of applications suggesting more effort is being directed toward technological development. The relationship with renewable and non-renewable resource exports is likely negative, however. While innovations continue to occur in renewable and non-renewable resource-relevant fields, the vast majority of research and development funding and effort is directed toward technological and pharmaceutical development in most modern economies.[cxxxviii] It is also well-known that a few countries are responsible for the the vast majority of patent applications - ten countries produce roughly 96 per cent of global patent applications - see Table 5. As we can observe, the vast majority of all global patent applications originate from LNDE countries. Meanwhile, the majority of countries instead produce few patents per year and the resulting distribution of patent activity is highly bi-modal.

Table 5: Top 10 Countries by Annual Patent Applications.
Annual averages over the period 2011-2020. Based on World Bank data on patent applications of residents.

Country	Renewable NDE	Annual patent applications
China	L	985,836
United States	L	280,682
Japan	L	261,801
Republic of Korea	L	161,465
Germany	L	46,827
Russian Federation	L	25,890
France	M	14,249
India	M	14,073
United Kingdom	L	13,984
Islamic Republic of Iran	L	11,221

Climate resilience

The final factor that Planet Tracker explores in relation to NDEs is a country's climate change resilience using the Notre Dame Global Adaptation Initiative (ND-GAIN) Country Index.[cxxxix] The index summarises a country's vulnerability to climate change and other global challenges in combination with its readiness to improve resilience. It is a composite index of 45 indicators ranging from projected population changes to projected changes of warm periods, disaster preparedness, ICT infrastructure, rule of law and, importantly, ecosystem services. The index is intended to help governments, businesses and communities better prioritise investments for a more efficient response to the global challenges ahead. As natural resource dependency is an input to the calculation of climate resilience scores in many ways, it is immediately obvious that the score and natural resource export scales are related. Rather like patent applications, the climate resilience score is more a salient proxy for the wide range of institutional and social decisions that impact natural resource dependency. Unfortunately, we also note that the countries with the poorest climate change resilience scores in Table 6 also tend to be exceedingly poor and as such have less capacity to make the sort of substantial changes necessary to avert climate change-driven crises.

Table 6. Bottom 10 countries by Worst Composite Risk (ND-GAIN)

Country Name	ND Gain	Renewable NDE %
Chad	27.2	4.1
Central African Republic	27.7	59.5
Somalia	27.7	68.3
DRC	30.8	1.4
Afghanistan	31.4	73.3
Guinea-Bissau	31.6	99.1
Sudan	32.3	48.5
Niger	32.5	58.6
Zimbabwe	33.3	22.8
Liberia	33.5	15.4

The result of exploring long-term factors is that we have identified a couple proxies for underlying national trends that may differ strongly by NDE group. Figure 30 summarises the linkages.

