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THE RESOURCE DEPENDENCE AS A DOUBLE-SIDED COIN

LA DIPENDENZA DALLE RISORSE COME UNA MONETA A DUE FACCE

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SUMMARY

INTRODUCTION

Ecological transition is a concept that aims to put in place a new social and economic model in order to smartly respond to ecological challenges. It aims to rethink the way we live together on a territory, work and produce in order to reduce our environmental impact. In the past few years, the number of emission reduction targets that major mining companies have announced has increased dramatically, with more than two-thirds of the top 20 mining companies having set emission reduction targets for 2030. Market-led initiatives have also encouraged companies to undertake voluntary disclosure of their environmental impact, helping to bridge the gap between consumer and investor expectations.

While these steps are encouraging, more pressure is required from governments, investors, and end customers to spread emissions reduction initiatives beyond the limited group of companies that have made voluntary commitments (i.e. Paris Agreement[1]). The great dependence on fossil fuels, that are highly environmentally damaging, will have tragic consequences worldwide in the medium-long term.

The expected ecological transition process, which indeed aims to feed our economic system with sustainable and renewable energy sources, will bring about profound changes to the global economic landscape. In fact, there are a number of

[1] https://unfccc.int/process-and-meetings/the-paris-agreement/the-paris-agreement

minerals that are crucial for producing microchips, batteries and electric circuits (essential for clean energy sources) that today are only produced and extracted in a few specific geographical areas and in insufficient quantities to achieve zero net emissions targets. Even though the production of energy transition minerals results in significant GHG (Greenhouse Gases) emissions, generally requiring much more energy per unit of product than other resources, this contribution to emissions does not negate the climate benefits of clean energy technologies when considered together with the whole life cycle emissions of other technologies.

The global clean energy transitions will have far-reaching consequences for mineral demand over the next 20 years. By 2040, total mineral demand from clean energy technologies will double, or even quadruple.

In light of these considerations, this work will attempt to outline a world map of the production and endowment of minerals critical to the energy transition, seeking to understand the effects this unequal distribution may have on economic development.

However, according to a theory originated in the 1980s, countries with high natural resource capital tend to have worse long-term performance than those without such endowment. This theory is called “Resource Curse” and lays its foundation on the so-called Dutch disease.

At the end of the paper, after drawing a world map of natural resources and explaining the resource curse theory, a new quantitative study will be proposed.

this quantitative and descriptive analysis will aim to understand the effects that resource dependence can have on economic growth. Resource dependence will be treated from two different perspectives: import and export. We discuss import resource dependence when we refer to countries almost completely lacking such resources, thus forced to import their needs. Conversely, the term export resource dependence is used when referring to those countries rich in such resources which therefore base much of their economic activity on exporting and producing this abundance of resources

CHAPTER 1: THE ECOLOGICAL TRANSITION AND THE NEEDED CRITICAL MINERALS

In this first chapter it will be discussed the present supply of minerals, oil and natural gas. It will be analysed the unequal distribution of production and reserves of these critical minerals as well as the evolution of their demand in the last years, and the forecasted one for the following decades, trying to create a world map of natural resource distribution.

1.1 SUPPLY OF MINERALS

The dramatic increase in demand for critical minerals expected in the coming years poses important questions regarding the availability and reliability of supply. In the past, an imbalance between supply and demand (insufficient supply), has often stimulated further investments as well as the search for possible substitutes. Unfortunately, however, these initiatives take time and are accompanied by considerable volatility in the price of raw materials. An inadequate supply of critical minerals is therefore a major limitation to the necessary and rapid clean energy transition.

The cost of raw materials significantly influences the production costs of most of the technologies required for the energy transition. Non-raw material costs can be reduced considerably through technology learning and economies of scale, but this implies that raw materials' costs influence the total production costs even more.

Example: Cost for producing lithium-ion batteries has been pushed down by 90% over the past decade by technology learning and economies of scale. However, nowadays raw material costs account for some 50-70% of battery costs, up from 40-50% five years ago.

Indeed, the price of raw materials will play a key role in the production cost structure of certain technologies. For example, A doubling of lithium or nickel prices would induce a 6% increase in battery costs. If both lithium and nickel prices were to double at the same time, this would offset all the anticipated unit cost reductions associated with a doubling of battery production capacity. In the case of electricity networks, copper and aluminium currently represent around 20% of total grid investment costs; higher prices as a result of tight supply could have a major impact on the level of grid investment.

Critical minerals are also present in unequal amounts; there are minerals that are expected to be in surplus in the coming years, lithium and cobalt, while others such as nickel and rare earth elements could observe a supply deficit. Analysing a longer time frame, the scenario is also not very reassuring for lithium and cobalt. In fact, expected supply from existing mines and projects under construction is estimated to meet only half of projected lithium and cobalt requirements[2].

[2] IEA (2021), The Role of Critical Minerals in Clean Energy Transitions, IEA, Paris https://www.iea.org/reports/the-role-of-critical-minerals-in-clean-energy-transitions

Even though there are projects in development, there are still many weaknesses in the current outlook for a clean energy transition:

- High geographical concentration of production: the production of many critical minerals for the production of technologies useful for the ecological transition are highly concentrated in specific geographical areas. There are minerals such as lithium, cobalt and REEs whose ¾ of production is concentrated in the world's top three producing nations. High levels of concentration, coupled with complex supply chains, increase the risks that could arise from physical disruptions, trade restrictions or other developments in major producing countries;
- Long project development lead times: mining projects take time, an estimated 16.5 years from mine discovery to first production. This obviously creates problems and slowdowns in the case of rapidly growing demand, mainly related to project slowdowns and commodity price volatility;
- Quality of mined resources: a key factor, besides the quantity of raw materials, is the quality. In recent years, the quality of mined minerals has been on a downward trajectory. This decreasing quality of ores has important consequences, as extracting metal from lower quality ores requires more energy, which has important repercussions not only on extraction costs but also on GHG emissions and waste volumes;

- Growing scrutiny of environmental and social performance: The extraction and processing of mineral resources raises a number of issues with regard to environmental and social issues. There is a growing demand from investors and consumers for environmentally and socially sustainable production. Poorly managed mineral production can significantly increase not only GHG emissions but also the risks of damaging local communities, undermining the supply of resources;
- Higher exposure to climate risks: Mineral assets are exposed to increasing climate risks. For example, copper and lithium are particularly vulnerable to water stress, given their high-water requirements. Many of the major producing regions, such as Australia, China and Africa, are subject to extreme temperatures or flooding, which pose greater problems in ensuring reliable and sustainable supplies;

The risks described above are manageable, but they are real. Policy makers and companies in their strategies must put these risks at the centre of their priorities, as how they manage these risks will determine whether critical minerals will be a vital element in the clean energy transition or a limitation.

1.2 CRITICAL MINERALS FOR CLEAN ENERGY TRANSITION

This section will explain some of the minerals that are fundamental to the energy transition. These minerals are in fact used for the production of all those technologies that allow clean energy generation and lower emissions in certain activities (e.g. transport). These raw materials are used in batteries as conductors, for cable production, as protection or for equipment construction.

After an initial overview of mineral properties, the distribution of minerals will be analysed in geographical terms in order to outline a world map of minerals.

1.2.1 Copper

Copper is a key element in the ecological transition. Essential for electricity networks, given its use in cable production. Copper is used in making wires as it is easy to stretch, and it is not expensive. Therefore, large wire companies will use copper as it is cheaper and takes less time to get.

In fact, copper is among the most widely used minerals, in terms of kg, to produce electric cars, wind turbines and solar panels.

According to the SDS scenario the demand for copper is expected to rise significantly over the next two decades, over 40%. the price of copper has risen significantly over the past three years, indicating a growing demand for the mineral. In fact, in July 2019, the price was around $2.5-2.7/pound, reaching its highest price ever of $5.02/pound in March 2022, thus doubling its value. Although there are frequent fluctuations in the price of copper due to Covid-19 restrictions, mainly in China, which is the world's largest importer, the price trend is upward, as shown in Figure 1.

Copper production also appears to be the most profitable of all mineral productions. Revenue forecasts for copper production predict revenues of USD 112.3 billion in 2040 (USD 35.4 billion in 2020)[3].

As regards copper reserves, these are, as already mentioned, concentrated in large quantities in specific geographical areas. In 2020, Chile, with 200 million tonnes, held 23% of the world's resources[4]. Peru and Australia are just below in the world ranking with 11% and 10% of the world's copper reserves, respectively. Chile, besides being the country with the largest copper reserves worldwide, is also the largest producer of this mineral, producing 28% of the world's copper in 2020. In terms of production, even though the quantity produced is far less than that of Chile, we find in second and third place respectively Peru (12% of world copper production) and China (8% of world copper production). Just below in fourth and fifth place are the Dominican Republic of Congo (7%) and the United States (6%).

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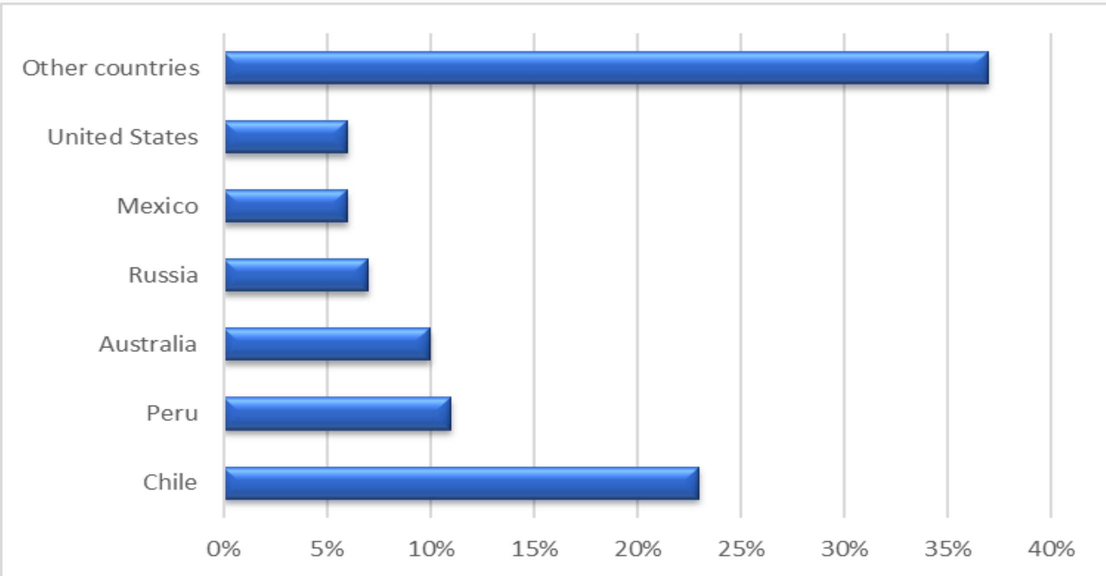
[3] IEA (2021), The Role of Critical Minerals in Clean Energy Transitions, IEA, Paris https://www.iea.org/reports/the-role-of-critical-minerals-in-clean-energy-transitions

[4] https://www.nrcan.gc.ca/our-natural-resources/minerals-mining/minerals-metals-facts/copper-facts/20506

Figure 1 - Copper price ($/pound), 2019-2022

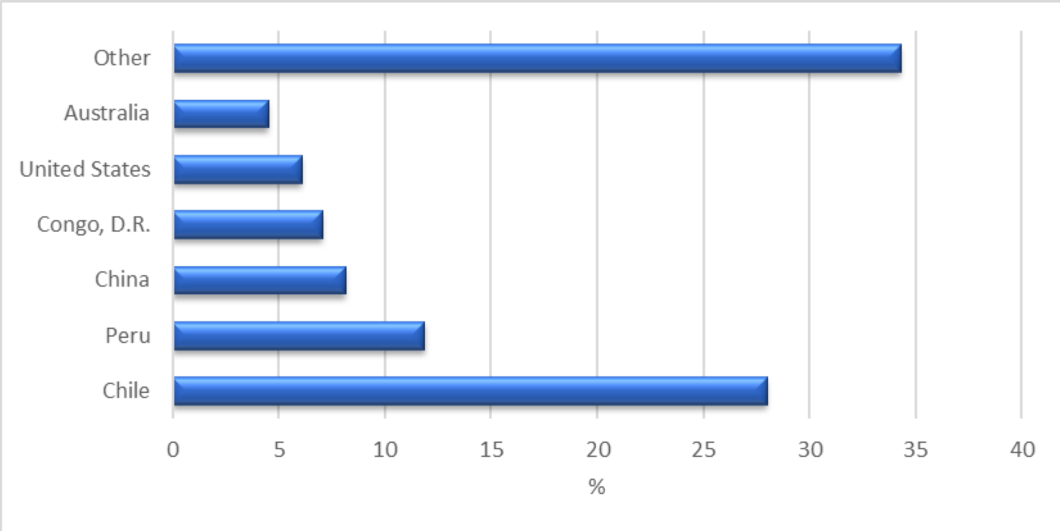
Source: tradingeconomics.com

Figure 2 - World's reserves of copper, by country, 2020



Source: nrcan.gc.ca

Figure 3 - Share of World's Copper production by country, 2019



Source: World Mining Data

1.2.2 Cobalt

Cobalt is used in batteries to ensure a longer life span. In fact, the potential demand for cobalt is also strongly influenced, not only by the stringency of ecological policies, but also by innovation in the energy field that could lead to a decrease in demand for this mineral.

The development of demand for cobalt therefore depends to a large extent on the evolution of battery cathode chemistry. The composition of cathode chemistries is increasingly shifting towards those with a high nickel content, which could weigh on the demand for cobalt. However, the strong uptake of electric vehicles is driving a seven-fold growth in cobalt demand for clean energy technologies in STEPS and more than twenty-fold growth in SDS in the period to 2040.

Cobalt demand could be between 6 and 30[5] times higher than today based on assumptions about the evolution of battery chemistry and climate policies.

For what concern with the price, it has risen significantly over the past three years (Figure 4). Although the price peak was reached in March 2018 ($95,250/tonne), following a downward trend between 2018 and 2019, the price between July 2019 and July 2022 more than doubled from a valuation of about $34,000/tonne in 2019 to about $71,500/tonne in 2022.

Cobalt production and reserves are heavily concentrated in one geographical area: Congo. In fact, the Democratic Republic of Congo holds a veritable monopoly of this mineral. In 2019, the 63%[6] of the world's cobalt was in fact produced in the Democratic Republic of Congo (the second largest cobalt-producing country is Russia with 7 per cent) and almost 50 per cent of the world's reserves are also located there[7] (2021) (second is Australia with 17%).

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[5] https://www.iea.org/reports/the-role-of-critical-minerals-in-clean-energy-transitions/mineral-requirements-for-clean-energy-transitions#abstract

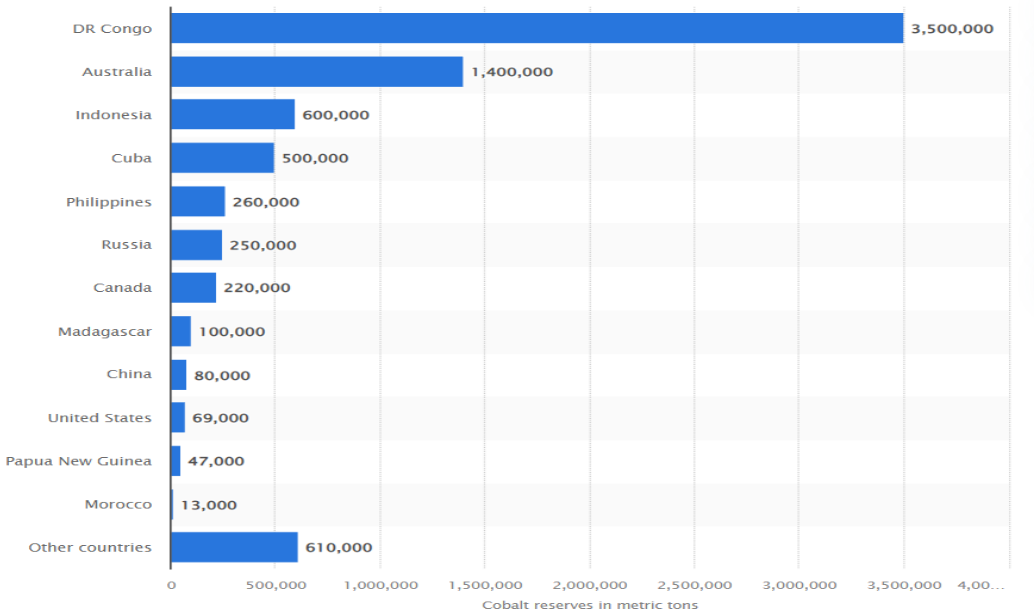
[6] https://www.world-mining-data.info/?World_Mining_Data___Data_Section

[7] https://www.statista.com/statistics/264930/global-cobalt-reserves/

Figure 4 - Cobalt price ($/tonne), 2019-2022

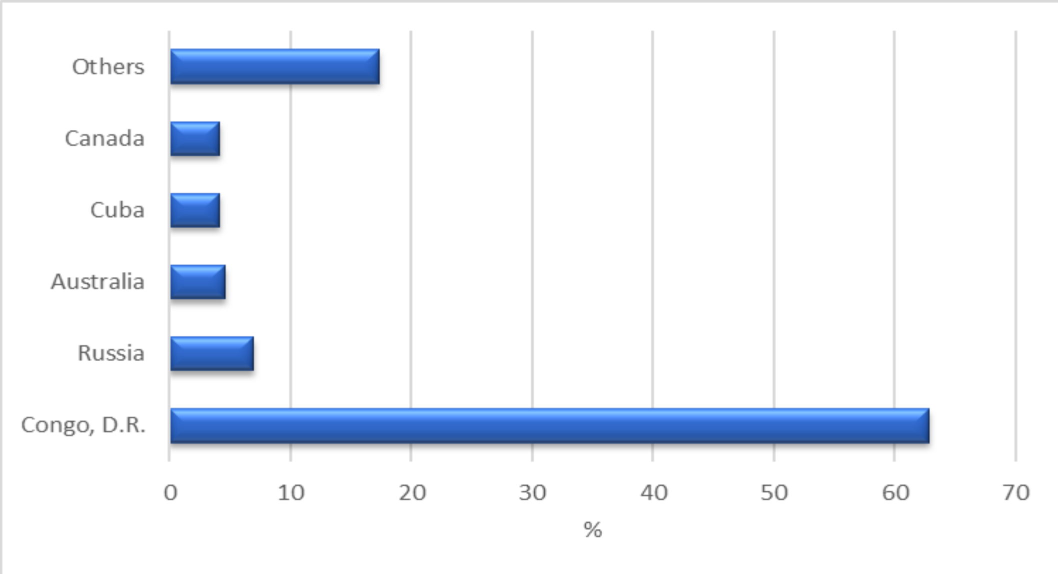
Source: tradingseconomics.com

Figure 5 - Cobalt reserves worldwide by country, 2021



Source: Statista.com

Figure 6 - Share of World's Cobalt production by country, 2019



Source: World Mining Data

1.2.3 Zinc

Zinc, along with copper, is one of the most important minerals for building new energy systems. It is one of the most versatile and essential materials known to mankind and it is the fourth most widely used metal in the world, after iron, aluminium and copper.

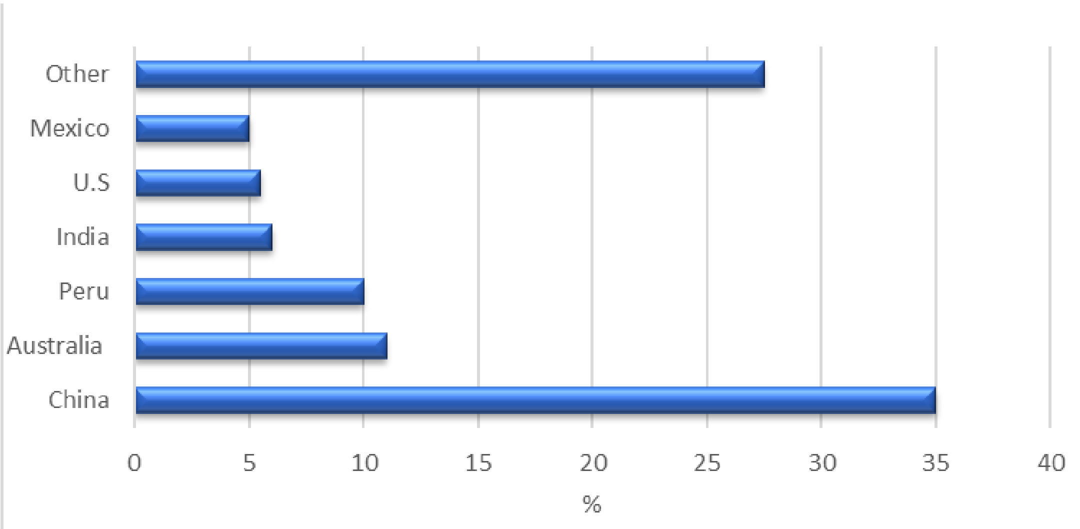
The main use of zinc is the galvanising process, which protects iron and steel against rust. Zinc coatings play a key role in public transport and infrastructure, extending the life of steel used for rails and bridge support beams, railway tracks and public transport hubs and terminals.

Zinc ion batteries are also considered safer than lithium-ion batteries for use in electric vehicles. Zinc is also 100 per cent recyclable, can be indeed recovered and reused without loss of quality and its production requires very low levels of greenhouse gas emissions.

The growing demand for this mineral is also evident from the price trend over the past three years. as shown in the Figure 7, the price trend has been increasing between July 2019 and July 2022. Although the trend is not as increasing as in the case of cobalt and copper, in April 2022 the price of Zinc reached $4,500/MT almost equalling the all-time high of November 2006.

The 54% of World's Zinc production is concentrated in 3 countries[8]: China (35%), Peru (11%) and Australia (10%). In terms of Zinc reserves the two most important countries are Australia with 27% of World's Zinc reserves and China with 18%.