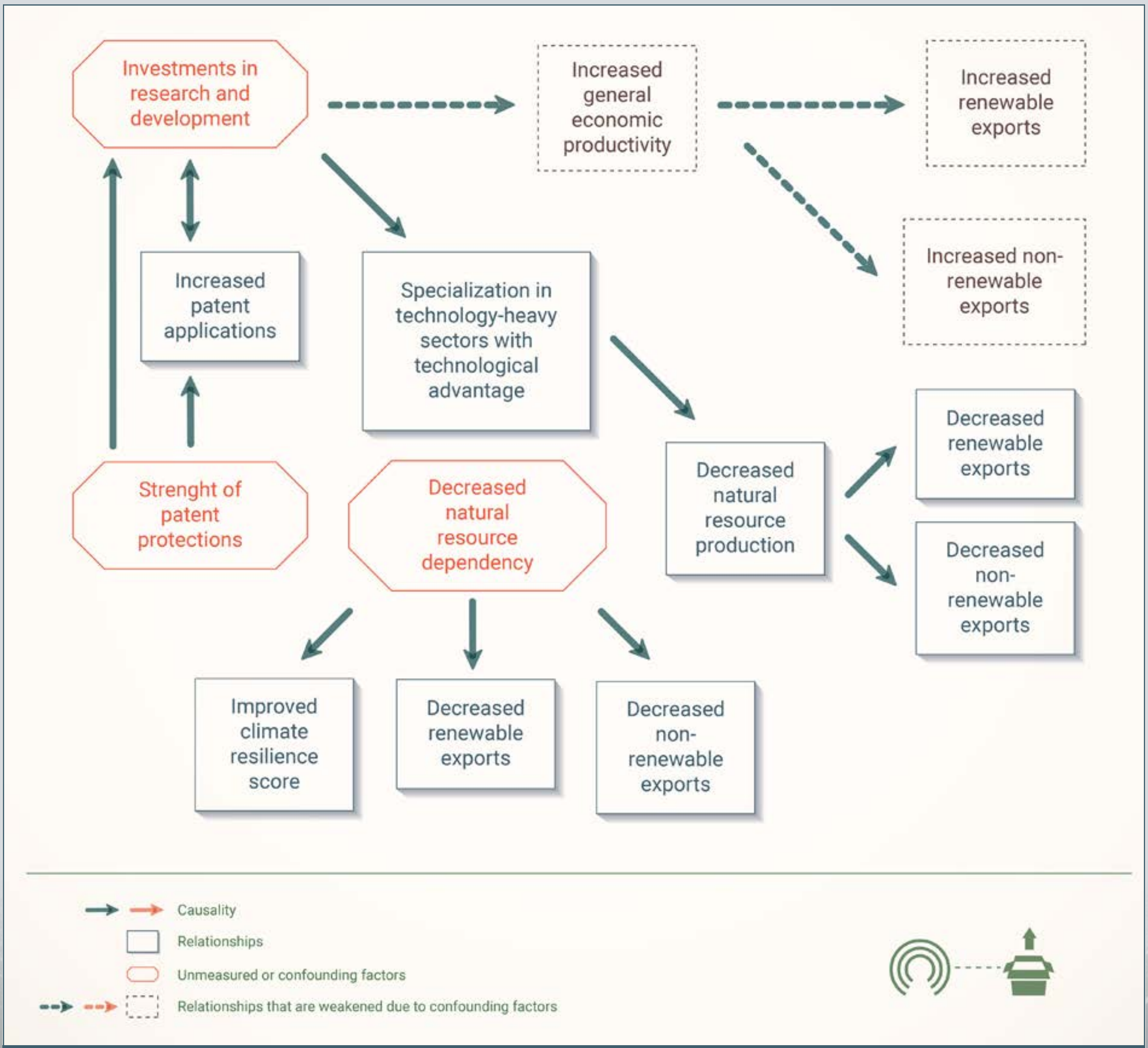
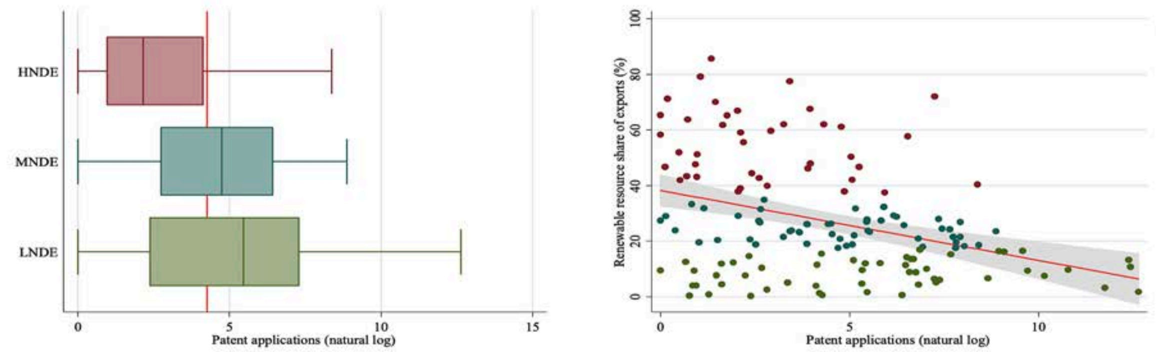


Figure 30: Proposed linkages between long-term influences and NDEs
Arrows suggest causality, boxes suggest relationships, octagons suggest confounding factors. Dashed arrows or boxes suggest relationships that are weakened due to confounding factors.

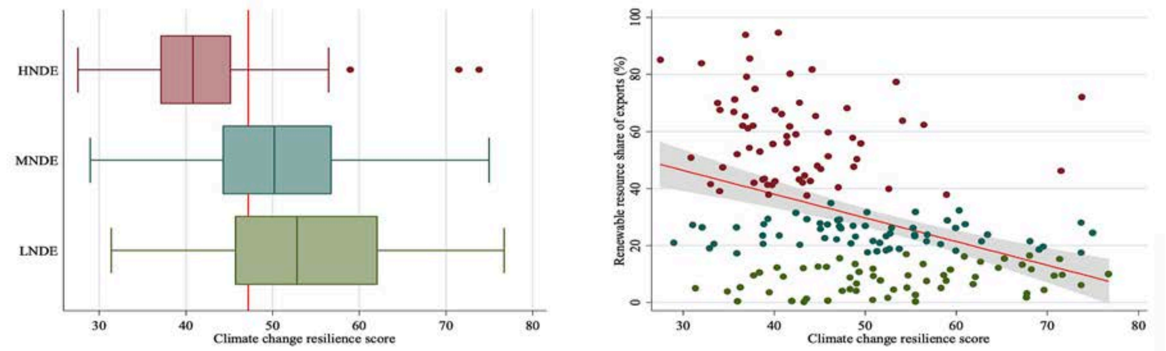
Analysis

As we have discussed, increased research and development efforts, encouraged by appropriate patent protection, both increase the rate of patent applications and general economic activity. However, the main result of research and development efforts is more likely a transition in their economies to being centred around high-tech endeavours rather than natural resource production and extraction. As a result, we expect renewable resource extraction to be negatively related to patent applications as suggested by Figure 31, top row. We also expect that climate resilience score improvements are negatively related to renewable resource dependency as in Figure 31, bottom row, but this is by definition.



$$\rho = -0.18,\ \ \beta = -0.28^{**},\ \ \sigma = 0.13,\ \ R^2 = 0.03,\ \ N = 146$$

PATENT APPLICATIONS



$$\rho = -0.40,\ \ \beta = -0.83^{***},\ \ \sigma = 0.15,\ \ R^2 = 0.16,\ \ N = 181$$

CLIMATE RESILIENCE

Figure 31: Renewable resource exports and long-term influences. Shading represents 95% confidence interval.

P-value: ns = P > 0.05, * = P ≤ 0.05, ** = P ≤ 0.01, *** = P ≤ 0.001

We also observe that the rates of patent applications divided into NDE group have been fairly consistent across time as in Figure 32. HNDE countries have been consistently less focused on technological innovation over at least the last three decades.

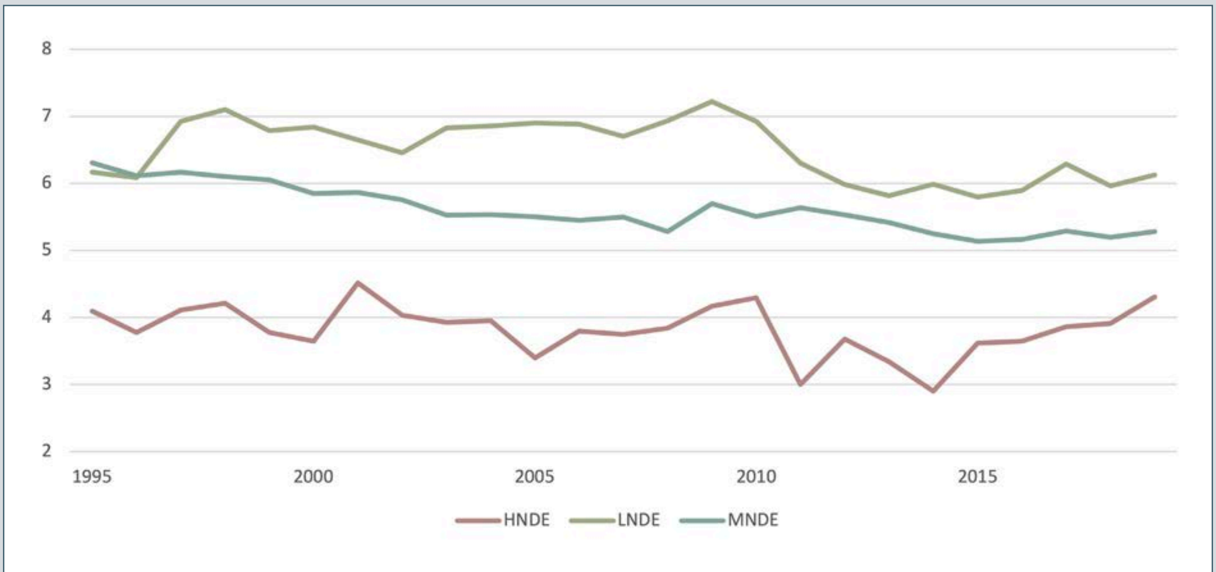


Figure 32: Patent applications over time (high, medium and low NDEs)