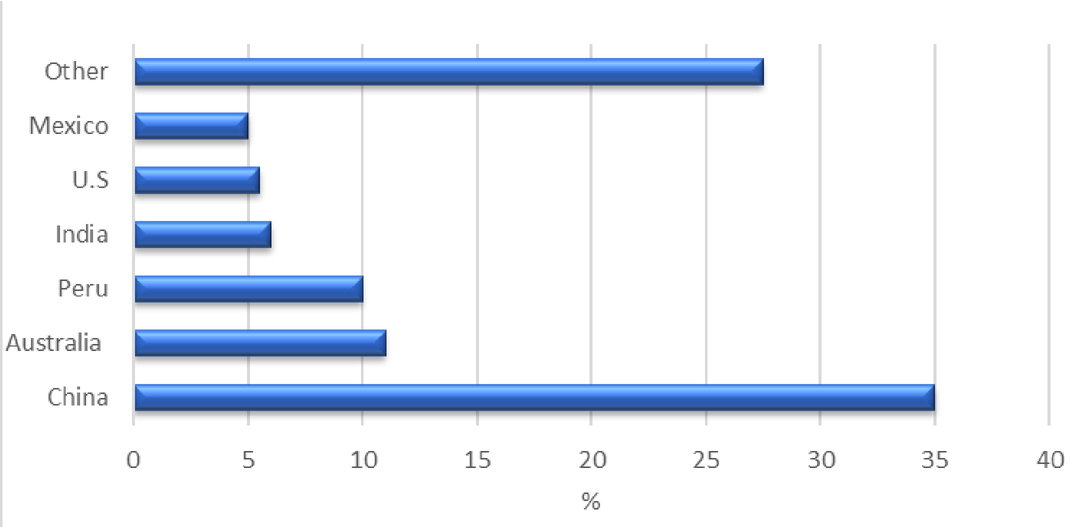
Figure 7 - Share of World's Zinc production by country, 2020



Source: World Mining Data

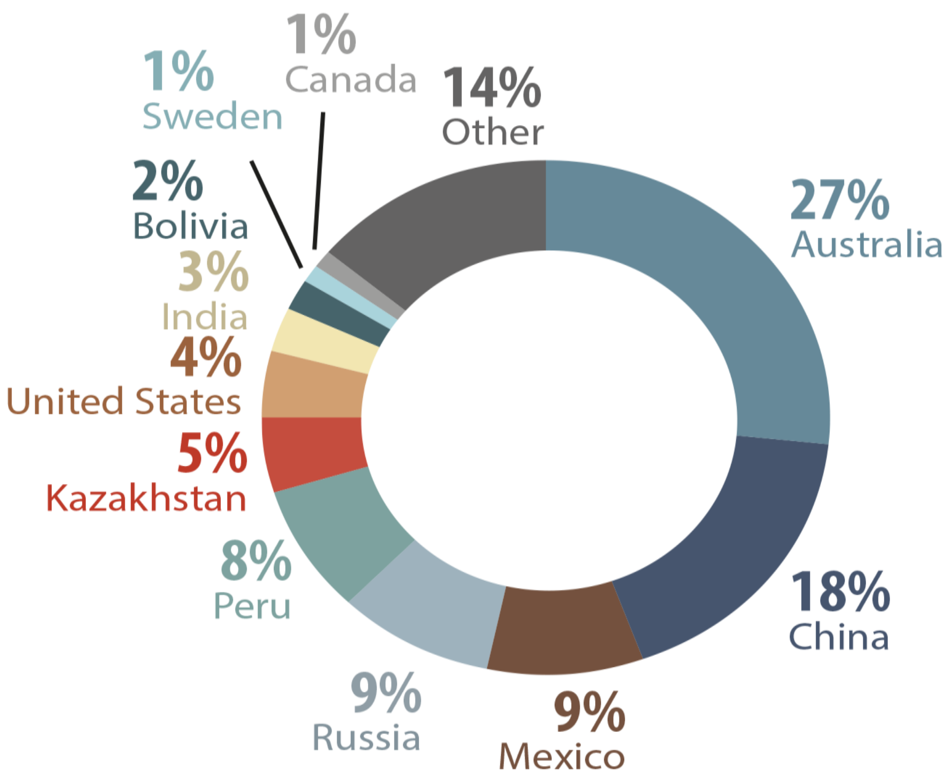
[8] https://www.world-mining-data.info/?World_Mining_Data___Data_Section

Figure 8 - Share of World's Zinc production by country, 2020



Source: World Mining Data

Figure 9 - Share of World's Zinc reserves by country, 2020



Source: nrcan.gc.ca

1.2.4 Lithium

Like cobalt, lithium is a key component of lithium-ion batteries. In recent years, demand for lithium has been growing at a steady rate of around 20 per cent per year. This trend looks set to continue in the future as electric mobility becomes more widespread as part of the ecological transition. However, it is not so much the geological risk that is of concern for this metal, but the high concentration of reserves, production and market, and China's control over the entire value chain. The fields of lithium use have changed enormously in the last decade. As can be seen from Figure 7, in 2010, lithium was mainly used for ceramics and glass, while in the last 10 years, the share of lithium used for batteries increased dramatically to 71%.

Demand for lithium for clean energy technologies is growing at the fastest rate among the major minerals. While other minerals used in electric vehicles (e.g. cobalt and nickel) are subject to the uncertainty of chemical choices, demand for lithium is relatively immune to these risks, with further benefits if solid-state batteries are widely adopted.

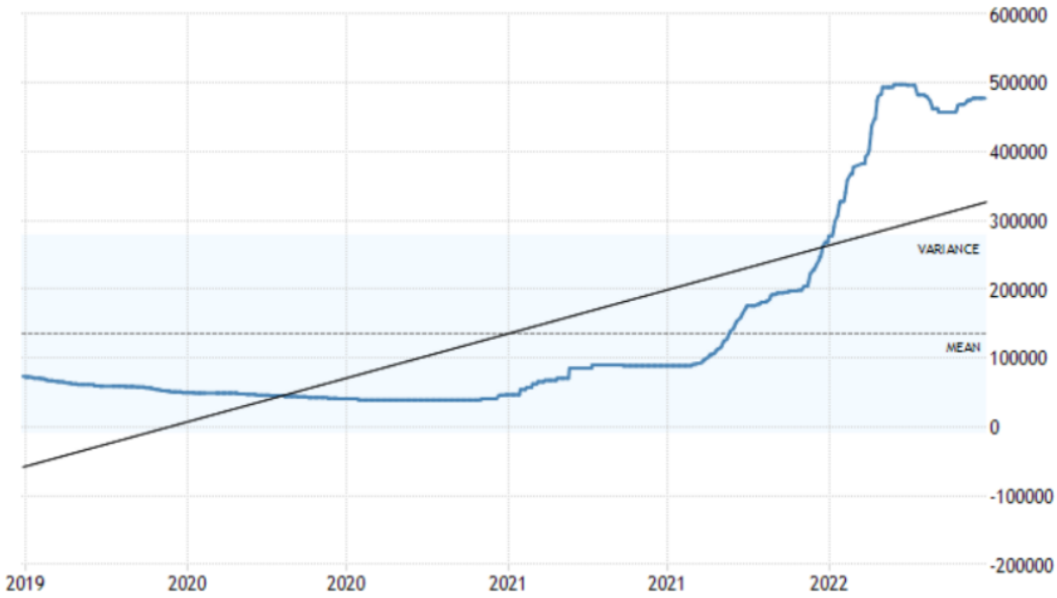
In fact, lithium has the fastest growth rate, with demand increasing more than 40 times in the SDS.

The rapid increase in demand is reflected in the price of lithium, which has soared over the past three years. Starting from about CNY 100,000/tonne in July 2019, the price of lithium has more than quintupled, reaching CNY 477,500/tonne in

July 2022. It should also be noted that the price of lithium during this period reached an all-time high in March 2022 (CNY 500,000/tonne).

In terms of production, the largest lithium producer globally is Australia, which produces almost 50 per cent of the lithium produced worldwide.[9], below it Chile (22%), China (17%) and Argentina (8%). In terms of reserves, Chile is the country where this mineral is available in the largest quantity (44% of the world's lithium reserves), Australia in second place (22%) and Argentina third (9%). In terms of both production and reserves, this mineral therefore appears to be highly concentrated in a few geographical areas, mainly Australia and Chile, although China is also abundant.

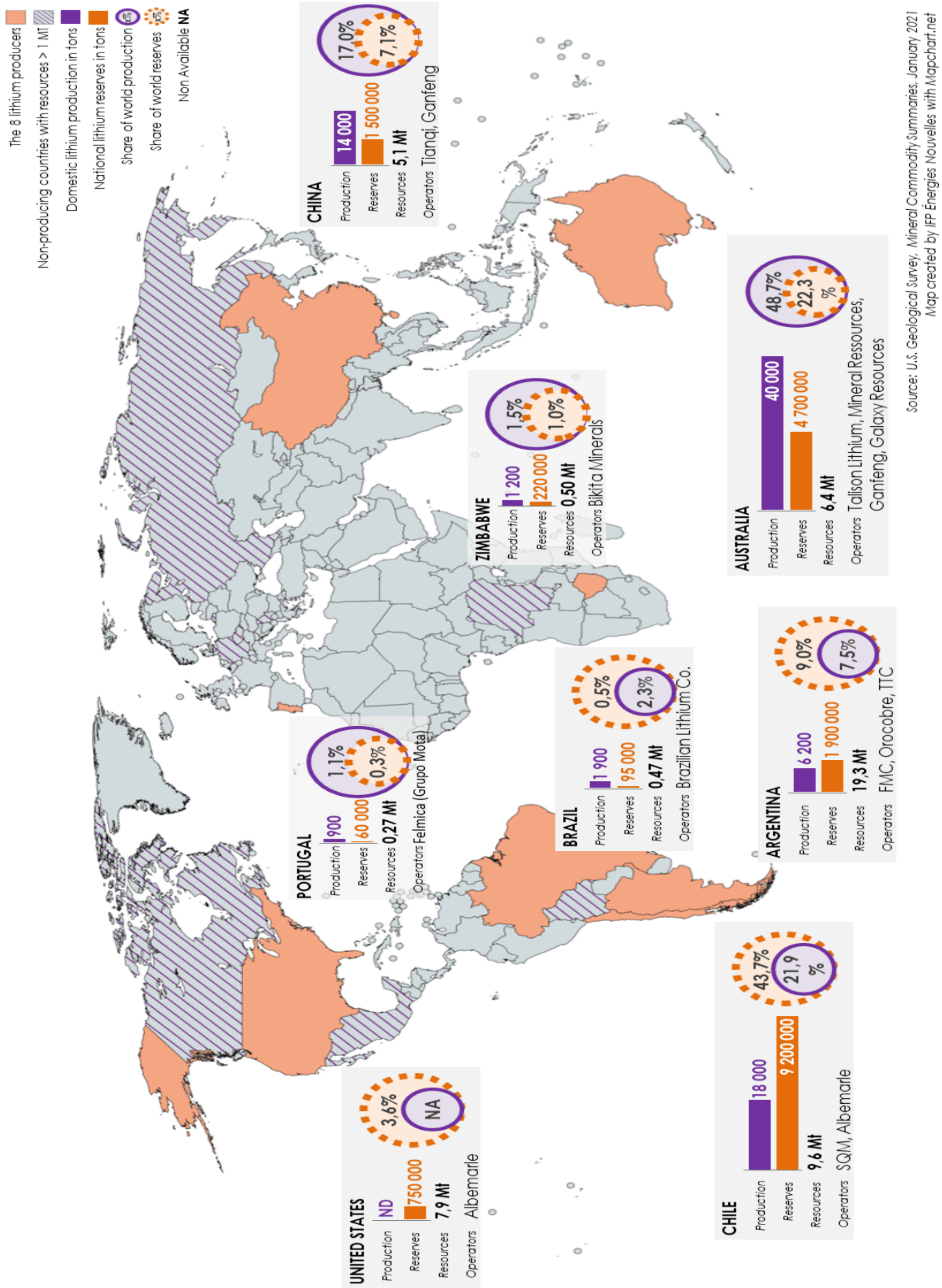
Figure 10 - Lithium price (CNY/tonne), 2019-2022



Source: tradindeconomics.com

[9] https://pubs.usgs.gov/periodicals/mcs2021/mcs2021-lithium.pdf

Figure 11 - Global lithium production and reserves, 2020



Source: ifpenergiesnouvelles.com

1.2.5 Nickel

Nickel is a mineral of central importance for the energy transition.

It is a key component for most renewable energy technologies and for battery production. Nickel's properties facilitate the deployment of the full spectrum of clean energy technologies: geothermal, electric vehicle batteries and energy storage, hydrogen, hydroelectric, wind and concentrating solar power. Nickel is one of the main cathode materials in lithium-ion batteries.

In nickel-containing stainless steels, nickel provides toughness, strength and increased corrosion resistance, significantly increasing the life of the end product. In addition, nickel is highly recyclable and contributes to the circular economy. Nickel and nickel-containing alloys can be restored to their original state or converted to a different, but still valuable, form.

It is projected to be the second largest mineral by production revenues in 2040 according to the SDS, being of central importance along with lithium for battery production.

Looking at Fig.11, it is evident how the future increase in nickel demand is driven by the development of new markets. Although the share of "other sectors" remains more or less stable over the years, there is a huge growth in demand for this mineral from "Evs and Storage" but demand from "low carbon power generation" is also growing.

The price of nickel has also risen significantly in the last three years, reaching $23,000/tonne in 2022 ($13,000/tonne in 2019). As can be seen from the Figure 13, the trend is upward, with an incredible peak in March 2022, with an average price between the 4th and 10th of that month of $48,000/tonne. It should also be noted that in early March, prices briefly crossed the $100,000 mark (all-time high price) following a fierce buying spree by the Chinese Tsingshan Holding group, one of the world's leading producers, to hedge its short bets on the metal. Now, market moves signal a return to normalcy after several weeks of chaos, with trading volumes at average levels and investors' attention focused on concerns that slowing global growth will hit demand for metals, particularly in China, the main consumer[10].

Indonesia and the Philippines now account for 45% of global nickel production and their dominance of nickel production is set to intensify in the coming years. Indonesia alone accounts for about half of global production growth in the period to 2025. This suggests that the future of nickel supply will most likely be driven by Indonesia's progress and that global nickel supply chains could be significantly influenced by physical events or political changes in Indonesia.[11]. Even though nickel production and reserves are less concentrated than those of other minerals

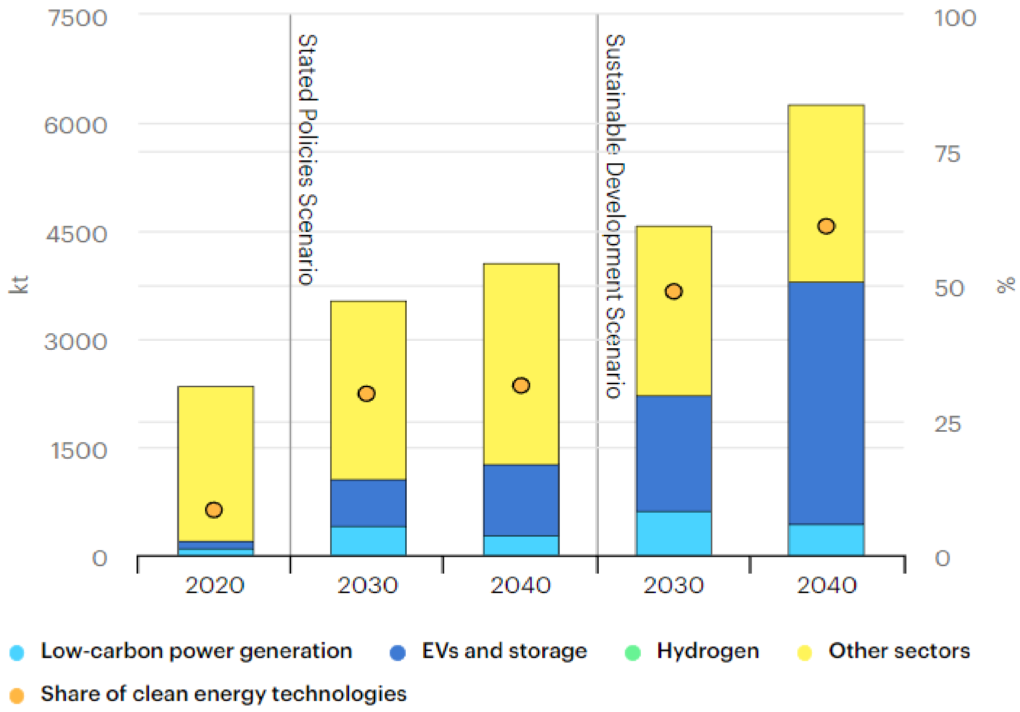
[10] https://tradingeconomics.com/commodity/nickel

[11] https://www.iea.org/reports/the-role-of-critical-minerals-in-clean-energy-transitions/reliable-supply-of-minerals#abstract

(e.g. Cobalt in Dem. Rep. Congo), even in this case the top 3 countries hold most of the production and reserves in their own hands.

As already mentioned, Indonesia is the largest nickel producer globally producing 30.4% of the nickel produced, followed by the Philippines with 12.8% and Russia with 11.2%.[12]. In terms of reserves, Indonesia retains the lead with 22% of the world's nickel reserves, followed by Australia (21%) and Brazil (17%).

Figure 12 - Total nickel demand by sector and scenario, 2020-2040



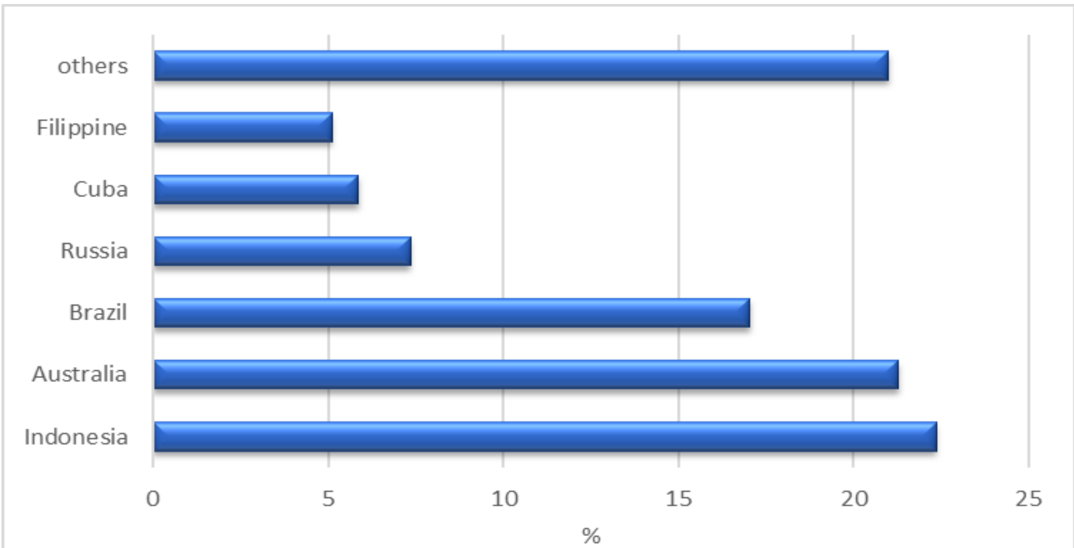
Source: IEA

[12] https://www.nrcan.gc.ca/our-natural-resources/minerals-mining/minerals-metals-facts/nickel-facts/20519

Figure 13 - Nickel price ($/tonne), 2019-2022

Source: tradingeconomics.com

Figure 14 - Share of World's nickel reserves by country, 2020



Source: World Mining Data

1.2.6 Rare Earth Elements

Rare earth elements (REE), also known as rare earth metals, are a collection of 17 soft, almost indistinguishable, silvery-white, lustrous heavy metals. These minerals are essential for new technologies because they are essential for the permanent magnets used in wind turbines and electric vehicle motors.

However, like lithium, REEs have almost no recycling capacity globally, partly due to limited technical and collection constraints.

Future demand for these minerals is closely linked to market developments in wind turbines and electric vehicles. As far as wind turbine production is concerned, REEs are of paramount importance. Installed wind power capacity worldwide has almost quadrupled in the last ten years, thanks to falling costs and policy support in more than 130 countries. Wind energy is expected to grow further in the coming decades, with the maturing offshore wind industry adding to onshore wind developments thanks to technological improvements and low-cost financing, thus leading to growing demand for these minerals.

By 2040, demand for rare earths could be three to seven times higher than today, depending on the choice of wind turbines and the strength of political support.

As far as the electric car market is concerned, on the other hand, 90 per cent of currently marketed cars use permanent magnets. However, the use of some REEs results in a significant increase in engine weight, and the very high geographical concentration of these elements could incentivise less use of these minerals through new technologies. Indeed, the high prices of rare-earth elements could lead to a shift from permanent-magnet motors to induction motors, increasing the demand for copper or aluminium.

Figure 16 shows the expected evolution of REE demand in the coming decades under different assumptions

In the case of constrained rare earth elements, it is assumed that manufacturers will gradually switch to magnet less technologies and that project developers will adopt hybrid configurations with a gearbox and a smaller magnet.

Figure 15 shows the price development of Neodymium over the past three years. Neodymium is one of the most important rare earths, it is in fact used to alloy with boron and iron to create very strong permanent magnets. In this time period, the price of Neodymium has tripled from CNY 444,000/MT in July 2019 to CNY 1,200,500 in July 2022, reaching its highest price ever in February 2022, CNY 1,510,000/MT.