FOCUS A CLOSER LOOK AT HNDEs RESILIENCE

Figure 33 groups each of the countries in the HNDE grouping by continent and plot against their ND-GAIN resilience score. It shows that European HNDEs (e.g. Iceland, Latvia, Moldova) generally have higher resilience scores, followed by South America. However, Asian and African HNDEs have lower resilience scores with laggards such as Afghanistan and Somalia.

An analysis by the International Monetary Fund (IMF) examined a causal link between ND-GAIN scores and sovereign credit ratings.[cxi] This suggested that if countries' preparedness for climate change and other resilience does not improve, their credit rating could be downgraded - HNDEs with lower resilience composite scores, most likely due to income constraints, could therefore also be at greater risk of poorer credit ratings and less financial access in the future as well.

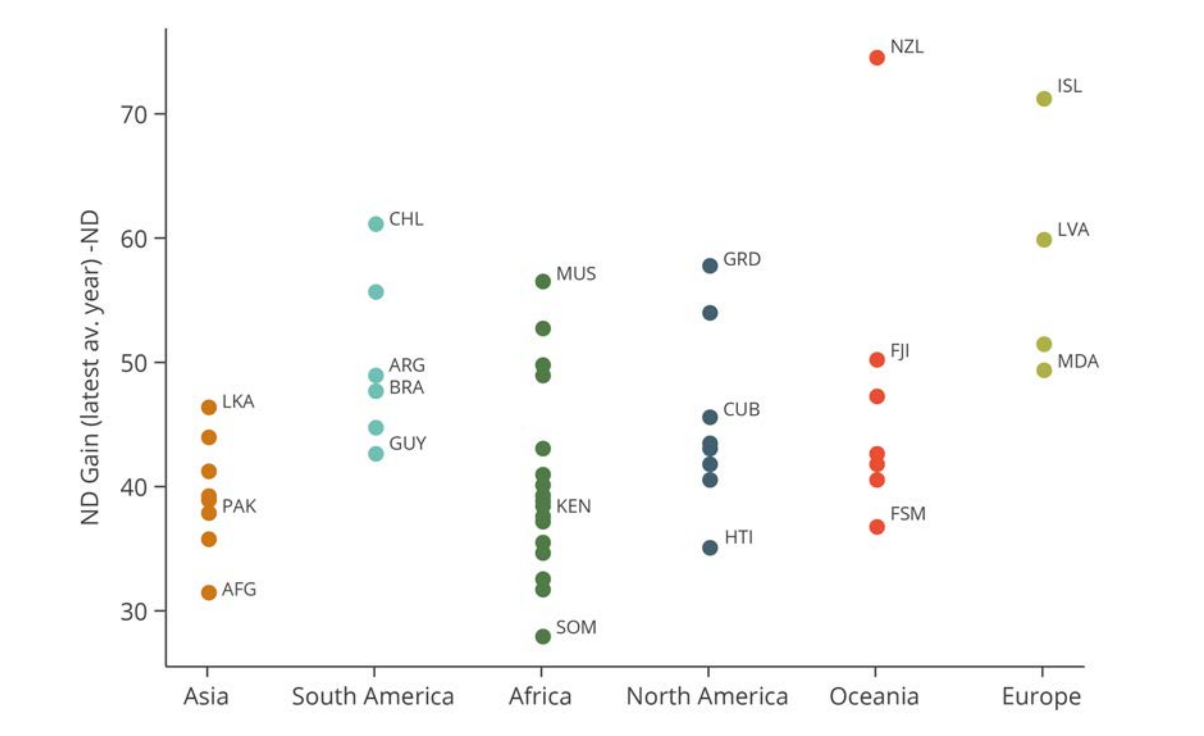
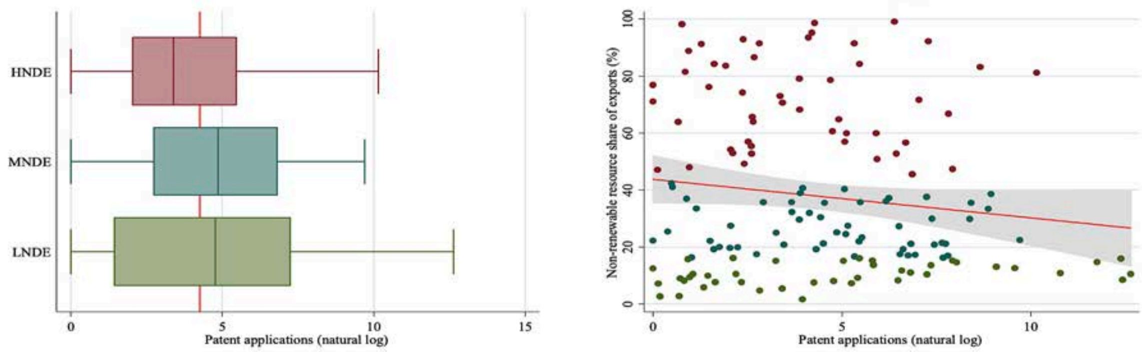