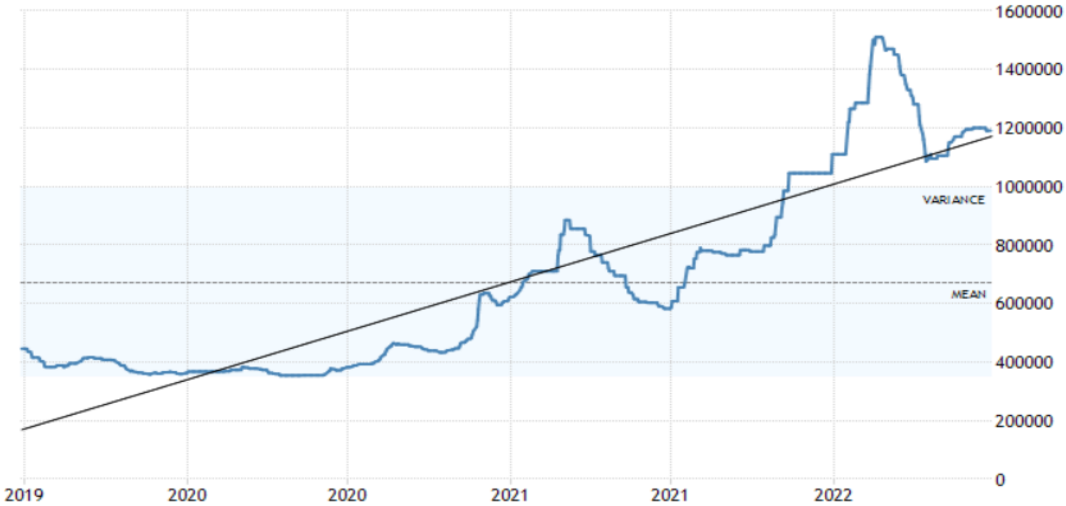
The supply of rare earths is particularly complex as its production is concentrated in very few areas, mainly in China. (Figure 11) (57% of World production in 2020[13], 65% in 2019[14]). In this case, the top 4 producing countries (China, United States, Burma and Australia) produce 92.4% of the world's REEs (Figure 13). As

[13] https://www.nrcan.gc.ca/our-natural-resources/minerals-mining/minerals-metals-facts/rare-earth-elements-facts/20522

[14] World Mining Data - Data Section

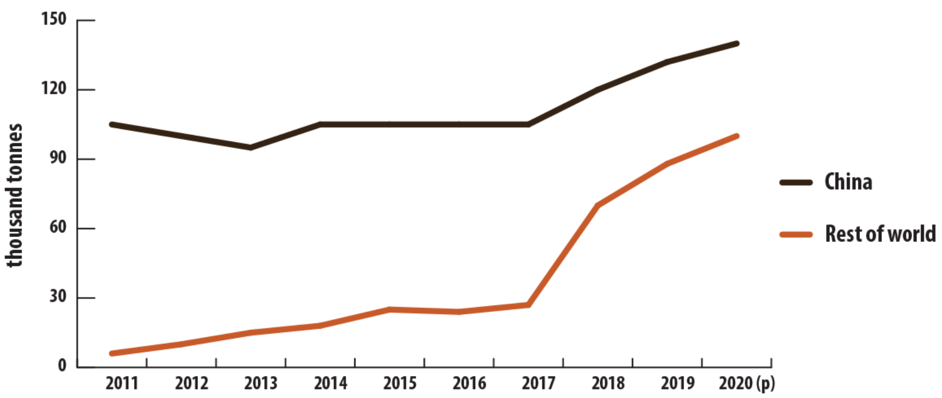
far as world reserves are concerned, we find China still at the top, followed by Vietnam and Brazil. Burma's REEs reserves are not known.

Figure 15 - Neodymium price (CNY/MT), 2019-2022



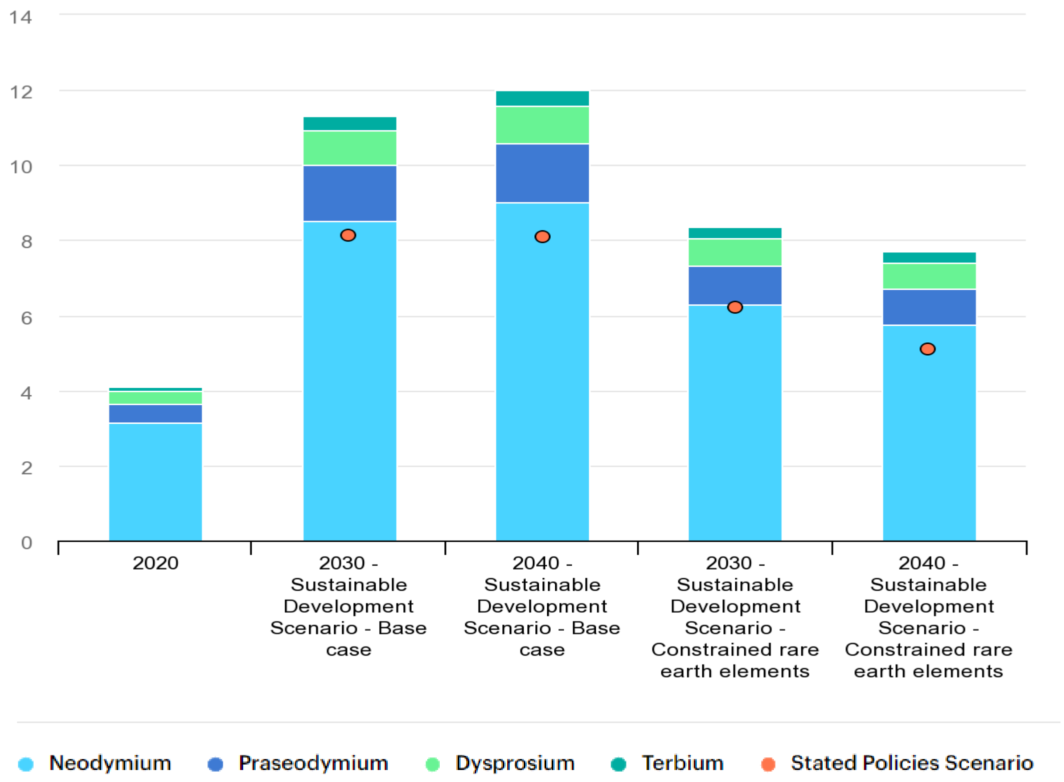
Source: tradingeconomics.com

Figure 16 - World REE production, 2011–2020



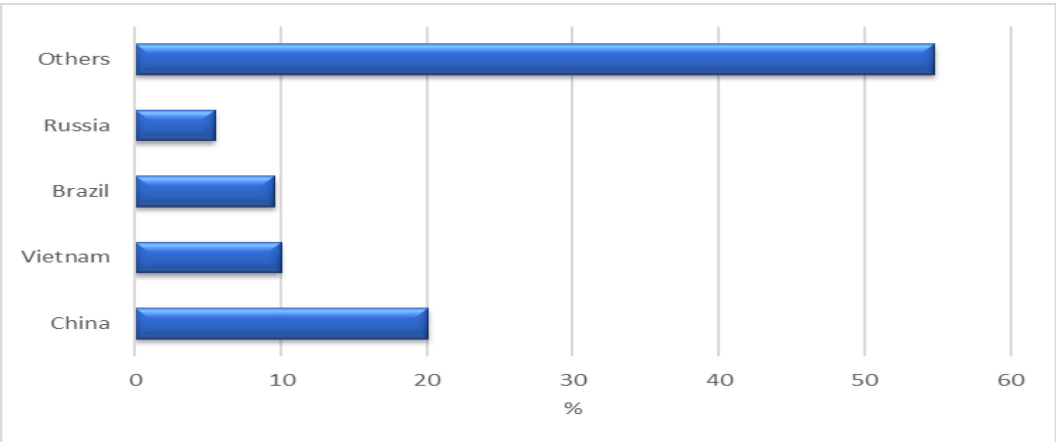
Source: nrcan.gc.ca

Figure 17 - Demand for rare earth elements from wind in the Sustainable Development Scenario, 2020-2040



Source: IEA

Figure 16 - Share of World's REEs Reserves by country, 2020



Source:World Mining Data

1.3 CRUDE OIL AND NATURAL GAS

In order to better understand the possible shift that will take place in the coming years in terms of raw material supplies, we will now also try to outline a distribution of those energy sources that will have to be replaced by cleaner energy resources in the coming decades.

In the first part we will analyse the global distribution of oil, based not only on production and reserves but also on the export of this commodity. The oil trade is strongly influenced by the countries belonging to the Organisation of the Petroleum Exporting Countries (OPEC), which acts as a real oil cartel. In this organisation, in fact, we find among the largest oil producers and exporters.

Natural gas and its distribution on a global level will also be dealt with later, following the same variables mentioned above for oil.

1.3.1 Crude Oil

Crude oil and other liquids produced from fossil fuels are refined into petroleum products useful for many different purposes. Oil has always been the world's main energy source and oil products are used for transport (oil meets 90% of the world's transport needs), to produce electricity and to heat buildings. Oil is not only used as an energy source but also as a raw material for the production of plastics, polyurethane, solvents and many other products.[15].

[15]https://www.eia.gov/energyexplained/oil-and-petroleum-products/use-of-oil.php#:~:text=We%20use%20petroleum%20products%20to,intermediate%20and%20end%2Duser%20goods.

Although petroleum products are relatively cheap compared to possible substitutes and make life easier, the exploration, production and transportation of crude oil negatively impact the environment[16]. While progress is being made towards reducing the pollution associated with such activities, the environmental footprint of oil is still high. Indeed, being a fossil fuel, its combustion results in polluting emissions, especially of carbon dioxide (one of the most dangerous GHGs). As we know, the human footprint has led to an incredible increase in the concentration of GHGs in the atmosphere, thus altering the greenhouse effect, which is fundamental to the balance of global temperatures. These issues, as already mentioned, are becoming central to socio-political issues, thus stimulating interest in reducing our dependence on oil-based technologies. For these reasons, the future oil demand and production is strongly influenced by environmental policy stringency and the development of new technologies that allow efficient and cheap alternatives to oil. Today, there are no alternatives as cheap and efficient as oil that can be adopted on a large scale, suggesting that oil will remain a major energy technology at least in the short term[17].

Like critical minerals for the ecological transition, crude oil is particularly concentrated in certain geographical areas. There are areas rich in this resource, Saudi Arabia for example, while others where it is practically absent, see Europe.

[16] https://www.eia.gov/energyexplained/oil-and-petroleum-products/oil-and-the-environment.php

[17] https://wwf.panda.org/discover/knowledge_hub/teacher_resources/webfieldtrips/climate_change/petroleum/

This unequal distribution has obviously created an imbalance globally, as oil is the main energy source used, there are countries that are totally dependent on the import of this commodity. Conversely, there are countries and regions that have based their economy on oil exports. For example, oil exports for Libya, the Democratic Republic of Congo, Kuwait and Iraq contribute 40% of GDP (in the EU on average 0.04% of total GDP).

As can be seen from Figure 17, the price of crude oil, although less dramatically than the critical minerals already analyzed, has also risen over the past 3 years. starting from July 2019, the price remained more or less stable (60-65 USD/bbl) until March 2020 when a price collapse is observed during the first months of the pandemic in 2019. Since 2021, on the other hand, a steady growth of the price is observed, accentuated moreover in the last months by the outbreak of the Russian-Ukrainian war (around 100$/bbl in July 2022).

In 2020[18] 43% of World crude oil production was concentrated in the top three producers: the United States, Russia and Saudi Arabia. Interestingly, the growing production of oil from the US has gone from 7% of world production in 2006 to 16% today. The US is not only the largest producer of oil but also the largest consumer, consuming 18.88 million barrels per day. (20% share of world total)[19].

[18] https://asb.opec.org/data/ASB_Data.php

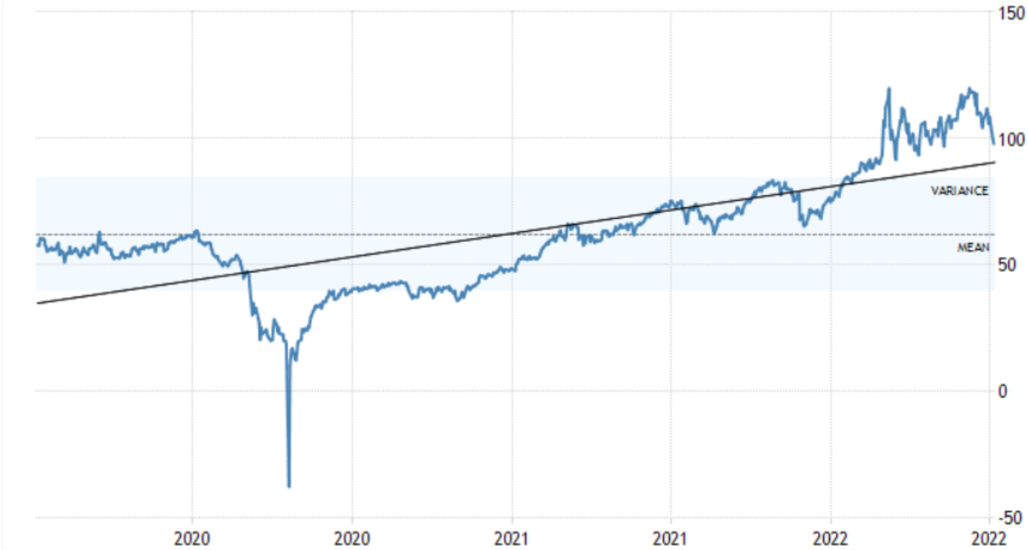
[19] https://www.eia.gov/tools/faqs/faq.php?id=709&t=6

Figure 18 shows the largest producers of crude oil globally, the larger the circle, the larger the production in percentage terms. As can be seen from the map, the largest producers are the United States, Saudi Arabia and Russia. We also find an important production concentration around Saudi Arabia, in fact some of the world's largest producers are located there (Iraq, United Arab Emirates, Kuwait, Iran).

In terms of exports, the two market leaders are Saudi Arabia, which exports 16% of the oil exported globally, and Russia (11%); the U.S. falls in the ranking of the top oil exporting countries, exporting 'only' 8% of the exported crude oil.It should be noted that, in total, OPEC countries are exporters of 48% of the oil exported globally. OPEC also holds 75% of global crude oil reserves, the top 8 countries by crude oil reserves are part of OPEC with the exception of Africa (Venezuela, Saudi Arabia, Iran, Iraq, United Arab Emirates, Kuwait).

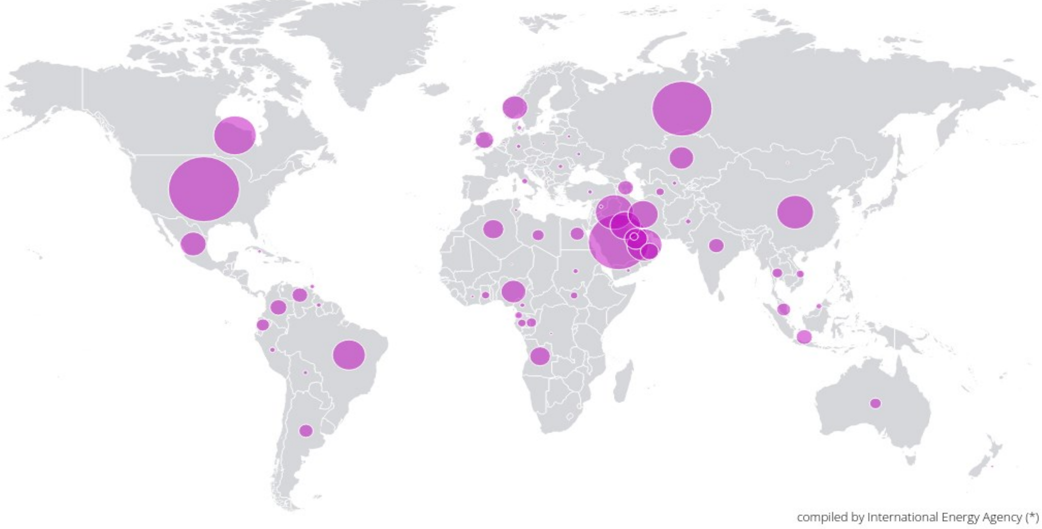
Figure 20 shows a representative world map of Oil Net Trade, i.e. the difference between oil Imports and oil Exports. The brighter the green, the higher the oil imports compared to exports, see China. Countries coloured lilac are oil exporting countries, i.e. where oil exports are higher than imports, see Canada. There is only one country coloured fuchsia, indicating a much higher oil export value than import value, i.e. Russia. It should be noted that the US, despite being the main oil producer globally, is a net importer of oil due to its very high oil consumptions.

Figure 17 - Crude Oil price (USD/bbl), 2019-2022



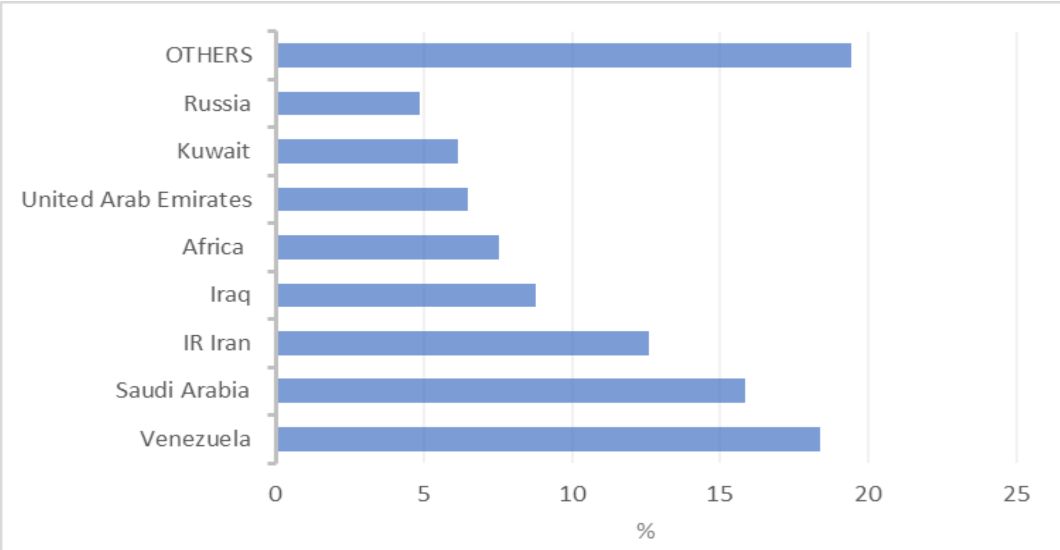
Source: tradingeconomics.com

Figure 18 - Crude Oil Production, 2020



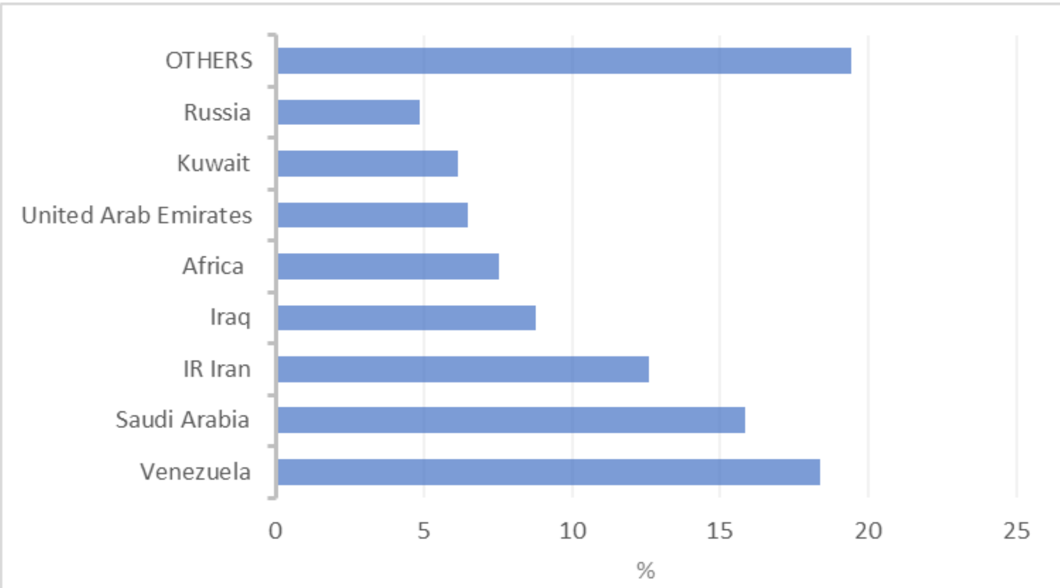
Source: IEA

Figure 19 - World's crude oil reserves, 2020



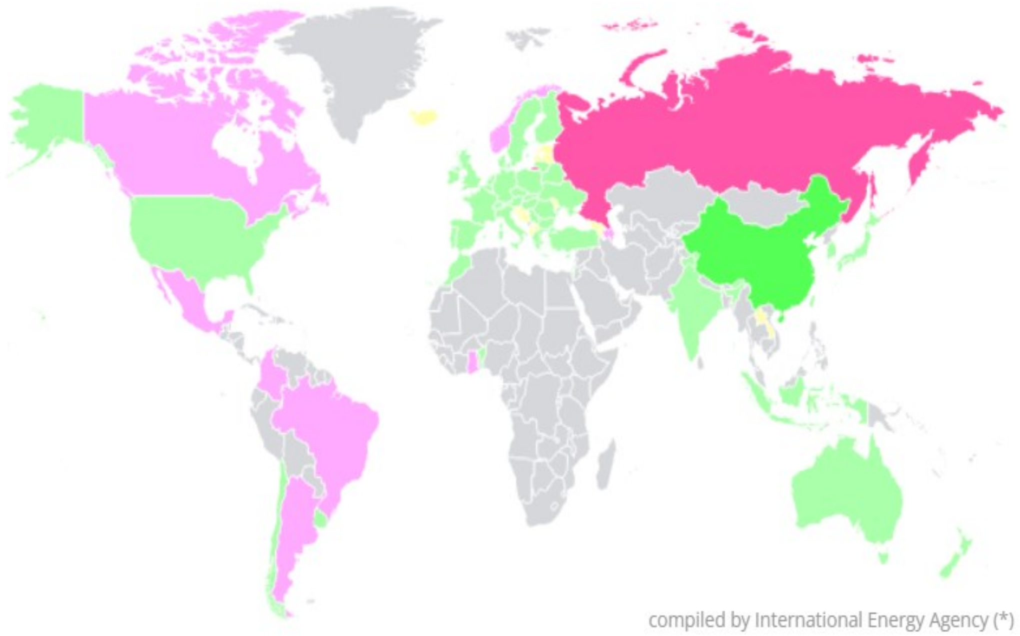
Source: World Mining Data

Figure 20 - World's crude oil reserves, 2020



Source: World Mining Data

Figure 21 - Oil Net Trade, 2020



Source: IEA

1.3.2 Natural Gas

The last commodity that will be discussed in this first part is natural gas.

Natural gas is a natural combination of gaseous hydrocarbons consisting mainly of methane, plus various smaller quantities of other higher alkanes. Natural gas is a fossil fuel and a non-renewable resource that was formed through the decomposition of layers of organic matter under anaerobic conditions and subjected to intense thermal pressure underground over millions of years. The energy that decomposing organisms originally obtained from the sun through photosynthesis is stored as chemical energy within the molecules of methane and other hydrocarbons.

Natural gas can be used for heating, cooking food and generating electricity. It is also used as a raw material in the production of plastics and other commercially important organic chemicals and, less commonly, as a vehicle fuel.

The extraction and consumption of natural gas is an increasing contributor to climate change. Both the gas itself (particularly methane) and the carbon dioxide released when the gas is burned are greenhouse gases. When burned, natural gas emits fewer toxic air pollutants, less carbon dioxide and almost no particulate matter than other fossil fuels. However, gas venting and flaring (i.e. burning excess natural gas extracted along with oil without energy recovery), along with unintentional fugitive emissions along the supply chain, can cause natural gas to have a carbon footprint similar to that of other fossil fuels.

In Figure 20 we can appreciate the increasing path of the natural gas demand over the last decade. As evident in the figure, total demand for natural gas had declined slightly in 2020 due to the pandemic period, but by 2021, demand levels were already back above pre-pandemic levels. Demand and consumption of natural gas are still too high to meet net zero emission targets in the longer term. Consumption and demand are also expected to increase annually, mainly due to the growing demand for such gases from the Asia Pacific region. In this case, as in others mentioned above, environmental policies aimed at reducing the overall level of GHG emissions and the development of substitute technologies will play a key role in the future demand for natural gases.

Unlike in the case of crude oil, here we do not find many countries that have largely based their economies on natural gas production and exports. Looking at the revenues from natural gas (% of GDP) in 2019, the two countries with the highest percentages are Brunei, a small nation located on the island of Borneo that borders Malaysia and overlooks the South China Sea, with 28% of GDP from natural gas production and export, and Uzbekistan (10% of GDP). [20]

Also the price of natural gas, on average, has increased over the past 3 years. In June 2019 the price was 2.3 USD/MMBtu, not registering a collapse in the price during the pandemic period like crude oil, in fact the price during that period dropped but not drastically. Albeit with some sporadic price declines, the interpolation line expresses an overall increasing price trend between 2019 and 2022.

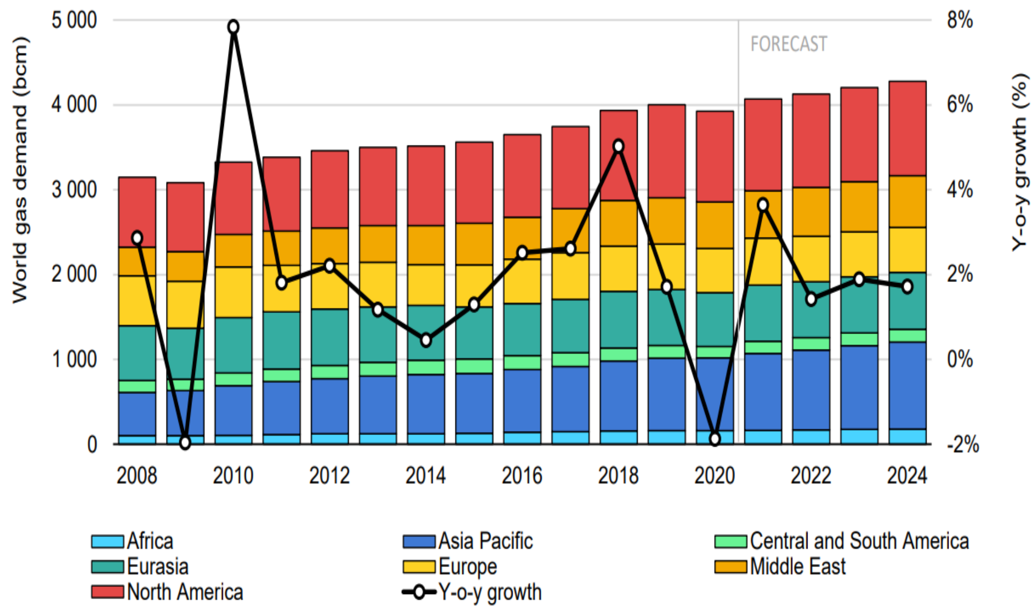
Again, natural gas production is highly concentrated in the hands of a small circle of countries, with the top 2 producers producing almost 60% of the world's natural gas. The two largest producers of natural gas in 2020 were the US (33% of the world's natural gas) and Russia (25%).[21]. As Figure 21 shows, there are other natural gas producing countries, but the United States and Russia dominate this production

[20] https://databank.worldbank.org/source/world-development-indicators#

[21] http://energyatlas.iea.org/#!/tellmap/-1165808390/0

Russia is also the country with the largest natural gas reserves owning 24% of world proven natural gas reserves, followed by Iran with 16.5% and Qatar with 11.5%.[22]. Russia also dominates in terms of exports of this commodity, exporting 16% of Exported World natural gas. The United States comes second along with Qatar (12%), then Norway (9%) and Australia (8%). Figure 22 explains the Natural Gas Net Trade or, in this case, the difference between natural gas imports and exports in 2020. The countries in red are countries with a negative Natural Gas Net Trade, i.e. they are exporters rather than importers. The countries in green, on the other hand, are countries with a positive Natural Gas net Trade, i.e. countries with a higher import than export in 2020.

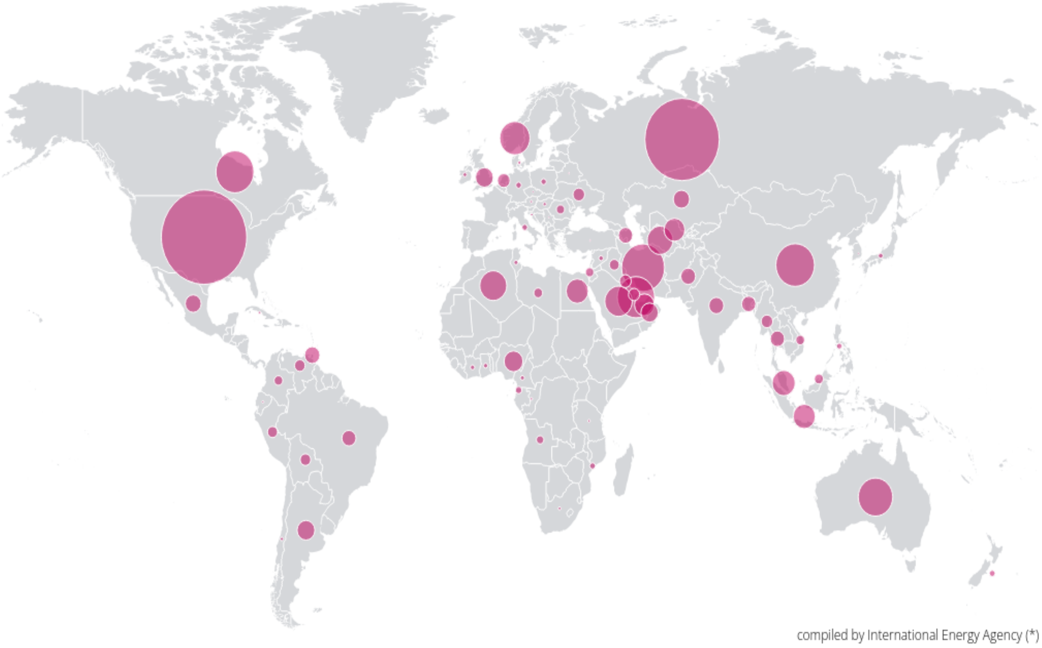
Figure 22 - Global natural gas demand by region, 2008-2024



Source: IEA

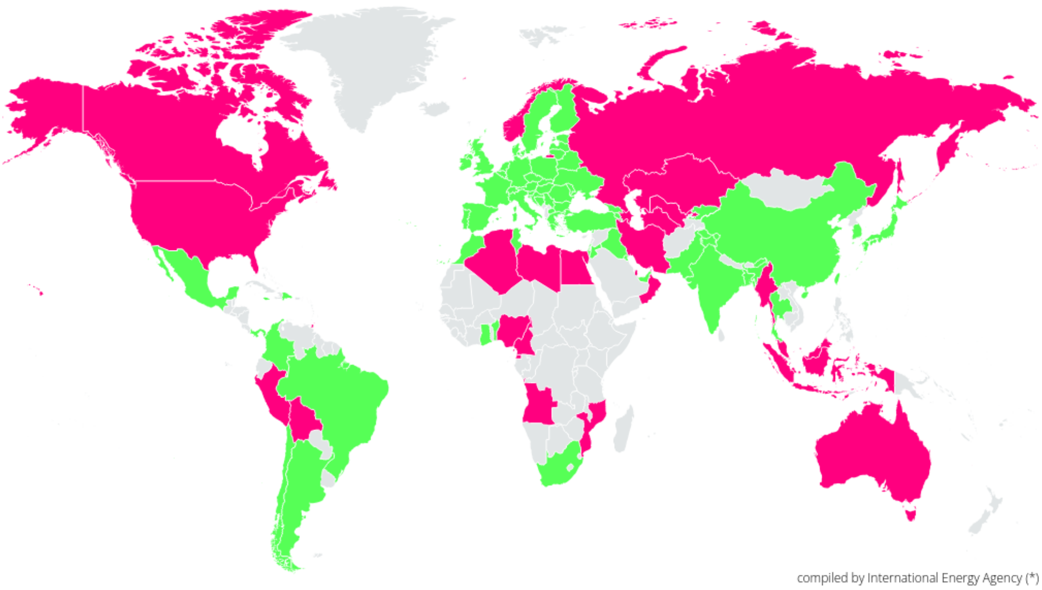
[22] https://asb.opec.org/data/ASB_Data.php

Figure 23 - Natural Gas Production, 2020



Source: IEA

Figure 24 - Natural Gas Net Trade, 2020



Source: IEA

Figure 25 - Natural Gas price (USD/MMBtu), 2019-2022

Source: tradingeconomics.com

1.4 THE NEW ERA OF SCARCITY

This first chapter analysed the distribution of resources useful for the ecological transition, highlighting the unequal distribution of such resources around the world. As expressed in the opening section, the demand for such items has grown strongly in the last 3 years, this trend can also be inferred from the price trends of such raw materials, all of which have shown price growth.

In the coming decades, the demand for such minerals is expected to grow even more, and this creates questions about the reliability of future supply. In fact, the current mineral supply would be totally insufficient to meet the projected future demand according to the SDS. This insufficient mineral supply also is reflected in a considerable increase in price due to an increase in demand that is not met by a sufficient increase in supply. This has important consequences in the energy transition process, the production apparatus in fact needs readily available and relative affordable raw materials. The low production of critical minerals, which in turn is reflected in a higher price for such commodities, would thus currently prevent large-scale development (as called for by SDS) of green technologies.

Production and reserves of such minerals are also enormously concentrated in a few countries. This few sources of supply of mineral resources could create enormous problems globally in case of shocks in producing countries. The high concentration of production and the current insufficient production, therefore, portends a "new era of scarcity", during which the current geopolitical balances could also change. In fact, unless new sources of supply (mines) are discovered and current extraction techniques are made more efficient, supply will not be able to support the energy transition, also making the entire world economy dependent on the extraction activities of those few economies rich in such critical minerals.

Table 1 - Synoptic Table Mineral Resources

Natural resource	*Production*	*Reserves*	*Price trend*
Copper	28% Chile	28% Chile	upward
	12% Peru	11% Peru	
	8% China	10% Australia	
Cobalt	63% D.R. Congo	45% D.R. Congo	upward
	7% Russia	18% Australia	
Zinc	35% China	27% Australia	upward
	11% Peru	18% China	
	10% Australia		
Lithium	49% Australia	44% Chile	upward
	22% Chile	22% Australila	
	17% China	9% Argentina	
		[23]	
Nickel	30% Indonesia	22% Indonesia	upward
	13% Philippines	21% Australia	
	11% Russia	17% Brazil	
REEs	57% China	20% China	upward
	16% U.S.	10% Vietnam	
	12% Burma	9% Brazil	
Crude oil	16% U.S.	18% Venezuela	upward
	14% Russia	16% Saudi Arabia	
	13% Saudi Arabia	13% Iran	
Natural Gas	24% U.S.	24% Russia	upward
	16% Russia	17% Iran	
	6% Iran	12.5% Qatar	

[23] no available data for Burma's lithium reserves

CHAPTER 2: NATURAL RESOURCE DEPENDENCE AND ITS POSSIBLE CONSEQUENCES

As seen in the previous chapter many natural resources (mineral and oil) are highly concentrated in certain countries. Many of these base their economies and productive system on the extraction and marketing of such resources.

This second chapter will precisely address the natural resource dependence that some countries demonstrate. As a matter of fact, over the decades numerous economists and political scientists have analyzed these countries to understand why some of them have succeeded in achieving economic and social development while others seem to be "cursed" by failing to achieve growth. This chapter will also mention some works from the very large literature in this area containing quantitative analysis as well.

2.1 THE ROLE OF NATURAL RESOURCES IN LONG-TERM ECONOMIC DEVELOPMENT

So far the work has focused mainly on the study and analysis of large commodity-exporting countries. Such countries, as mentioned earlier, will be able to make incredible gains in the long run from the export of such natural resources. There are in fact countries that, given the high concentration of resources and their central importance in the world economy, have based much of their economy on the extraction and export of these resources. In fact, there are countries that almost all of their export is composed of the export of specific natural resources.

Countries such as Libya, Nigeria, Angola, Azerbaijan, Brunei, Kuwait, Qatar, Congo Rep. e Saudi Arabia where more than 80 percent of the annual export is composed of oil exports. In this case, the role of natural resources means that there is a true export resource dependence of these economies.

The development of natural resource export-dependent economies has been widely discussed in the economic literature. In this area we can recognize two main currents of thought, the conventional view derived from neoclassical theory and according to which high levels of natural resource exports can actually help long-term economic development, and the alternative view, which recognizes the possibility that dependence on natural resource exports, can actually restrain economic development.

On the contrary, there are countries that are completely lacking in natural resources and thus find themselves forced to procure these ressources through international imports. An example of this is most European countries. Europe in fact in terms of resources is like an island that relies on global matrix of supply chains. This of course entails not only higher costs of procuring these resources but also higher risks as any shocks in the supply chain could leave countries with insufficient quantities of natural resources.

2.2 THE CONVENTIONAL VIEW

First, it is important to explain the definition of "natural resources." According to the Oxford Dictionary, natural resources generally refer to natural assets such as materials, minerals, forests, water, and fertile land that are found in nature and can be used for economic gain. Natural resources such as oil, gas and minerals can be depleted, unlike renewable natural resources such as land.

From an economic perspective, natural resources are thus less like a source of income and more like an asset (Humpreys et al, 2007)

Therefore, such resources can offer great opportunities for economic growth, as they can provide great benefits to poor economies:

- The income stream from resource extraction (natural resource rents) can finance higher levels of private and public consumption, raising real living standards;
- Higher levels of investment can be financed by resource extraction either through natural resource income or through borrowing made possible by this higher income;
- Resource income can offset scarce fiscal resources. Because resource income typically goes to the public sector budget, it can obviate a huge obstacle to development: the lack of fiscal resources needed to finance key public goods, including infrastructure;

For all these reasons, in the early decades of the 19th century, Adam Smith and David Ricardo, later echoed by neoclassical theory, argued that natural resources play a beneficial role in the process of economic development. In fact, the positive relationship between mining and economic development advanced by the conventional view is based on neoclassical economics and in particular the concept of production function. The conventional view considers mineral reserves that can be profitably mined as part of a country's stock of natural capital, along with agricultural land, forests and other natural resources. For some countries, this mineral wealth represents a significant part of the natural and total capital that can be mobilized for development. In general, according to the neoclassical production function, the more capital a country has, the higher its output and the higher its per capita income. This is not always true for natural capital in the form of mineral reserves, since as long as these deposits lie dormant in the ground, they remain unproductive.

According to the conventional view, mining can play a key role in the development process by converting mineral resources into output that can be consumed or invested in other forms of capital that increase future output in other sectors. These assumptions, of course, assume that the funds are invested wisely; otherwise, mining may provide little or no future benefit. In this pessimistic case, according to the conventional view, the government and other entities that decide how to invest the income are to blame; mining provides only the opportunity for growth.

The conventional view was also held by many postwar economists, such as Walter Rostow (1959), who summarized this popular belief by highlighting the cases of Australia, the United States, and Great Britain.

2.3 THE ALTERNATIVE VIEW

The conventional (optimistic) view, proposed by Smith and Ricardo, and supported by the neoclassical economics, prevailed until the early 1980's, even though there was already some opposition to this conventional wisdom.

At this time, Corden and Neary (1982) and Corden (1984) first developed a work which analysed the Dutch manufacturing declining after the discovery of natural gas sources. Corden and Neary were the first to develop a model for the so-called "Dutch disease," a term coined in 1977 by an edition of "The Economist." The Dutch disease thesis can be considered as the predecessor of resource curse theory which suggests an inverse association between natural resource dependence and economic growth. The literature regarding this alternative view has increased significantly in the last decades through both descriptive and quantitative analysis which try to identify different causal channels by which a resource curse might operate, and different outcome variables related to economic growth that it might affect.

2.3.1 The Dutch disease

In the 1960s, in Holland, a mineral boom, such as the expansion of the natural gas sector, occurred after the discovery of the Groningen fields. This sector expansion increased the domestic income and the demand for goods. Typically, domestic wage rates rise as the booming mineral sector is forced to offer workers higher salaries to attract the labour it needs. This increase generates inflation and appreciation of the real exchange rate. This phenomenon harm those domestic non-mineral based sectors, such as agriculture and manufacturing, that have to compete in home and foreign markets. As a matter of fact, the price of non-natural resource commodities increases due to the higher inflation and the exports become expensive relative to the world market prices because of the appreciated real exchange rate. This negative effect is called the “spending effect”.

In addition, internal domestic inputs such as materials and labor are shifted to the expanding sector, the mineral one. As the demand for inputs increases, their prices rise in the domestic market, increasing the production costs of other traditional export sectors, resulting in the contraction of these sectors. This adverse effect of non-resource sectors is called the resource “pull effect”.

If non-resource sectors, such as manufacturing, were able to generate greater positive development spillovers than resource sectors, the "spending" and "pull" effects of resource production growth could have partly or more than partly crowded out non-resource production, and overall growth. In fact, these two effects impede economic diversification and increase dependence on the volatile mineral markets.

Finally, according to the alternative view, after the mineral boom is over, the country's traditional source of exports will be devastated and beyond resuscitation, or there will be significant adjustment costs in moving back to agriculture and manufacturing.

2.3.2 The resource curse

The studies regarding the resource curse started in 1988 when Alan Gelb published his book called "Oil Windfalls: Blessing or Curse". In this book, through a descriptive analysis, Gelb, analysed the economic effects of oil rents, establishing a resource curse thesis. He found out that oil economies, during the boom period between 1971-1983, experienced a more serious deterioration in the efficiency of their domestic capital formation than did non-oil economies. Gelb argued that the oil revenues can offset the gains from the revenues themselves.

Auty, following Gelb, used the term 'resource curse' in 1993, describing how countries rich in natural resources had lower economic growth than countries without natural resources. Analysing oil-producing countries, Auty also examined the industrial policies promoted by these countries and their consequences. He also emphasised the volatile nature of mining revenues and described the mining sector as an enclave. He highlighted the tendency of governments of mineral-rich countries to collect low earnings because foreign-owned mining companies repatriated their earnings.

The first quantitative work regarding the resource curse thesis was written by Sachs and Warner that launched a series of cross-sectional studies between 1995 and 2001. They tested empirically the existence of a negative relationship between natural resources dependence and economic growth, producing the first scholarly work confirming the adverse effects of resource dependence based on empirical evidence. Following Sachs and Warner a lot of subsequent works found the same results.

2.4 ECONOMIC AND POLITICAL MECHANISMS OF THE CURSE

This section will discuss the mechanisms by which resource curse operates: the possible causes behind inefficiency in environmental resource management will thus be explained. In fact, the abundance of natural resources is not in itself bad for an economy; there are countries that started their development process precisely from the extraction and use of raw materials. One of the mechanisms, the Dutch Disease through the spending effect and the pulling effect, has already been discussed in the previous section, in this one the other political and economic channels through which the resource curse could occur will be discussed.

2.4.1 Declining terms of trade

According to the alternative view, raw material prices tend to fall relative to those of manufactured goods. This is mainly due to the high competition in raw material markets; a reduction in production costs would therefore immediately translate into a reduction in the price of the raw material itself. In manufacturing markets, on the other hand, it is hypothesized that producers enjoy some market power that allows them to pass on a reduction in production costs to higher labor wages or higher dividends, keeping the final price of the product nearly constant. This theory, as stated by Prebisch (1950) and Singer (1950) , would then imply that commodity-exporting countries must export increasing quantities over time.

However, over the years many studies have refuted this theory of declining terms of trade. As stated by Tilton (2005), one of the challenges, perhaps the most important, that is posed to this theory is that although there may be a decline in the value of such commodities, the relevance of this decline to developing countries is not clear. Furthermore, although there may be a decline in the final price of such commodity, this decline is often due to improvements in extraction technologies that drastically reduce its cost. So, although the producing country receives a lower price for its minerals, it is at the same time true that its costs have fallen. If the country's costs fall faster than the natural resource price, the benefits flowing to the country from mining may be rising despite the trend in the price of the natural resource. This is also underscored by Garcia (2001) who found that the opening of new mines and the implementation of new technologies in existing mines more than doubled productivity in Chile's copper mines in the 1990s.