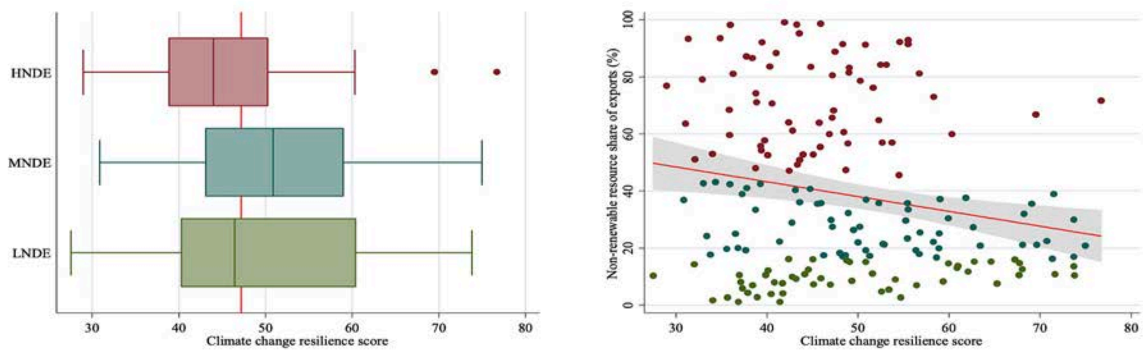
Figure 33: HNDE individual country analysis against resilience composite (ND-GAIN)

When we discussed renewable resources, we expected a negative relationship between exports and patent applications and climate resilience. However, non-renewables tend to be more often point source and extracted by multinationals. We then expect a weaker relationship to occur as under such conditions non-renewable extractions are more likely to be independent of a nation's long-term technological and resilience trends. Figure 34 plots patent applications and resilience by NDE groups as before and the results suggest negative relationships. However, these should be considered with caution. The explanatory power of these characteristics is low, for instance as noted by their R^2 values.



$$\rho = -0.16,\ \ \beta = -0.34^{*},\ \ \sigma = 0.18,\ \ R^2 = 0.03,\ \ N = 146$$

PATENT APPLICATIONS



$$\rho = -0.20,\ \ \beta = -0.52^{***},\ \ \sigma = 0.17,\ \ R^2 = 0.04,\ \ N = 181$$

CLIMATE RESILIENCE

Figure 34: Non-renewable resource exports long-term influences.
Shading represents 95% confidence interval.

P-value: ns = P > 0.05, * = P ≤ 0.05, ** = P ≤ 0.01, *** = P ≤ 0.001

CONCLUSION - THE EXPLORATORY NATURE OF THIS REPORT

The exploratory nature of this report has enabled a scrutiny of the complex linkages between natural resource export shares and national characteristics. As our objective was to explore what may determine a nation's natural resource export choices, we studied the strength of connections between several national characteristics grouped into six categories based on what they indicate to us about a nation.

In addition to the share of natural resources in exports as a numerical value, we divided the world into high, medium and low nature dependency export groups. We could then focus more effectively on the countries most highly dependent on nature - the HNDEs - as the group of most interest in our time of unprecedented environmental change.