2.4.2 Market Volatility

Another economic channel through which the resource curse might operate is the volatile nature of the price of natural resources in global markets. Indeed, it is not uncommon to observe price changes of 30 percent or even more in a year or two; such volatility occurs because demand for such mineral resources varies considerably according to the business cycle. When the economy grows, sectors consume more resources, and the demand for such commodities grows even faster than the whole economy, thus increasing the price of such resources. Conversely, when the economy goes through a recession, mining sectors are even more depressed, the price of such resources therefore decreases. As stated by Davis and Tilton (2005) and later by Frankel (2010) , such volatility can in fact affect the chances of economic growth. Market instability leads to greater uncertainty, thus making effective planning for economic development complex, thereby reducing the effectiveness of both public and private investment. Price volatility, indeed, causes cyclical fluctuations in government and earnings from export activities.

Humpreys et al. (2007) also argue that the magnitude of price fluctuations in mineral resources can also be amplified by international lending. When the price is high, natural resource-rich countries will borrow from outside, exacerbating the boom. When prices fall, on the other hand, international lenders will demand repayment of debts thereby forcing debtors to reduce their expenditures, thereby increasing the negative effects of price reductions. This mechanism led many natural resource-rich countries into debt crises in the 1980s, as stated by Van der Ploeg (2011) .

Van der Ploeg and Poelhekke (2009) , presented evidence that per capita growth is inversely proportional to the volatility of unanticipated output growth, which in turn is caused by the high volatility of world resource prices in countries that depend heavily on them.
Van del Ploeg and Poelhekke, for example, explain how countries with a ratio of natural resource exports to GDP greater than 19 percent have a standard deviation of output growth of 7.37 percent versus the standard deviation of just 2.83 percent in the case of a Natural resource export/GDP ratio of less than 5 percent.

Some countries that base much of their economic activity on natural resource production have tried to mitigate the effects of such price fluctuations through the establishment of stabilization funds. When natural resource markets are booming, governments can put some of their commodity revenues into the stabilization fund; when the market is in recession, they can draw on these funds to finance government programs that would otherwise be impossible to finance sustainably. Countries that have established similar funds include Alaska, Canada, Chile, Ghana, Norway, Papua New Guinea, and Venezuela.

2.4.3 Rent seeking

"Political Dutch Disease", or rent seeking, was defined by Lam and Wantchekon (2003). People seek political rent when they try to obtain benefits for themselves through their political influence. Following this definition, many economists, such as Gylfason (2001), Hodler (2006), Iimi (2007), Deacon and Rode (2012), argue that in some countries, the windfall of resource revenues increases the power of elites, who have the capacity to widen income inequalities. Powerful groups generally take a major part of these revenues and distribute it for the benefit of their immediate circles rather than investing it to support a sustainable economic development.

Windfall resource revenues are also considered one of the biggest causes of internal conflicts between politicians, local tribes, and citizens as stated by Sala-i-Martin and Subramanian (2003). As a matter of fact, Paul Collier (2009) finds that for any given 5-year period, the probability of a civil war in an African country ranges from less than 1% in countries without resource wealth to nearly 25% in those countries with it.

The presence of mining rents, according to Ross (2001) and Sala-i-Martin and Subramanian(2003), may lead also to a decline in institutional quality. According to this thought, which is criticized by a lot of economists and political scientists, resource rents bring not only conflict but also downward pressures on institutional quality. Arezki and Bruckner (2011), through a panel of 31 oil-exporting countries between 1992 and 2005, have found out that an increase in oil rents significantly increase a Political Risk Services sourced corruption score, especially in countries with a high share of state participation in oil production.

Ross, in 2001, also explained, through a quantitative work, that oil rents seem to hinder democracy. Authoritarian regimes in resource-rich states can indeed rely more on resource rents than tax revenues, which correspondingly weaken public demands for democratic accountability. Moreover, Iimi (2007) argues that natural resource revenues may imbue policymakers with overconfidence in their economies.

Revenues from natural resource rents may also relieve pressure on government regarding tax collection and the need for fiscal discipline. Resource-funded fiscal cushions, as proposed by Ross (2007), can enable governments to ignore or delay urbanization, pressure for higher supply of education, and the creation of other infrastructure requirements that would help long term economic development. There is evidence, indeed, that public expenditure on education relative to national income is inversely related to natural income.

2.5 RESOURCE IMPORT DEPENDENCE

While it is true that there are countries rich in mineral resources (i.e. oil), it is at the same time true that there are countries poor in such resources. Since oil, for example, is of fundamental importance to most sectors, such countries are forced to import in many cases the entirety of the oil used in their production apparatus in order to fuel their economies. This is reflected into positive net oil exports for countries rich in natural resources and positive net oil imports for countries that are poor in such resources instead. Given the central importance of these resources in the world economy, net importer countries have over the years, become in every sense, dependent on the extraction processes of natural resource rich countries (Russia, Saudi Arabia, Iran, Qatar, and OPEC). In fact, the decisions made by OPEC, Organization of the Petroleum Exporting Countries, which holds a real oil cartel, have great consequences for the entire world economy. An oil price shock can indeed have huge impact on economic growth, inflation and unemployment. For these reasons, it has become critically important for natural resources importer countries to differentiate sources of supply, as any crises or shocks within the net exporter countries could lead to huge consequences in the global resource supply system (i.e. Russian-Ukrainian war).

Some of the largest oil importers in 2019 are presented in Table 2. As can be seen, it is interesting to note that these large oil importers are among the most developed countries globally, all of them in fact have high GDP per capita (among the highest globally). The development of these countries is not only among the highest in economic terms, but also in governmental-institutional terms. As a matter of fact, these are countries where institutions guarantee fundamental human rights, low levels of corruption, there is transparency and no oppressive governments, as evidenced by the Rule of Law index.

Table 2 - Oil Importing countries, 2019

Country	***Daily oil import (b/d per 1.000 population)***	***2019 per capita gdp (2015$ costant)***	***Rule of Law (0<index<1)***	***Rule of Law (rank, out of 139)***
Belgium	60,62	43.066	0,83	13
Canada	22,77	45.109	0,85	8
France	14,51	38.912	0,74	17
Germany	20,90	43.329	0,85	6
Japan	23,87	36.081	0,71	23
Netherlands	66,47	31.640	0,72	22
Singapore	148,62	48.444	0,86	5
South Korea	56,49	61.340	0,69	27
United Kingdom	13,62	47.751	0,84	11
United States	20,71	60.687	0,73	19

Source: data.worldbank.org

2.5.1 EU's import dependence case

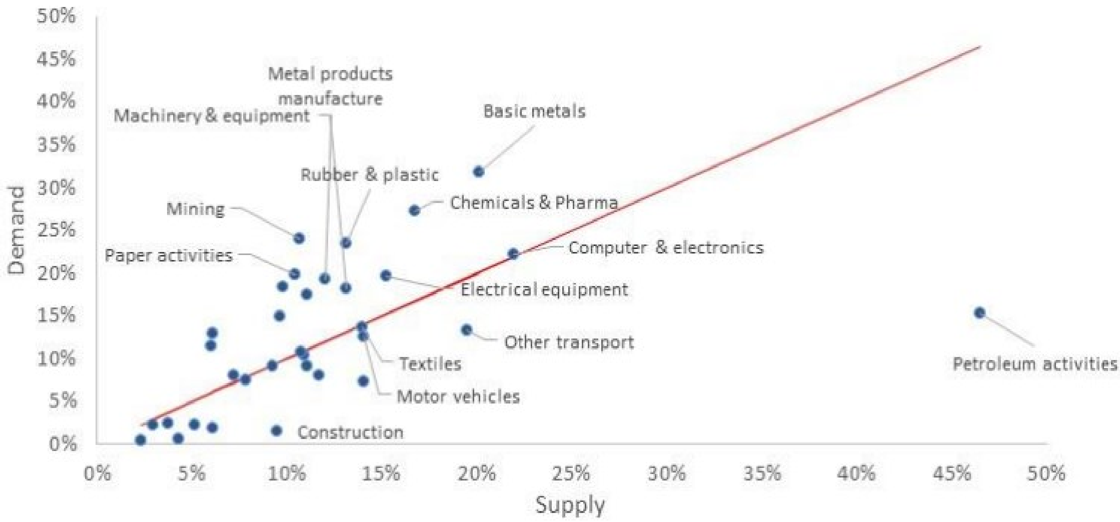
In terms of resources, Europe is an island. It does not have the raw materials to meet its basic needs and therefore must import them. Like isolated nations, Europe relies on global supply chains to meet its need for raw materials. If just one of these were to break down, the European economy would be at risk. Although the weight of the import of fuels and minerals has decreased in recent years (2014-2019) the same could not be said for the period 2000-2014 when the import fuels share came to measure 30 percent of total EU imports. In fact, European countries belonging to the OECD import a total of 70 percent of their oil consumption, 50 percent of their natural gas consumption, and 44 percent of their coal consumption. Since these fossil fuels account for about three-quarters of Europe's total energy supply, with renewables and nuclear power providing the rest, dependence on energy imports is a growing problem. Although renewable energy sources are on the rise, if Europe does not make changes it would find itself completely dependent on imported fossil fuels in the coming decades by predicting an increase in oil imports to 78 percent by 2035, imported gas to 64 percent, and coal to 51 percent.

Europe's import dependence includes not only fossil fuels, but also many basic industrial minerals. In fact, according to the U.S. Geological Survey, European members of the OECD produce only about 1 percent of the world's iron ore and 4 percent of its copper, although they naturally use a much larger share of these materials for manufacturing and construction. Europe's dependence is also increasing on most of the critical materials used in high-tech applications, such as cobalt, lithium and REEs. As discussed, these minerals are not used in massive quantities, but they are essential for batteries and green technologies such as advanced solar panels and wind turbines.

Of course, European economic sectors are heterogeneously exposed to international commodity markets. There are sectors that base much of their production process on the international commodity supply chain, and thus are more exposed to potential shocks, and sectors where this risk is lower. Figure 26 shows EU industry's exposure to non-EU markets in terms of both supply and demand, which are then used in each sector's production process. The graph shows that the sectors with the largest upstream and downstream links to foreign countries are computers and electronics, chemicals and pharmaceuticals, basic metals, and electrical equipment. Sectors above the 45-degree line depend more on non-EU demand than on supply from non-EU countries.

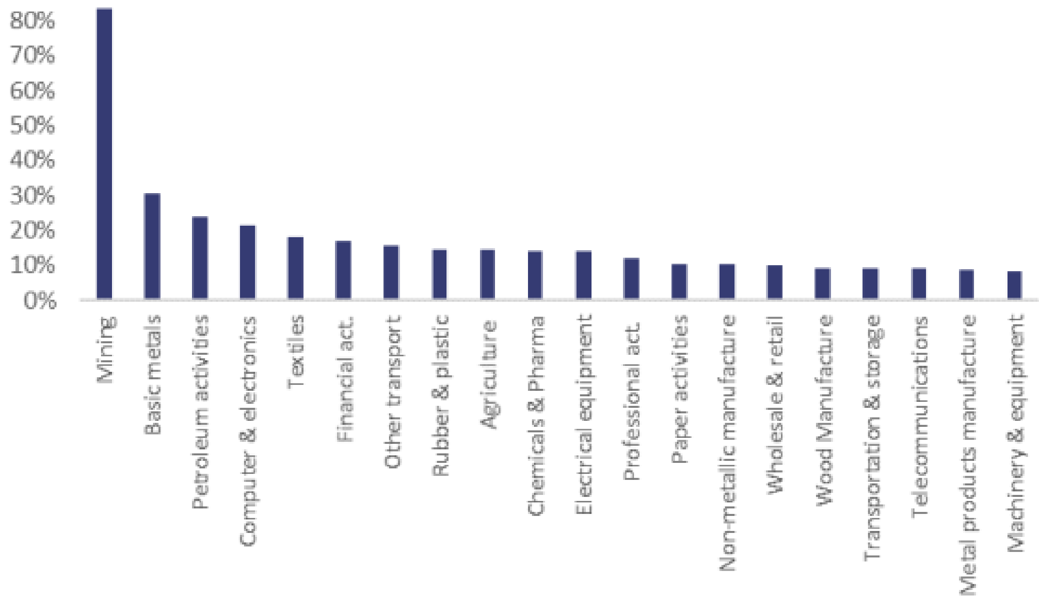
Figure 27 ranks the sectors according to the extent to which EU production depends on foreign supply. The EU is particularly dependent on non-EU countries for raw materials and electronics, but also for textiles, financial activities, chemicals and active pharmaceutical ingredients. Consequently, this highlights the need for the EU to continue to be integrated into the global economy.

Figure 26 - EU industry's exposure to non-EU markets



Source: European Commission

Figure 27 - European sector dependence on international supply



Source: European Commission

With more countries around the world becoming even more reliant on materials from remote locations, threats of attact to vital supply routes are becoming an attractive means for various actors to apply pressure, for political or economic purposes. Iran's leaders, for example, have threatened in the past to block the Strait of Hormuz, linking the Persian Gulf and the Indian Ocean, through which a third of the world's seaborne traded oil passes, to deter any attack on its nuclear facilities.

2.5.2 The Russian-Ukrainian War and the supply of natural gas

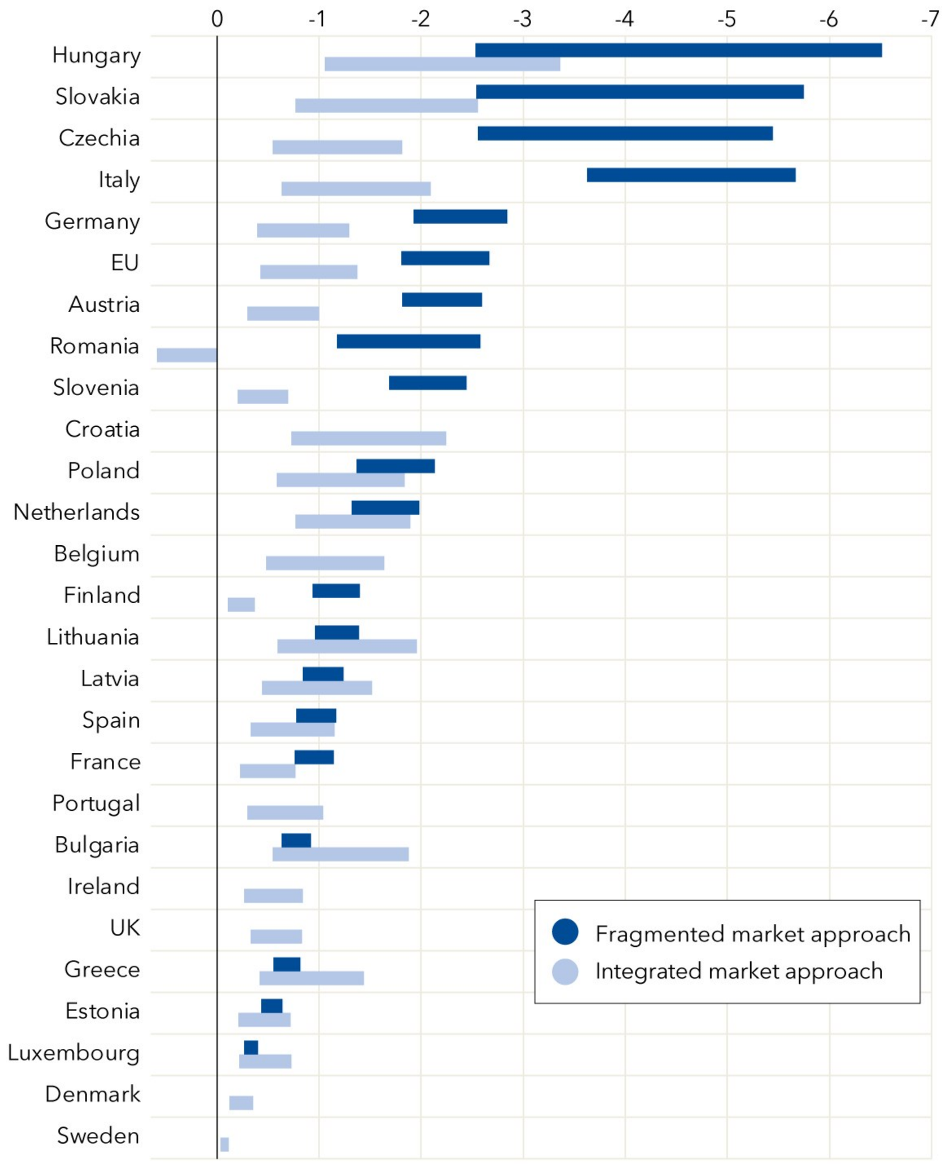
Russia's invasion of Ukraine has further darkened global growth prospects, with the European economy facing a major setback due to trade, investment and financial ties with the warring countries. Now Europe is experiencing a partial disruption of natural gas exports from Russia, its main energy supplier.

Appendix 1 represents dependence on Russian gas as a share of total energy consumption. As can be seen, exposure to the risk of reduced Russian gas supply is highly heterogeneous across Europe. The countries of Central and Eastern Europe are the most exposed as more than 20 percent of their energy consumption is derived from the use of imported Russian gas.

The economic impact of a disruption in Russian gas supplies also has different effects across Europe. Figure () represents the impact of this disruption according to two different approaches. The integrated market approach assumes that gas can get to where it is needed and that prices will adjust. The fragmented market approach is more suitable when gas cannot get where it is needed, regardless of price increases.

If EU markets remain integrated both internally and with the rest of the world, our integrated market approach suggests that the global LNG market would help buffer economic impacts. This is because the reduction in consumption is distributed among all countries connected to the global market. At the extreme, assuming no support for LNG, the impact is amplified: soaring gas prices are expected to act by depressing consumption only in the EU.

Figure 28 - Economic effect of a Russian gas supply disruption



Source: blogs.imf.org

CHAPTER 3: A RESOURCE CURSE ECONOMETRIC ANALYSIS

This third chapter will initially highlight the most frequently used variables in the literature concerning the resource curse. Some of the works have already been mentioned at the beginning of the previous chapter; now, taking up some of the notions already explained, additional quantitative works will be brought to the reader's attention as well as criticisms of them.

In the last part of the chapter, an empirical model study of the resource curse will be proposed in order to understand any negative correlation between resource dependence in output and economic growth over the past 20 years.

3.1 THE EMPIRICAL RESOURCE CURSE STUDIES

In this section will be analysed multiple all the variables that have to be considered when dealing with empirical studies regarding the resource curse. Particular issues that might affect the outcome of the studies will also be highlighted, as well as cautions that need to be considered in order to have the most objective results as feasible.

3.1.1 Resource dependence vs. Resource abundance

First of all, we need to distinguish the two main measures of dependence most commonly used in studies of resource curse theory. The first is resource dependence in output; this measure refers to the degree to which a country is actually dependent on resource income.

Examples of the various variables of resource dependence in output include:

- Primary exports over GDP: exports of agricultural, mineral and energy products, divided by GDP;
- Natural resource rents on GDP: difference between the value of raw natural resource production at world prices and the total cost of production divided by GDP;
- Share of natural capital in national wealth: natural capital to the sum of natural capital and the value of the perpetual inventory of produced goods and "human resources";
- Share of natural resource exports in total exports: measures a country's degree of trade specialization in mineral exports;

On the other hand, resource abundance refers to a country's estimated finite endowment of subsoil wealth or mineral, oil and gas deposits. This measure is itself endogenous to exploration, influenced by resource prices.

Some examples of measures of natural abundance are:

- Total natural capital and mineral resource wealth in dollars per capita: estimates subsurface wealth, cropland, timber and non-timber forest resources, and protected areas;
- Subsoil wealth: major stocks of combustible and noncombustible minerals found in a country;

Of course, a resource-rich nation may not be resource dependent if it diversifies its productive structure. In fact, the International Monetary Fund defines a country as "resource dependent" when the average multi-year share of a country's resource revenues in total revenues is more than 25 percent, without regard to the measure of natural resource abundance.

Stevens and Dietsche (2008) identify 54 countries that, according to their definition, can be defined as resource dependent. In fact, they identified countries whose fuel and mineral exports exceeded 30 percent of total exports at any time between 1965 and 1995. The countries are listed in the table. Geographically, these resource-dependent countries are found in all regions of the world, but are most commonly associated with the Middle East and Africa.

Table 3 - Countries at risk of contracting the Resource Curse

Algeria	Congo	Jordan	Niger	Suriname
Angola	D.R. of Congo	Kiribati	Nigeria	Syria
Australia	Rep. of Cyprus	Kuwait	Norway	Togo
Bahrain	Ecuador	Lao PDR	Oman	Trinidad and Tobago
Bolivia	Egypt	Liberia	Papua New Guinea	Tunisia
Botswana	Gabon	Libya	Peru	United Arab Emirates
Brunei	Greenland	Malaysia	Qatar	Venezuela
Cameroon	Guyana	Mauritania	Saudi Arabia	Virgin Islands
Canada	Indonesia	Mexico	Senegal	Yemen
Chile	Iran	Morocco	Seychelles	Zambia
Colombia	Iraq	New Caledonia	Sierra Leone	

Source: Steven and Dietsche (2008)

3.1.2 Empirical evidences for the effect of natural resources on variables related growth

Chapter 2 has already mentioned some of the past work showing a negative correlation between natural resources and economic growth. The literature concerning resource curse, however, has not been limited to only explaining the correlation between these two variables. In fact, th ere are numerous works showing a negative correlation between natural reosurce dependence and many other variables (however related to long-run growth).

This larger group of outcome variables includes the development of human capital (Gylfason, 2001; Stijns, 2006; Daniele, 2011; Blanco and Grier, 2012; Shao and Yang, 2014), savings rates (Atkinson and Hamilton, 2003; Gylfason and Zoega, 2006; Dietz et al., 2007; Boos and Holm-Müller, 2013), growth of manufacturing exports (Wood and Berge, 1997), investment (Mehlum, 2006; Boschini et al., 2013). The majority of these studies show that the abundance or dependency on natural resources has a negative impact on the variables of interest. Appendix 2 from Ramez, Lean, and Clark's resource curse survey provides a summary of the findings (2016).

3.1.3 Critics to the resource curse thesis

By the 2000s the existence, mainly in developing countries, of the negative correlation between natural resource wealth and economic growth, as well as the mechanisms by which the curse operates, was well established and accepted. However, in these years a new trend was emerging in resource curse theory that challenges the entire curse theory as a "statistical mirage", as stated by James (2015).

One of the most important works coming from this trend is the work of Brunnschweiler and Bulte (2008) who criticized the results and modus operandi of Sachs and Warner's work, one of the most important works concerning resource curse theory. In fact, they argue that Sachs and Werner's results may be misleading given the endogenous nature of the chosen resource dependece variable. Specifically, GDP placed in the denominator (resource export/GDP) explicity measures also the magnitude of other activities in an economy. The ratio therefore between resource export and GDP is not independent of the economic policies and institutions that influence both the level of GDP and growth. Brunnschweiler and Bulte therefore argue that factors such as economic policies and institutions can influence both sides of the regression. In their study, using different variables, they conclude that resource abundance, proxied by subsoil assets, have a positive correlation with growth. The resource dependence variables, on the other hand, do not appear to be significant.

Other criticisms have been made regarding the time samples used in these quantitative studies. Alexeev and Conrad (2009) argue that using a time samples that start between 1965 and 1970 can lead to incorrect results. They argue that this interval is troublesome because commercial oil exploitation began prior to 1950, leaving 15 years out of the analysis.

Also other economists highlighted the time samples issue in their critiques (Stijns, 2005; Lederman and Maloney, 2007; Boyce and Emery, 2011; Cavalcanti et al., 2011). Most of these more recent studies also state that by substituting resource abundance variables for resource dependence variables, the correlation becomes positive. The results of these more recent studies are also summarized in Appendix 3 taken from the survey by Ramez, Lean and Clark (2016).

3.2 CROSS SECTIONAL VS. PANEL MODELS

Studies using single-period average growth rates as the dependent variable have a significant econometric weakness, as they lose information because there can be only one observation per nation in the cross-sectional analysis.

By adopting a single, normal growth rate from a very turbulent two-decade period, 1970-1990, it is assumed that the economy has seen costant rate of growth (Maloney 2001; Neumayer 2004). One exception is Manzano and Rigobon (2003). They replicated the Sachs and Warner's cross-sectional research (1995) using panel data. Nevertheless, they calculate the averages for the panel's two to four periods.

In addition, any time.invariant factors are removed from the estimation since they have used a fixed-effects estimator. Finally, dividing the panel into such large time periods may again fail to adequately capture the effects of expansions and contractions in the resource sector.

In the estimation proposed by this work it will be used a panel analysis based on 110 countries over 16 year time sample in order to avoid massive information losses. The period taken into account, as already said, starts in 2002 and ends in 2017; this is a major difference with past works that were focused mainly on the period 1970-2000.

3.3 RESOURCE INTENSITY VARIABLE DEBATE

The main theoretical argument behind the Resource Curse hypothesis is the Dutch Disease, according to which windfall gains from a resource boom have a negative impact on productivity and competitiveness in other tradable goods sectors as stated by Sachs and Larrain (1993).

Since supply shocks are more common in non-renewable industries, the effects of Dutch disease are more frequent in these industries.

This is because a country's supply of these products can change suddenly with the discovery of new deposits. In addition, the inelastic demand for some non-renewable goods, for example energy products, makes their price more volatile. Large price increases, increasing rents, can also create a boom in these industries. For these reasons, the inclusion of renewable resources in the measure of natural resource intensity, particularly agricultural production, is questionable. During an episode of Dutch Disease, the boom industry excludes other export industries. If such effects were in place, a large measure of resource intensity would be obscured by the very process it seeks to capture. Sachs and Warner (2001) defend their adherence to a measure of resource intensity that includes both non-renewable and renewable industries, arguing that cross-country variation in non-renewable mineral exports explains most of the variation in primary exports.

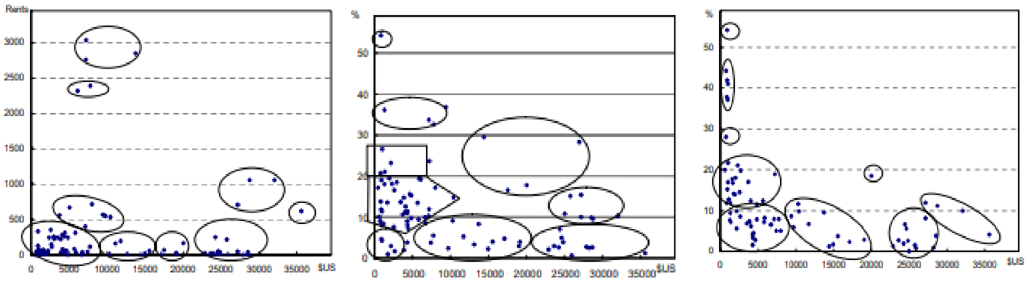
Rambaldi and Brown (2006) tested the effects that a different choice of resource intensity variable may have on the final results, comparing three cluster analysis based on three different resource intensity measures. The three different resource measures were:

1. Sachs and Werner (1995): Primary Products as a share of total export;
2. Gylfason and Zoega (2002): Natural capital as a fraction of total wealth;
3. their measure: Rents per capita, averaged from 1983-2000;

Interestingly, the classification of countries, as shown in Figure 29, changes considerably in some cases according to the measure of resource intensity considered.

The same countries are often assigned to a different cluster group, sometimes ranging from one extreme to the other. This confirms the concern that alternative measures result in considerable differences in the classification of resource intensity.

***Figure 29 - Comparing cluster group according to the resource intensity variable*[24]**



Source: Rambaldi and Brown (2006)

As an economy develops, it undergoes structural changes, including a decline in the share of primary production in GDP and exports. As manufacturing capital accumulates, a given stock of natural capital will decrease in proportion to total capital. Countries that used to be resource-rich by these measures and managed to avoid the resource curse will stop to be classified as resource-intensive countries. It was only because of vast mineral and coal deposits that countries like Britain and Germany were able to industrialize.

In contrast, resource-rich countries that have performed poorly will continue to be considered resource-intensive. Sachs and Werner (2001) defend their adherence to a GDP-based measure by claiming that currently rich countries that have successfully reinvested natural resource rents have not enjoyed the same degree of resource intensity as the most resource-rich countries in the mid- and late 20th

[24] Starting from the left: Rents per capita averaged from 1983-2000 (Rambaldi and Brown*)*, primary products as a share of total exports (Sachs and Warner), natural capital as a fraction of total wealth (Gylfason and Zoega).

century. Although this statement is empirically correct, the goal of econometric analysis is to test the relationship between the degree of resource intensity of countries and economic growth.

If the measure of the independent variable (resource intensity) is affected by historical changes in the dependent variable (economic growth), circularity and distortion are unavoidable.

3.4 THE DIFFERENT PHASES OF THE STUDY

This final section of the paper will discuss the procedures and results of the descriptive and econometric model. These studies has as its ultimate goal the analysis and understanding of the influence that high levels of dependence on mineral resources, both in imports and exports, can have on long-run growth. For this purpose, initially a descriptive analysis of this phenomenon will be proposed by means of simple graphs, and later, through different econometric models (cross-sectional and panel) the phenomenon will be analyzed in more depth also trying to understand how much the choice of model specification can actually influence the final results.

3.5 THE CHOSEN VARIABLES

For this descriptive model and the econometric model, the same dataset will be used although considered under different circumstances.

For the dependent variable, that concerning economic growth, per capita GDP (2017 International $)[25] was considered. This measure was chosen because it is not influenced by inflation levels and the size of the population of the different countries. In fact, the economies taken into consideration present highly heterogeneous socio-economic conditions. Indeed, in the sample we find countries that are virtuous in monetary economics, thus with controlled levels of inflation, and countries that are "less virtuous" in this respect. At the same time, the size of countries also differs profoundly within the sample.

Regarding the independent variables, two different variables were used for the study of resource import/export dependence:

1. M/IMP: the import of minerals in a given year divided by the country's total import in the same year;
2. F/IMP: the import of fuel in a given year divided by the country's total import in the same year;
3. M/EXP: the export of minerals in a given year divided by the country's total export in the same year;
4. F/IMP: the fuel export in a given year divided by the country's total export in the same year;

Data for these variables were taken from World Trade Organization (WTO).

[25] World Data Bank

For the descriptive study, the resource dependence variable considered combines the export/import of both Fuels and mineral resources:

1. F&M/IMP[26]: the import of fuels and minerals in a given year divided by the country's total import in the same year;
2. F&M/EXP[27]: the export of minerals in a given year divided by the country's total EXP in the same year.

3.6 DESCRIPTIVE MODEL

Two different moments in the time sample were considered for the descriptive model.

The relationship between per capita GDP and Fuel and Minining product export at the beginning of the time sample (2002-2003) is initially brought to the reader's attention. For this purpose, the arithmetic mean, for the years 2002 and 2003, of the values of per capita GDP (MPCGDP0203) and Fuel and Mining export over total export (MF&M/EXP0203), of each country was calculated. Data for the biennium 2018 and 2019 were re-processed in the same way, and for the import case the procedure was exactly the same.

[26] World Trade Organization

[27] World Trade Organization

3.6.1 The export case

As a first step, the sample was divided into quartiles based on the level of per capita GDP. Second, the number of countries, per quartile, that can be defined as resource export dependent was identified.

This definition was based on the definition proposed by the International Monetary Fund, which defines a country as "resource dependent" when the average share over multiple years of a country's resource revenues over total revenue is greater than 25 percent. In that definition, however, the IMF also considers natural resources, which will not be analyzed in this paper. A country will therefore be defined as export resource dependent if F&M/EXP is greater than 20 per cent.

The Table 4 lists the results for 2002-2003. The second column shows the values below which we can define the quantile. We find 27-28 countries per quantile, as described in column 3. The most interesting section is probably the last column of the table, there is the number of countries that can be defined as export resource dependent per quantile. As can be seen, the percentage of resource dependent countries is higher in the first quantiles, indicating how, usually, the dependent countries are those with worse levels of GDP per capita:

Table 4 - Analysis of export dependent countries according to the quartiles (2002-03)

Quartile	*mean per capita GDP (02-03)*	*n° of countries*	*n° dependent countries*
1	6.111	28	15
2	13.686	55	27
3	36.376	82	35
4	104.030	110	43

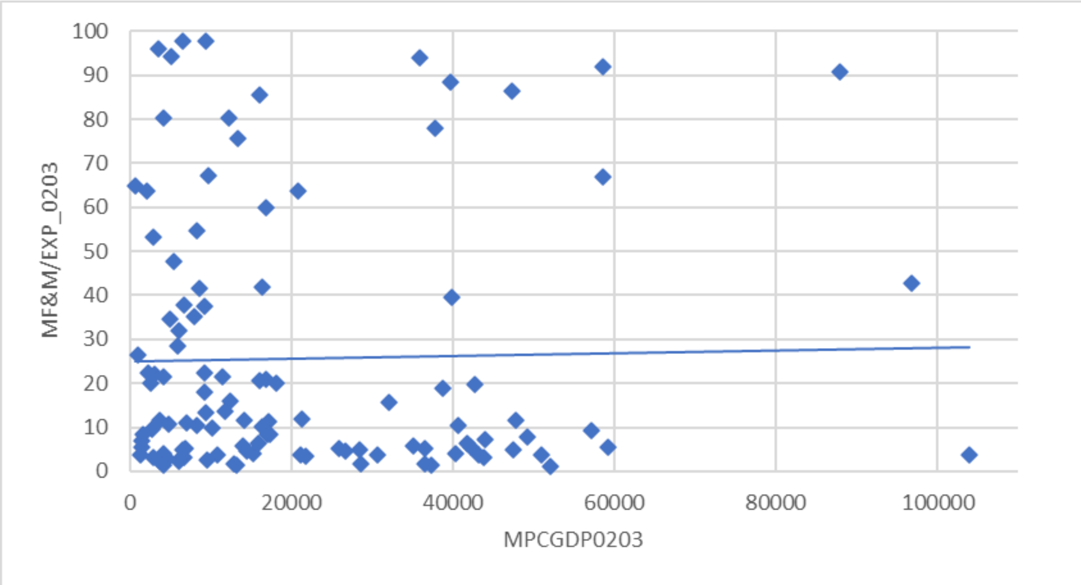
Source: own calculations

- 1st quartile: 15/28 = 53% dependent countries;
- 2nd quartile: 27/55 = 49% dependent countries;
- 3rd quartile: 35/82 = 42% dependent countries;
- 4th quartile: 43/110= 39% dependent countries;

It should be noted, however, that this analysis only takes into account the number of dependent countries, not distinguishing between highly dependent or medium dependent countries, thus neglecting the magnitude of these variables.

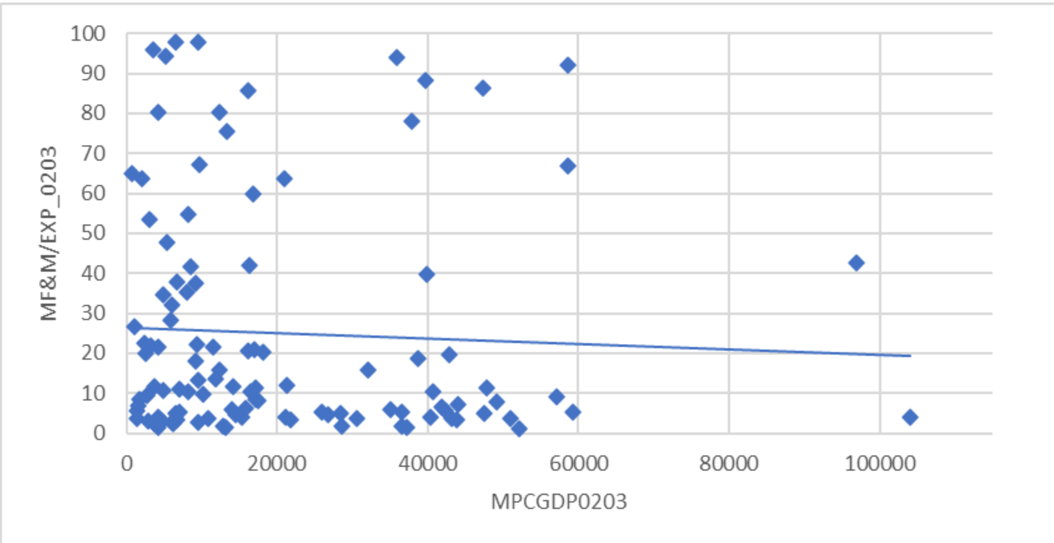
In fact as depicted in the Graph, the per capita GDP and Fuel and mining products over export relationship appears to be positive for 2002-2003 (Figure 30). However, the slope of the Graph (Figure 31) changes sign if Qatar, , which seems to act as a real outlier being the only one with very high levels of F&M/EXP and with high levels of PCGDP, is removed from the sample.

Figure 30 - Mean Fuel and Mining product export (% of total export) and mean per capita GDP (2002-03)



Source: own calculations

Figure 31 - Mean Fuel and Mining product export (% of total export) and mean per capita GDP, without Qatar (2002-03)



Source: own calculations

The results do not differ to a great extent with regard to the 2018-2019 biennium (Table 5). Overall there are 3 additional countries that can be considered resource export dependent (43 in 2002-03. 46 in 2018-19), but the composition of the quartiles has not changed significantly. There has been a slight "upward" trend whereby the percentage of dependent countries has risen by a few percentage points, mainly and only in the quartiles where the per capita GDP is highest (3rd and 4th).

Table 5 - Analysis of export dependent countries according to the quartiles (2018-19)

Quartile	*mean per capita GDP (18-19)*	*n° of countries*	*n° dependent countries*
1	20.425	28	14
2	43.228	55	28
3	82.842	82	37
4	231.568	110	46

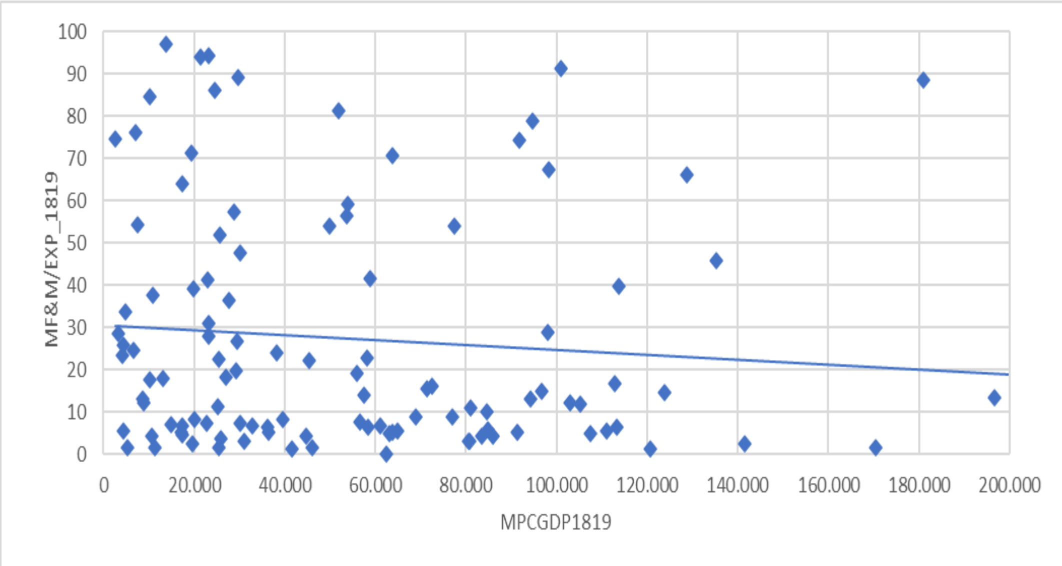
Source: own calculations

- 1st quartile: 14/28 = 50% dependent countries;
- 2nd quartile: 28/55 = 51% dependent countries;
- 3rd quartile: 37/82 = 45% dependent countries;
- 4th quartile: 46/110= 42% dependent countries;

Overall, the conclusions we can draw from this are the same as in 2002-03 according to which countries with a F&M/EXP ratio demonstrate lower levels of GDP per capita.

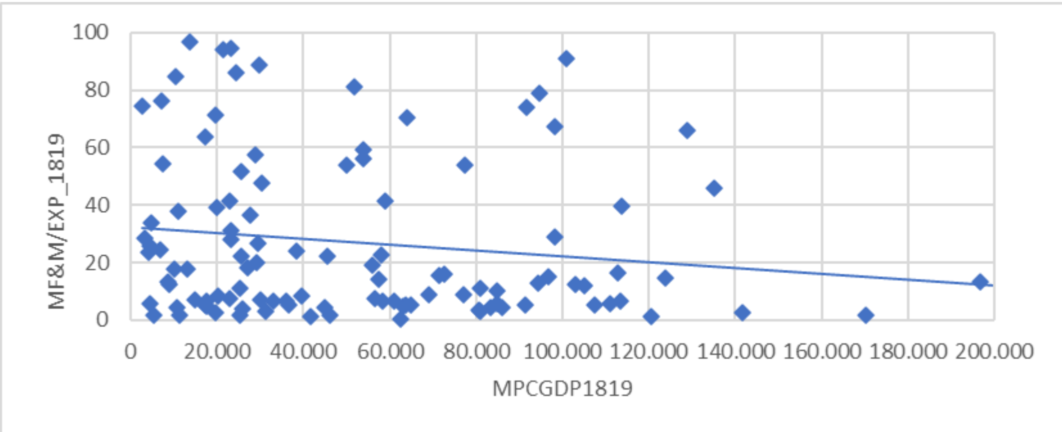
The Graph (Figure 32) confirms the conclusions drawn from the quartile analysis, even including Qatar, the trend line has negative angular coefficient. Excluding Qatar (Figure 33), the slope of the curve increases while keeping the sign of the angular coefficient unchanged.

Figure 32 - Mean Fuel and Mining product export (% of total export) and mean per capita GDP (2018-19)



Source: own calculations

Figure 33 - Mean Fuel and Mining product export (% of total export) and mean per capita GDP, excluding Qatar(2018-19)



Source: own calculations

3.6.2 The import case

As explained initially, the modus operandi for the descriptive study of import resource dependence is the same as that for the study of export. In this case, however, we have no definition from which to take our cue in order to have a benchmark to help define when a country can be considered import dependent.

This benchmark will be defined by calculating the quartiles of the mF&M/IMP variables for the two-year periods 2002-2003 and 2018-2019; the data are shown in Table 6. Making an estimate, albeit a general one, the import dependence benchmark will be estimated at 15 percent of total exports; this implies that all countries with a mF&M/IMP ratio greater than or equal to 15 will be considered import dependent.

Table 6 - Benchmark estimation by quartiles calculation

Quartile	*Mean F&M/IMP(2002-03)*	*Mean F&M/IMP(2018-19)*
1	8,27	11,48
2	12,21	15,63
3	16,84	21,13
4	63,13	37,58

Source: own calculations

Analyzing the Table 7 and 8, it is evident that there has been a profound revolution in the import of fuels and mining products. As can be seen by looking at the 4th quartile in both two-year periods there has been an incredible increase in countries dependent on resource imports. This is probably due to two main reasons that have already been discussed in the first chapter: concentration/scarcity of such resources and increasing demand.

As a matter of fact, the deposits of such resources are highly concentrated in a few countries that are very rich in such resources. There are others, on the other hand, that are poor in them if not totally devoid of deposits, thus forced to import the needs for such resources entirely. Second, as again highlighted in Chapter 1, demand for fuel and mining products has been increasing in recent years being of central importance to most of the world's production processes. These two factors combined, the concentration of resources and their growing demand, mean that more than half of the countries belonging to the sample are dependent on global supply chains.

Table 7 - Analysis of import dependent countries according to the quartiles (2002-03)

Quartile	*Mean per capita GDP (02-03)*	*n° of countries*	*n° dependent countries*
1	6.111	25	15
2	13.686	47	25
3	36.376	72	36
4	104.030	110	39

Source: own calculations

Table 8 - Analysis of import dependent countries according to the quartiles (2018-19)

Quartile	*Mean per capita GDP (18-19)*	*n° of countries*	*n° dependent countries*
1	20.425	28	22
2	43.228	55	39
3	82.842	82	50
4	231.568	110	61

Source: own calculations

Between the first and the last biennium, all quartiles observed an increase in the percentage of countries dependent on resource imports, however, countries belonging to the third quartile observed a smaller increase than the other three (Table 9).