To conclude this study, Planet Tracker's findings presented in this report contribute significantly to the understanding of the global trade in renewable and non-renewable exports. Figure 35 reiterates our results by comparing the percentage point changes in nature-dependent exports estimated to result from a 10 percentage point improvement or increase in the characteristics of interest. The overall result is that in almost all cases, as conditions improve in a nation, they tend to transition away from nature-dependent exports. Direct reliance on nature for export revenues appears to be less preferred - to be inferior - to other means of production.

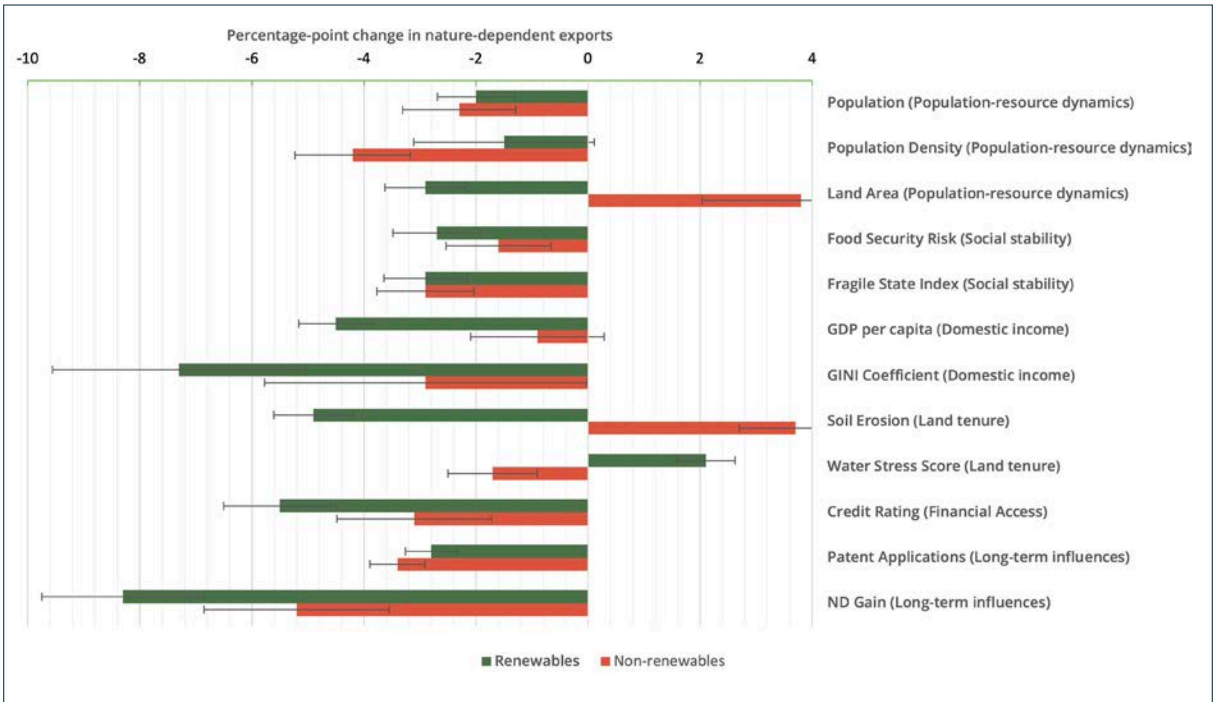


Figure 35: Percentage point change in nature-dependent exports with a 10 percentage point improvement/ increase in the characteristics. Bars indicate the 95% confidence interval around each estimate.

CONCLUSIONS ON RENEWABLE RESOURCE EXPORTS

An interesting picture has emerged of renewable resource production and trade. Renewable resource harvesting generally involves many people in a society - many harvesters, processors and traders. Subsequently, renewable resource production and export shares are strongly linked to a nation's economy through the many people involved.

Interestingly, we also find that nations tend to move away from renewable resource-based exports as income levels and other factors improve. We note that renewable resource harvesting tends to involve arduous work and so we are not surprised by this result. Rather, we were surprised by how consistently it emerges.