Table 9 - The evolution of import dependent countries

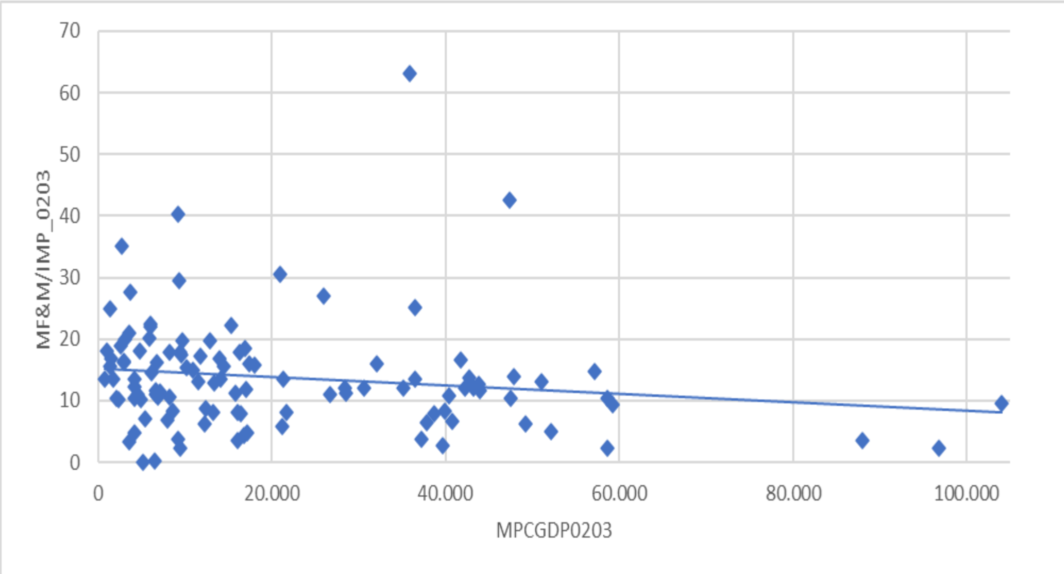
Quartile	*import dependent countries (2002-03)*	*import dependent countries (2018-19)*	*increase in import dependent countries*
1	60%	79%	19%
2	53%	71%	18%
3	50%	61%	11%
4	35%	55%	20%

Source: own calculations

Looking at Figure 34 and 35, it can be seen that in both two-year periods there is a negative relationship between the import of fuels and mining products and the

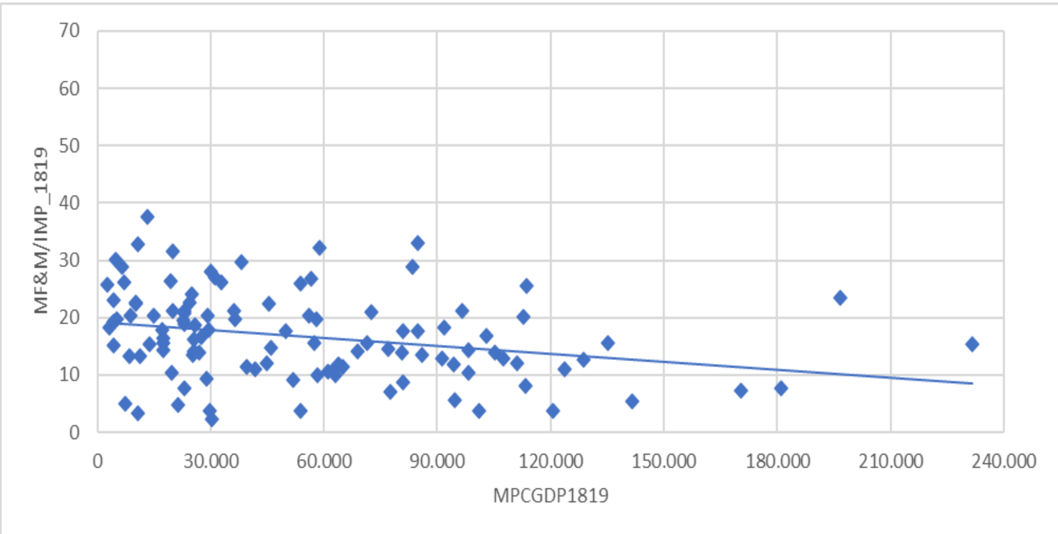
GDP per capita. Although in both cases the interpolation line has negative angular coefficient, in the last two-year period the slope is slightly higher.

Figure 34 - Mean Fuel and Mining product import (% of total import) and mean per capita GDP (2002-03)



Source: own calculations

Figure 35 - Mean Fuel and Mining product import (% of total import) and mean per capita GDP (2018-19)



Source: own calculations

3.7 INTRODUCTION TO THE QUANTITATIVE STUDY

This section will propose several econometric models designed to study import and export resource dependence in more detail. With these quantitative studies, an attempt will be made to understand whether import/export dependences can influence economic growth. To do this, cues were taken from the most famous existing economic literature in this area but making some modifications.

A total of 110 countries were considered, i.e., all countries for which sufficient data could be obtained, thus excluding those less "transparent" in this area. The time sample consists of 18 years, studying the period 2002-2019, thus leading to an estimated total number of observations of 1750 observations.

The variables that will be taken into consideration have already been partially listed in the preceding paragraph; the Table 10 shows all the variables used with their respective descriptions.

As explained in the preceding paragraphs, a cross-sectional study with thus a single time unit considered for each country does not seem to be the optimal choice for such studies. This constraint requires the use of averages in order to analyze time periods that exceed a single year. This obviously results in a loss of a large amount of information for the study (moving to a number of observations of 220). Studies of resource dependence (concerning the export case) have often proposed "simplified" models based on cross-sectional specifications, but I consider these specifications to be not very comprehensive. As matter of fact, using a cross-sectional model, the results could be misleading in that not only is the dynamics of the phenomena lost (there being only one time variable summarizing 18 of them) but there is also a risk of confusing the effect of dependence with that of convergence in growth. In fact with cross-sectional specification, although widely used in the study of resource curse (see Sachs and Warner) the loss of information does not allow the distinction of effects in the results.

However, the phenomena of resource import and export dependence were analyzed with 2 different cross-sectional studies for information purposes Appendix 4 . Average annual growth of GDP per capita (meanGRPCGDP0219) was chosen as the Dependent Variable, and meanF/EXP0219, meanM/EXP0219, meanF/IMP0219, meanM/IMP0219 and PCGDP02 as explanatory variables. Unfortunately, the low reliability of these models does not allow a 'comprehensive analysis of the two phenomena. The growth convergence theory seems to be respected whereby countries with lower GDP levels enjoy better economic growth rates, but the results for the study of dependence phenomena are not satisfactory.

Table 10 - Variable description

Variable Name	*Description*
PCGDP02	2002 per capita GDP (2017 international $)
meanPCGDP0219	Arithmetic mean per capita GDP in the period 2002-2019
meanGRPCGDP0219	Average annual per capita GDP growth in the period 2002-2019
meanF/EXP0219	Arithmetic mean Fuel Export/Total Export in the period 2002-2019
meanM/EXP0219	Arithmetic mean Mineral Export/Total Export in the period 2002-2019
meanF/IMP0219	Arithmetic mean Fuel Import/Total Import in the period 2002-2019
meanM/IMP0219	Arithmetic mean Mineral Import/Total Import in the period 2002-2019
Conv	Convergence process control variable
infl	Log Annual inflation rate, GDP deflator (annual %), one year lagged
fexp	Log Annual Fuel Export/Total Export (%), one year lagged
mexp	Log Annual Mineral Export/Total Export (%), one year lagged
fimp	Log Annual Fuel Import/Total Import (%), one year lagged
mimp	Log Annual Mineral Import/Total Import (%), one year lagged
ecGrowth	Log Difference Annual per capita GDP

3.8 PANEL DATA ANALYSIS: EXPORT

For a more in-depth study, the phenomenon will be analyzed with a panel, static and dynamic specification. By implementing a panel model, the number of observations increases considerably and the loss of information is drastically reduced compared to a cross-sectional specification. In this way, constant annual growth is not even assumed but actual annual growth rates are considered thus adequately capturing the effects of expansion and contraction in the resource sector.

3.8.1 Static Panel Model for Export dependence case

In this case, using a panel specification makes it possible to account for possible convergence in growth with greater attention and focus. Because the panel study is based on multiple T's it is in fact possible to construct a control variable for growth convergence to best "capture" all the effects of this phenomenon; thus avoiding them affecting the study of resource dependence. A (static) fixed-effects model was chosen because all the variables taken into account show some variability over time and there are no static ones.

The dependent variable is the annual growth rate of per capita GDP in percentage terms (ecGrowth). Some of the explanatory variables are lagged by one year because effects in the dependent variable originating from changes in the explanatory variables may be subject to some persistence over time. A change, for example, in the Fuel Export over Total export ratio would therefore, according to this hypothesis, have an influence mainly in the economic growth of the following years.

As explanatory variables have been used: the ratio Fuel Export over Total Export lagged by one year(fexp), the Mining Export over Total Export lagged by one year (mexp), the annual inflation rate (%GDP) lagged by one year(infl), and a control variable for convergence in growth(conv).

This last explanatory variable deserves further explanation. According to economic theory, developing countries go through the so-called growth convergence process. In general, economic convergence between countries occurs when GDP per capita levels tend over time to a common level that represents the equilibrium of the growth process. During this process, developing countries usually enjoy much higher annual growth rates than already developed countries. This control variable is adopted precisely in order to purge the model of this phenomenon. This variable was thus constructed starting from the division of the 2002-2019 time sample into 4 sub time samples(2 of 5 years lenght and 2 of 4 years lenght):

sub-time sample	*period*	*assigned p.c. GDP value*
1	2002-2006	2002
2	2007-2011	2007
3	2012-2015	2012
4	2016-2019	2016

To each sub-time sample is assigned the per capita GDP value of the beginning of the interval (2002-2006 was assigned the per capita GDP value of 2002 for all 5 years, 2007-2011 was assigned the per capita GDP value of 2007...).

In this way, countries that initially demonstrate levels of per capita GDP should demonstrate higher growth in the long run. A coefficient of negative sign in the regression is then expected, since as this parameter increases, growth decreases.

The model is therefore composed as follows:

$$ecGrowth = \propto +\beta fexp_{i,t} + \gamma mexp_{i,t} + \varphi infl_{i,t} + \omega conv_{i,t} + \varepsilon_{i,t}$$

Where: i= country, t= year

The results of the static panel specification are shown in the Figure 36. The results do not seem to portend the existence of a resource curse. Although the coefficient is negative, the fuel export variable does not appear to be significant. Mining export also demonstrates a negative coefficient, and appears to be moderately significant (pvalue=0.0822). In contrast, the highly significant variables (***) are infl and conv, with negative coefficients. According to this first model, therefore, countries with higher inflation rates demonstrate worse economic performance as well as those with higher initial GDP per capita levels (thus confirming the growing covergence theory). The control variable seems also to be the most influencing due to the coefficient value of ≈ 0.066.

The effect of Fuels and Mineral exports on long-run growth is still not entirely clear. Even thought both coefficients have negative sign, they seems to be highly significant for what concerns economic growth.

The model seems to have been specified correctly, the null hypothesis of the joint thesis on named regressor (F-test) is rejected thus demonstrating sufficient variability of the measures considered. There is first order autocorrelation, the time observations then are not completely independent with previous observations, this probably due persistence of some phenomena studied.

Figure 36 - Static Panel Model for Export Dependence

Model 1: Fixed-effects, using 1670 observations
Included 110 cross-sectional units
Time-series length: minimum 2, maximum 17
Dependent variable: ecGrowth
Robust (HAC) standard errors

	Coefficient	*Std. Error*	*t-ratio*	*p-value*	
const	0.665868	0.0686716	9.696	<0.0001	***
infl	−0.00373140	0.00121284	−3.077	0.0026	***
fexp	−0.00152308	0.00116609	−1.306	0.1943	
mexp	−0.00390693	0.00222726	−1.754	0.0822	*
conv	−0.0656386	0.00713742	−9.196	<0.0001	***

Sum squared resid	1.638634	S.E. of regression	0.032452

Joint test on named regressors -
Test statistic: F(4, 109) = 24.8595
with p-value = P(F(4, 109) > 24.8595) = 1.22143e-014

Wooldridge test for autocorrelation in panel data -
Null hypothesis: No first-order autocorrelation (rho = -0.5)
Test statistic: F(1, 107) = 19.7272
with p-value = P(F(1, 107) > 19.7272) = 2.18363e-005

3.8.2 Dynamic Panel Model for Export dependence case

An even more complex model is now proposed in order to study the phenomenon even more deeply through a dynamic panel specification.

Interest in dynamic models for panel data has grown greatly, especially in relatively recent times, as the time dimension for which data were available has expanded. Even when the coefficient of the lagged dependent variable is not of direct interest, allowing a dynamic specification of the process being analysed can be critical to obtaining consistent estimates of the other parameters. Indeed, the possible omission of this explanatory variable, when it is significant, may result in biased estimates of the other parameters.

Using a dynamic panel specification, the persistence of certain variables can be taken into account in depth. By persistence we mean the natural tendency of many phenomena to evolve more or less smoothly over time, so that the one observed at a given instant t turns out to be more similar to the one observed at instant t-1, rather than to the one observed at distant epochs.

In fact, highly persistent variables, such as GDP per capita, are often included in growth models. By including the lagged dependent variable, we therefore attempt to isolate dependency-related effects as much as possible, capturing the persistent effects of the model in the lagged dependent variable.

With the introduction of the lagged dependent variable among the independent variables the model becomes:

$$ecGrowth = \propto + \tau ecGrowth_{i,t-1} + \beta fexp_{i,t} + \gamma mexp_{i,t} + \varphi infl_{i,t} + \omega conv_{i,t} + \varepsilon_{i,t}$$

Where: i= country, t= year

The generalized method of moments (GMM) will be used to estimate this model because it provides a suitable framework for obtaining efficient estimators in this context. A fixed-effects model in this case is not recommended. As a matter of fact, unless T→∞ the fixed-effects model would suffer from a number of biases that could compromise efficient estimation.

The results of the analysis are shown in Figure 37.

Figure 37 - Dynamic Panel Model for Export Dependence

```
Model 1: 1-step dynamic panel, using 1462 observations
Included 110 cross-sectional units
Time-series length: minimum 1, maximum 15
H-matrix as per Ox/DPD
Dependent variable: ecGrowth

                 coefficient    std. error      z      p-value
  -----------------------------------------------------------
  ecGrowth(-1)    0.228679      0.0645052      3.545   0.0004  ***
  fexp           -0.0110942     0.00338578    -3.277   0.0011  ***
  mexp           -0.0127237     0.00444623    -2.862   0.0042  ***
  infl           -0.00580148    0.00170519    -3.402   0.0007  ***
  conv           -0.0383655     0.0132560     -2.894   0.0038  ***
  const          -0.000621231   0.000396820   -1.566   0.1175

Sum squared resid    2.375610   S.E. of regression   0.040393
```

As can be seen from the results, these seem to confirm the Resource Curse hypothesis. In fact, in this case, the resource dependence variables appear to be both significant and with a negative sign. This suggests that countries, where the export of these two commodities weighed particularly heavily on total exports over the period 2002-2019, enjoyed worse economic performance than those who are not resource dependent. The economic mechanisms of this phenomenon have already been discussed in Chapter 2 during the review of the economic literature regarding the resource curse theory.

The inflation and convergence variables are also significant. The negative sign of the conv variable supports the growth convergence theory, so developing countries have empirically grown, in relative terms, more than more developed countries. This concept lays its foundation on the assumption of diminishing marginal returns to capital, according to which capital is more productive where it is scarcer, and on the free movement of factors of production and goods, which allows the convergence process to accelerate through the equality of the prices of goods and factors of production themselves. A condition that in the long run is complemented by the action of technological progress, which is in fact an exogenous fact of the model.

The negative sign of the inflation variable, on the other hand, is further evidence that poor governance of inflation levels can undermine a country's long-run growth.

The Sargan over-identification test is rejected, meaning that the instruments, as a group, are not completely exogenous. Even using the 2-step specification, the Sargan test is rejected even though the p-value has increased (Appendix 5).

Finally, is thus evident how as the model taken into consideration changes, the results change significantly. In fact, using a static panel, over the period 2002-2019 the resource curse hypothesis seems to be rejected; on the contrary, using a dynamic model, considered to be more reliable, a negative relation between resource dependence and economic growth is recognized.

3.8 PANEL DATA ANALYSIS: IMPORT

In this section, the previous analysis will be repeated but by considering the import dependence case. This phenomenon has become prominent in the present political-economic debate for two main reasons: recent shocks in the supply chain and the ecological transition.

It is a well-known fact that the international economy is going through an energy crisis as a result of the Russian-Ukrainian war that has greatly undermined the global gas supply chain. There have also been other shocks in recent years that have made the supply of certain fuels and minerals more difficult. These shocks of course create uncertainty regarding the cost of importing these kinds of resources. Second, the dependence that many countries demonstrate regarding mineral imports is calling into question the feasibility of a rapid ecological transition (necessary to limit climate change). Moreover, while it is true that we are entering in a new era of scarcity, given the high concentration of such resources, many are questioning whether this mineral import dependence will constrain long-term growth.

3.9.1 Static Panel Model for Import dependence case

Again, a static panel model will be initially proposed and then a dynamic one will be presented and possible differences discussed.

The model is defined as follows:

$$ecGrowth = \propto + \beta fimp_{i,t} + \gamma mimp_{i,t} + \varphi infl_{i,t} + \omega conv_{i,t} + \varepsilon_{i,t}$$

Where: i= country, t= year

The resource dependence variables, as with the previous static panel, do not appear to be significant (Figure 38). Therefore, it is not yet possible to say whether resource import-dependent countries have, on average, demonstrated lower or better economic performance. As in the previous model, the convergence and inflation variables are significant with negative sign. The null hypothesis of the F-test is rejected demonstrating sufficient heterogeneity in the observations.

Figure 38 - Static Panel Model for Import dependence

Model 2: Fixed-effects, using 1686 observations
Included 110 cross-sectional units
Time-series length: minimum 3, maximum 17
Dependent variable: ecGrowth
Robust (HAC) standard errors

	Coefficient	*Std. Error*	*t-ratio*	*p-value*	
const	0.637544	0.0699308	9.117	<0.0001	***
infl	−0.00392040	0.00117386	−3.340	0.0011	***
conv	−0.0627607	0.00697506	−8.998	<0.0001	***
fimp	−0.00166371	0.00374764	−0.4439	0.6580	
mimp	−0.00262736	0.00327853	−0.8014	0.4247	

Sum squared resid	1.612059	S.E. of regression	0.032023

Joint test on named regressors -
Test statistic: F(4, 109) = 20.5877
with p-value = P(F(4, 109) > 20.5877) = 1.1705e-012

Wooldridge test for autocorrelation in panel data -
Null hypothesis: No first-order autocorrelation (rho = -0.5)
Test statistic: F(1, 108) = 22.0842
with p-value = P(F(1, 108) > 22.0842) = 7.73562e-006

3.9.2 Dinamic Panel Model for Import dependence case

As in the case of export resource dependence, an analysis of import resource dependence based on a dynamic model is proposed. The lagged dependent variable (ecGrowth(-1)) will then be included among the independents in order to cleanse the analysis of business cycle-related effects. The econometric model yielded interesting results listed in Figure 39.

Figure 39 - Dynamic Panel Model for Import Dependence

Model 3: 1-step dynamic panel, using 1476 observations
Included 110 cross-sectional units
Time-series length: minimum 1, maximum 15
H-matrix as per Ox/DPD
Dependent variable: ecGrowth

	coefficient	std. error	z	p-value	
ecGrowth(-1)	0.300580	0.0576580	5.213	1.86e-07	***
fimp	0.000728590	0.00499939	0.1457	0.8841	
mimp	-0.0625248	0.0141048	-4.433	9.30e-06	***
infl	-0.00573763	0.00175963	-3.261	0.0011	***
conv	-0.0213063	0.0143674	-1.483	0.1381	
const	-0.000685039	0.000450521	-1.521	0.1284	

Sum squared resid 2.753782 S.E. of regression 0.043282

In this case the convergence control variable is no longer significant, while the inflation control variable retains its significance. The two resource dependence (import) variables do not seem to behave in the same way. As a matter of fact, a high Fuel import/Total import ratio does not seem to have significant effects on economic growth. In contrast, mineral import seems to carry with it more pronounced eff on a country's economic development.

It appears from the results that countries with Mineral import/Total import ratios seem to enjoy worse economic performance. One reason for this heterogeneity in the results could be explained by the fact that there are countries, developed, that are partly self-sufficient in fuels and energy (see United States). In contrast, there are still no countries that are self-sufficient in minerals, thus finding themselves entirely dependent on import activities. In addition, as already seen in Chapter 1, not only the demand for these minerals is growing rapidly, but the supply is totally insufficient nowadays. This therefore increases dramatically increase the costs associated with the import of such resources, hitting hard some sectors where certain minerals are crucial. As a matter of fact, comparing the coefficient of mimp with the one of the precedent analysis, mexp, it seems that the import dependence of minerals hits harder the economic growth than the export dependence. (mimp's coefficient ≈ -0.063 vs mexp's coefficient ≈ -0.013)

This possible inverse relationship between Mineral import and GDP per capita creates further questions. While it is true that we are about to embark on an era of scarcity given the imbalance between supply and demand for minerals, what impact might this have on the growth of more developed countries where these materials are fundamental to production processes?

The scarcity problem could be solved at the source by making the extraction process more efficient. But two additional problems arise from there. While making the extraction process faster would have to take into account the environmental footprint that such extraction would entail, which while in the long run less impactful than that of fossil fuels, would be better contained as already discussed. Moreover, one of the biggest problems is that such mineral reserves are deeply concentrated in very few countries and the process for discovering new mines is an expensive and time-consuming process.

CONCLUSIONS

It is now clear that the world production process will have to face a rapid energy transition in the coming years in order to contain its emissions, thus its footprint on the environment. Several treaties have been signed with the aim of encouraging this energy transition, setting ambitious goals and targets. While there is commitment from the subscribing countries, there are several issues to be considered. Among the most important is certainly the difficult availability of raw materials useful to produce the hardwares needed for sustainable energy production.

As we have seen, the results regarding import dependence seem to support the (naive) idea that countries forced to import natural resources attend worse economic performance. Although many import-dependent Western countries have actually enjoyed excellent level of per capita GDP (as seen in paragraph 2.5), the results of the quantitative analysis seem to show that countries importing minerals and fuels may be constrained in their economic development.. As a matter of fact, importing such commodities seems to have an inverse relationship with economic growth, given the steadily rising prices that minerals have shown over the past two decades due to imbalances in supply and demand.

Given the central importance of these resources in the present and future world production process, efficient extraction processes and diversification of supply risk for import-dependent countries are therefore essential to guard against shocks, which have become increasingly common in recent years.

Similarly, the export of fuel and minerals, also seems to negatively impact the economic development of some countrie The low economic growth rates demonstrated by rich countries in such resources is a symptom of faltering economic stability. Indeed, as has been explained, very often this dependence turns into economic instability related to the volatility of the price of such commodities, the concentration of access to such resources in the hands of a few, and declining terms of trade, as moreover argued by many scholars in recent years.

In conclusion, although the results emphasize this inverse relationship between resource dependence (both in imports and exports) and economic performance, there are contradictions in the results. This inconsistency is symptomatic of the fact that these studies ,and thus the results, are strongly influenced by several factors such as: the model used, the variables considered, and the time frame in which they are discussed. Indeed, as has been proven by this work and the relevant economic literature, the analysis of resource dependence can have multiple results depending on the factors and analysis methodologies in use.

BIBLIOGRAPHY

Alexeev, M., & Conrad, R. (2009). The elusive curse of oil. The review of Economics and Statistics, 91(3), 586-598.

Arezki, R., & Brückner, M. (2011). Oil rents, corruption, and state stability: Evidence from panel data regressions. European Economic Review, 55(7), 955-963.

Badeeb, Ramez & Lean, Hooi Hooi & Clark, Jeremy. (2016). The Evolution of the Natural Resource Curse Thesis: A Critical Literature Survey.

Blanco, L., & Grier, R. (2012). Natural resource dependence and the accumulation of physical and human capital in Latin America. Resources Policy, 37(3), 281-295.

Boschini, A., Pettersson, J., & Roine, J. (2013). The resource curse and its potential reversal. World Development, 43, 19-41.

Boos, A., & Holm-Müller, K. (2013). The relationship between the resource curse and genuine savings: Empirical evidence. Journal of sustainable development, 6(6), 59.

Boyce, J. R., & Emery, J. H. (2011). Is a negative correlation between resource abundance and growth sufficient evidence that there is a "resource curse"?. Resources Policy, 36(1), 1-13.

Brunnschweiler, C. N., & Bulte, E. H. (2008). The resource curse revisited and revised: A tale of paradoxes and red herrings. Journal of environmental economics and management, 55(3), 248-264.

Cavalcanti, T. V. D. V., Mohaddes, K., & Raissi, M. (2011). Growth, development and natural resources: New evidence using a heterogeneous panel analysis. The Quarterly Review of Economics and Finance, 51(4), 305-318.

Collier, P., & Hoeffler, A. (2009). Testing the neocon agenda: Democracy in resource-rich societies. European Economic Review, 53(3), 293-308.

Corden, W. M., & Neary, J. P. (1982). Booming sector and de-industrialisation in a small open economy. The economic journal, 92(368), 825-848.

Corden, W. M. (1984). Booming sector and Dutch disease economics: survey and consolidation. oxford economic Papers, 36(3), 359-380.

Davis, G. A., & Tilton, J. E. (2005). The resource curse. In Natural resources forum (Vol. 29, No. 3, pp. 233-242). Oxford, UK: Blackwell Publishing, Ltd.

Deacon, R. T., & Rode, A. (2015). Rent seeking and the resource curse. In Companion to the political economy of rent seeking. Edward Elgar Publishing.

Dietz, S., Neumayer, E., & De Soysa, I. (2007). Corruption, the resource curse and genuine saving. Environment and Development Economics, 12(1), 33-53.

Frankel, J. A. (2010). The natural resource curse: a survey (No. w15836). National Bureau of Economic Research.

Garcia, P., Knights, P. F., & Tilton, J. E. (2001). Labor productivity and comparative advantage in mining: the copper industry in Chile. Resources Policy, 27(2), 97-105.

Gelb, A. H. (1988). Oil windfalls: Blessing or curse?. Oxford university press.

Gylfason, T. (2001). Natural resources, education, and economic development. European economic review, 45(4-6), 847-859.

Gylfason, T., & Zoega, G. (2006). Natural resources and economic growth: The role of investment. World Economy, 29(8), 1091-1115.

Hodler, R. (2006). The curse of natural resources in fractionalized countries. European Economic Review, 50(6), 1367-1386.

Humphreys, M., Sachs, J. D., Stiglitz, J. E., Humphreys, M., & Soros, G. (2007). Escaping the resource curse. Columbia university press.

Iimi, A. (2007). Escaping from the Resource Curse: Evidence from Botswana and the Rest of the World. IMF Staff Papers, 54(4), 663-699.

James, A. (2015). US state fiscal policy and natural resources. American Economic Journal: Economic Policy, 7(3), 238-57.

James, A. (2015). The resource curse: A statistical mirage?. Journal of Development Economics, 114, 55-63.

Karl, T. L. (2007). Oil-led development: social, political, and economic consequences. Encyclopedia of energy, 4(8), 661-672.

Lam, R., & Wantchekon, L. (2003). Political dutch disease. Manuscript. New York: Department of Politics, New York University.

Lederman, D., & Maloney, W. F. (Eds.). (2006). Natural resources, neither curse nor destiny. World Bank Publications.

Maloney, W.F. (2001) 'Innovation and growth in resource rich countries'. Central Bank of Chile Working Paper 148. Santiago de Chile: Central Bank of Chile.

Manzano, O. and Rigobon, R. (2003). "Resource Curse or Debt Overhang?" National Bureau of Economic Research Working Paper Series (No. 8390).

Mehlum, H., Moene, K., & Torvik, R. (2006). Institutions and the resource curse. The economic journal, 116(508), 1-20.

Neumayer, E. (2004). Does the "resource curse" hold for growth in genuine income as well?. World development, 32(10), 1627-1640.

Prebisch, R. (1962). The economic development of Latin America and its principal problems. Economic Bulletin for Latin America.

Rambaldi, Alicia & Hall, Greg & Brown, Richard. (2006). Re-testing the Resource Curse Hypothesis Using Panel Data and an Improved Measure of Resource Intensity.

Ross, M. L. (2001). Does oil hinder democracy?. World politics, 53(3), 325-361.

Ross, M. L. (2007). How mineral-rich states can reduce inequality. Escaping the resource curse, 23775, 237-55.

Rostow, W. W. (1959). The stages of economic growth. The economic history review, 12(1), 1-16.

Sachs, J. and Warner, M. (1995). "Natural Resource Abundance and Economic Growth." NBER Working Paper Series (5398).

Sachs, J. D., & Warner, A. M. (2001). The curse of natural resources. *European economic review*, *45*(4-6), 827-838.

Sachs, J. D. (2007). How to handle the macroeconomics of oil wealth. Escaping the resource curse, 180.

Sala-i-Martin, X., & Subramanian, A. (2008). Addressing the natural resource curse: An illustration from Nigeria. In Economic policy options for a prosperous Nigeria (pp. 61-92). Palgrave Macmillan, London.

Singer, H. W. (2012). The distribution of gains between investing and borrowing countries. In Milestones and Turning Points in Development Thinking (pp. 265-277). Palgrave Macmillan, London.

Stevens, P., & Dietsche, E. (2008). Resource curse: An analysis of causes, experiences and possible ways forward. Energy Policy, 36(1), 56-65.

Stijns, J. P. C. (2005). Natural resource abundance and economic growth revisited. Resources policy, 30(2), 107-130.

Stijns, J. P. (2006). Natural resource abundance and human capital accumulation. World development, 34(6), 1060-1083.

Van der Ploeg, F., & Poelhekke, S. (2009). Volatility and the natural resource curse. Oxford economic papers, 61(4), 727-760.

Van der Ploeg, F. (2011). Natural resources: curse or blessing?. Journal of Economic literature, 49(2), 366-420.

SITES

https://www.nrcan.gc.ca/our-natural-resources/minerals-mining/minerals-metals-facts/copper-facts/20506

https://www.world-mining-data.info/?World_Mining_Data___Data_Section

https://www.iea.org/reports/the-role-of-critical-minerals-in-clean-energy-transitions/mineral-requirements-for-clean-energy-transitions#abstract

https://www.statista.com/statistics/264930/global-cobalt-reserves/

https://pubs.usgs.gov/periodicals/mcs2021/mcs2021-lithium.pdf

https://www.ifpenergiesnouvelles.com/article/lithium-energy-transition-more-resource-issue

https://www.nrcan.gc.ca/our-natural-resources/minerals-mining/minerals-metals-facts/nickel-facts/20519

https://www.nrcan.gc.ca/our-natural-resources/minerals-mining/minerals-metals-facts/rare-earth-elements-facts/20522

https://www.eia.gov/energyexplained/oil-and-petroleum-products/use-of-oil.php#:~:text=We%20use%20petroleum%20products%20to,intermediate%20and%20end%2Duser%20goods

https://www.eia.gov/energyexplained/oil-and-petroleum-products/oil-and-the-environment.php

https://wwf.panda.org/discover/knowledge_hub/teacher_resources/webfieldtrips/climate_change/petroleum/

https://asb.opec.org/data/ASB_Data.php

https://www.eia.gov/tools/faqs/faq.php?id=709&t=6

http://energyatlas.iea.org

https://en.wikipedia.org/wiki/Natural_gas

https://www.eia.gov/energyexplained/natural-gas/natural-gas-and-the-environment.php#:~:text=Natural%20gas%20is%20a%20relatively,an%20equal%20amount%20of%20energy

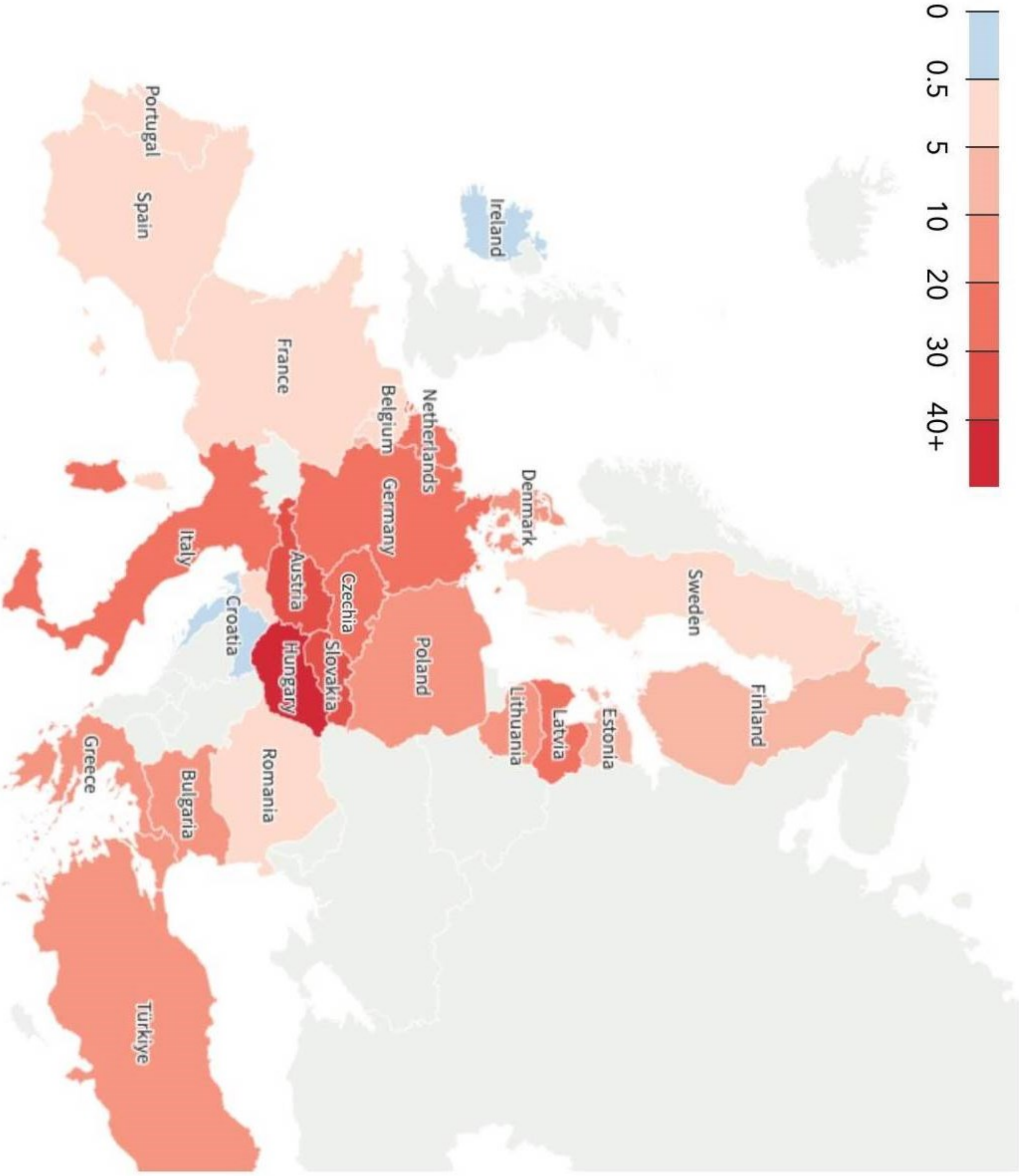
https://databank.worldbank.org/source/world-development-indicators#

https://asb.opec.org/data/ASB_Data.php

https://www.iea.org/reports/gas-market-report-q3-2021
https://blogs.imf.org/2022/07/19/how-a-russian-natural-gas-cutoff-could-weigh-on-europes-economies/
https://ec.europa.eu/eurostat/web/products-eurostat-news/-/ddn-20220419-1#:~:text=In%202021%2C%20the%20EU's,were%20imported%20in%20previous%20years.
https://wits.worldbank.org/Default.aspx?lang=en
https://stats.wto.org/

APPENDIX

Appendix 1 – Russian gas dependence as a share of total energy consumption



Source: blogs.imf.org

Appendix 2 – Summary of recent literature on natural resource and different economic variables

Authors	Periods	Sample	Variable	Natural Resource Measure	Main Findings
Gylfason (2001)	1980–1997	65 resource- rich countries	Human capital development	Share of natural capital in national wealth	The adverse effects of natural resource abundance on economic growth may in part reflect a negative effect on education.
Atkinson and Hamilton (2003)	1980–1995	103 countries	Genuine savings	Share of natural resource rent in GDP	The countries where growth has lagged have a combination of natural resource, macro-economic and public expenditure policies have led to a low rate of genuine savings (net savings adjusted for resource depletion).
Gylfason and Zoega (2006)	1965–1998	85 countries	Savings and investment	Share of natural capital in national wealth	A heavy dependence on natural resources may hurt saving and investment indirectly by slowing development of the financial system.
Stijns (2006)	1970–1999	102 countries	Human capital	Natural resource rent per capita	Resource wealth and its corresponding rents make a significantly *positive* difference in allowing countries to invest in human capital.
Dietz et al. (2007)	1970–2001	115 countries	Genuine savings	Share of fuel and mineral products in total exports	Negative effect of natural resource dependence on genuine savings.
Papyrakis and Gerlagh (2007)	1986–2001	United States	Investment, human capital and openness	The share of the primary sector's production in GDP	Natural resource dependence decreases investment, schooling, and openness.
Bornhorst et al. (2008)	1992–2005	30hydro-carbon producing countries	Fiscal policy	Share of hydrocarbon revenue in GDP	There is a statistically significant negative relationship between non-hydrocarbon revenues and hydrocarbon revenues.
Bond and Malik (2009)	1970–1998	78 developing countries	Export structure and investment	The share of natural capital intotal wealth	Finds important differences between fossil fuels and non-fuel resources. Significant fuel exports tend to increase private (and public) investment, but there is also a robust negative effect from export concentration.
Daniele (2011)	1980–2004	Countries grouped by income Level	Human development	Share of ores and fuel in total merchandise Exports; Subsoil assets per capita	Results show that human development measures are negatively correlated with natural resource dependence, but positively correlated with resource abundance.
Blanco and Grier (2012)	1975–2004	17 Latin American countries	Investment and human capital	Total exports of primary commodities divided by GDP	Overall, resource dependence has no significant direct effect on physical and human capital. When disaggregating, petroleum export dependence has a significant positive effect on physical capital, but negative effect on human capital.
Boos and Holm-Müller (2013)	1970–1990	87 developing countries	Genuine savings	Share of natural resource rents in GDP	The determinants that are responsible for the resource curse also have a negative effect on genuine savings.
Apergis et al. (2014)	1970–2011	MENA countries	Agriculture value added	Share of oil rent in GDP	Finds a negative relationship between oil rents and long run agriculture value added.
Bhattacharyya and Hodler (2014)	1970–2005	133 countries	Financial development	Share of natural resource rents in GDP	Resource rents hinder financial development only if institution quality is relatively poor.
Apergis et al. (2014)	1970–2011	MENA countries	Agriculture value added	Share of oil rent in GDP	Finds a negative relationship between oil rents and agriculture value added.
Bhattacharyya and Collier (2014)	1970–2005	45 developed & developing countries	Public capital	Share of natural resource rents in GDP	Resource rents significantly reduce the public capital stock, but this effect is mitigated by good institutions.
Farhadi et al. (2015)	1970–2010	99 countries	Productivity growth	Share of natural resource rents in GDP	Negative effects of resource rents on productivity growth may turn positive in countries with greater economic freedom.
Cockx and Francken (2016)	1995–2009	140 countries	Education Spending	The share of natural capital in total national wealth	There is an adverse effect of resource dependence on public education expenditures relative to GDP.

Source: Ramez, Lean and Clark (2016)

Appendix 3 – Summary of literature of natural resource curse critics

Author	Sample	Period	Natural resource measure	Findings
Lederman and Maloney (2007)	cross-section and panel	1980–1999	Primary exports divided by total merchandise exports + Primary exports divided by GDP	There is no evidence of a negative impact of this variable on growth neither in cross-section nor in the panel systems estimator.
Brunnschweiler and Bulte (2008)	60 countries from five regions: Europe, North America, Central and South America, Africa and the Middle East, Asia and Oceania	1970–1989	The GDP shares of total natural resource andmineral resource exports+ the logs of total natural capital and mineral resource assets per capita	Resource dependence does not affect growth and resource abundance positively affects growth and institutional quality.
Alexeev and Conrad (2009)	OPEC members and the major non-OPEC oil producers of more than 2 million barrels of oil per day.		hydrocarbon deposits per capita+ Oil/GDP ratio	The effect of a large endowment of oil and other mineral resources on long-term economic growth of countries has been on balance positive.
Cavalcanti et al. (2011)	53 oil exporting and importing countries	1980–2006	Real value of oil production per capita	Oil abundance has a positive effect on both income levels and economic growth.
Boyce and Emery (2011)	Panel data for U.S. states	1970–2001	Real natural resource price, natural resource sector employment.	The resources curse can only be determined by an investigation of the correlation between resource abundance and income levels, and they found that this relationship is positive.
James (2015b)	111 resource producing countries	Different growth periods from 1970 to 2010	Natural resource goods as share of income	In all growth periods, the relationship between resource dependence and economic growth in resource production sectors is non negative.

Source: Ramez, Lean and Clark (2016)

Appendix 4 – Cross-sectional estimations

Dependent variable: l_meanGRPCGDP0219
Heteroskedasticity-robust standard errors, variant HC1

	Coefficient	*Std. Error*	*t-ratio*	*p-value*	
const	−0.515835	0.754934	−0.6833	0.4961	
l_meanFEXP0219	−0.0870793	0.0603288	−1.443	0.1522	
l_meanMEXP0219	−0.0654677	0.0554883	−1.180	0.2410	
l_PCGDP02	−0.338522	0.0741318	−4.566	<0.0001	***

Sum squared resid	51.51978		S.E. of regression	0.732574

Dependent variable: l_meanGRPCGDP0219
Heteroskedasticity-robust standard errors, variant HC1

	Coefficient	*Std. Error*	*t-ratio*	*p-value*	
const	−1.09730	0.808020	−1.358	0.1776	
l_PCGDP02	−0.327397	0.0743362	−4.404	<0.0001	***
l_meanFIMP0219	0.0525632	0.175294	0.2999	0.7649	
l_meanMIMP0219	0.112935	0.120100	0.9403	0.3494	

Sum squared resid	52.63648		S.E. of regression	0.740471

Appendix 5 – Two Step GMM for Export dependence case

```
Model 2: 2-step dynamic panel, using 1462 observations
Included 110 cross-sectional units
Time-series length: minimum 1, maximum 15
H-matrix as per Ox/DPD
Dependent variable: ecGrowth

                 coefficient    std. error      z      p-value
  ------------------------------------------------------------
  ecGrowth(-1)     0.234346      0.0657893      3.562   0.0004  ***
  fexp            -0.0100895     0.00386320    -2.612   0.0090  ***
  mexp            -0.0120331     0.00503355    -2.391   0.0168  **
  infl            -0.00577939    0.00169667    -3.406   0.0007  ***
  conv            -0.0337932     0.0146643     -2.304   0.0212  **
  const           -0.000665763   0.000449220   -1.482   0.1383

Sum squared resid    2.372844   S.E. of regression   0.040370
```