Key findings on the linkages between renewable resource export shares and national characteristics follow. There appears to be a strong link between renewable resource exports and domestic income characteristics. However, we believe the relationship goes both ways. Greater GDP per capita levels and less inequality are likely one driver of decreasing renewable exports. As we have noted, as societies develop they tend to transition toward production and service-oriented industries involving comparatively easier lifestyles. However, decreasing renewable exports likely also impact GDP per capita and inequality - as international renewable markets tend to be more volatile than other markets, transitioning away reduces consumption volatility. Reducing consumption volatility is particularly important for improving the welfare of the poor who are less able to absorb repeated financial shocks. Food security and political stability improvements are also likely to result in reduced renewable resource dependence. As stability improves, individuals tend to invest more in production and service-based businesses than more difficult basic resource production. There is little observable relationship between population size or density and renewable exports for many countries, however. Trends in urbanisation as well as open economy trade are powerful confounding factors.

Other factors to consider are that renewable resource exporters tend to have worse soil erosion and less water stress. The former is likely to be a result of more intensive land use for exports and perhaps an inherent principal-agent problem. The latter is probably a prerequisite to competitive renewable resource production. Renewable resource exports are also negatively related to patent applications – HNDEs in particular are focused on natural resource production rather than research and development-intensive fields. Finally, credit ratings and climate resilience scores are both poorer for nations highly dependent on renewable resources for trade revenues. Credit ratings consider the volatility of trade revenues, which we have noted are more volatile for renewables and climate resilience scores consider natural resource dependency directly. As a result, HNDEs receive particularly worse scores on both metrics.

CONCLUSIONS ON NON-RENEWABLE RESOURCE EXPORTS

The picture that emerges on non-renewable resource production and exports is quite different from that of renewables. As the underlying dynamics involved - the resource extraction decisions - are quite different.

As opposed to renewables, non-renewable resources tend to be more point-source and subsequently more prone to capture by empowered groups. Non-renewables are generally more difficult to extract and often require large upfront investments and specialised knowledge. The excludable nature of non-renewables as well as the substantial barriers to entry - both in financial resources and knowledge – results in non-renewable export shares being more divorced from the status of nations. However, we can establish that a few relationships appear to hold.

Key findings on non-renewable export shares and national characteristics are summarised below.

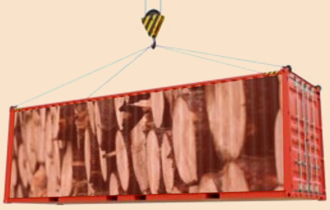
Unlike renewables, there is likely to be a positive relationship between the land area of a nation and non-renewable exports. We might think of the odds of discovering and extracting non-renewable resources as a lottery where the odds are based on a nation's total area. A spurious relationship with population density then follows – historically more hospitable areas likely discovered and subsequently extracted resource earlier and have higher population densities now. Unfortunately, political instability often follows from non-renewable resource extraction. The capture of point-source non-renewables and coinciding state capture by small groups within countries likely drives this result.

Non-renewables tend to be more isolated from national characteristics in other ways. There is little relationship between non-renewable exports and GDP per capita and inequality levels, except perhaps in a few oil-dependent gulf states. Soil erosion and water stress have little explanatory power over non-renewable export shares and the relationships that exist are likely the result of historical trends when non-renewables were first discovered and exploited across the world. We find that credit ratings are poorer for non-renewable resource extractors, but oil wealth and good governance can offset the effect resulting in a lot of variance. There are also weak negative relationships with patent applications – where a few outliers complicate the picture – and a weaker relationship with climate resilience than for nations focused on renewable exports.

Table 7: Credit ratings numerical scale conversion table.

AAA	100
AA+	93
AA	90
AA-	87
A+	83
A	80
A-	77
BBB+	73
BBB	70
BBB-	67
BB+	63
BB	60
BB-	57
B+	53
B	50
B-	47
CCC+	43
CCC	40
CCC-	37
CC	30
C	20
D	10
NR	-

FIGURES & TABLES



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ABOUT PLANET TRACKER

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As part of our overarching Food System Transition Programme, Food & Land Use Tracker changes the behaviours and business practices of global food system companies indirectly, by applying pressure on the financial institutions that provide their funding so that they pass that pressure on to the companies themselves. We provide them with information about the investment risks and opportunities that the transformation of the global food system will create, and we highlight the related reputational and operational risks that they themselves will be exposed to.

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