FONDAZIONE ARISTIDE MERLONI

ECONOMIA MARCHE **Journal of Applied Economics**

Vol. XLIII, No.1, Aprile 2024

Natural Resources and Economic Development: A Critical Perspective

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Abstract

This paper investigates "lights" and "shadows" of a specialisation in natural resources in (developing) resource abundant countries. It has been argued that the most negative consequence of such a specialisation is that it may hinder economic development (resource curse). However, the economic consequences of specialising in natural resources vary significantly across countries. Furthermore, we emphasise that natural resource specialisation tends to favour, and is hence associated with, the emergence of structural weaknesses that may lead a country to the extreme and variegated case of resource curse.

We suggest that the removal of two major and intertwined structural weaknesses associated with specialisation in natural resources production, i.e. the lack of innovation in the natural resources sector and the lack of diversification of productive activities – by developing new specialisations - in developing resource-abundant countries may be a successful strategy to reduce curse risks, and to pursue natural resource-based development.

JEL Classification: 013; O31; F23; F63; L72

Keywords: *Resource curse; Natural resource-based development; Innovation; Specialisation patterns; Diversification*

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Acknowledgements

This paper represents a revised and enriched version of one of my PhD thesis papers developed during my PhD in Global Studies at the University of Urbino (Italy), under the supervision of Professor Antonello Zanfei (University of Urbino, Urbino, Italy) and Professor Neil Foster-McGregor (UNU-MERIT, Maastricht, The Netherlands).
I am indebted to two anonymous referees for their valuable comments. I thank the participants at the PhD Seminar Sessions organised by the University of Urbino (Urbino, Italy, May 28-29th 2019) for their insightful comments on a previous draft of the paper. This paper also benefitted from discussion with Beatriz Calzada Olvera, Andrea Coveri, Giovanni Dosi, Giovanni Marin, Carlo Pietrobelli and Julio Raffo.

1. Introduction

Product of the natural resource industry are an essential part of our lives. We need them to satisfy our everyday needs. Without them industrial production would soon come to a halt (Mikesell and Whitney, 1987). Natural resources are the primary inputs to most production processes and they supply the energy for transport, light and heat around the world (Andersen et al., 2015). Mining and other associated activities are a significant part of the global economy. The value of global mine production has been estimated at around USD 1.3 trillion in 2014, corresponding to about 1.6% of world Gross Domestic Product (GDP) (Lof and Ericsson, 2016). In 2015, mining-related commodities represented approximately two percent of the world's total trade (UN COMTRADE, 2016). The direct and indirect impact of natural resource industries on economic growth and development is even more relevant – and still an open question - than their weight in total GDP and trade.

The first to suggest that countries can profit from their resource endowments was Adam Smith (1776) with his "vent for surplus theory" according to which poor countries can export under-used natural resources that are highly valued abroad, thus generating economic rents. Mainstream trade theories generally hold that free trade benefits every country taking part to it, even those showing an absolute disadvantage in every sector (see e.g. Ricardo, 1817; Krugman, 1980). However, the historical record has consistently shown a widespread underperformance of economic growth in resource-abundant countries (Auty, 1993; Sachs and Warner, 1997; Harding and Venables, 2016; Venables, 2016). In fact, many of the poorest countries in the world are also the most abundant in oil or other natural resources, even after controlling for many potential alternative explanations (Dosi and Tranchero, 2021).

Among the first scholars to question the view that specialising in natural resources may be a "blessing" for economic development, the "Structuralists" – followed by the "Evolutionary" economists - such as Singer (1949) and Prebisch (1950; 1959) considered natural resources an inferior specialisation strategy, notably with respect to manufacturing, because of the difference in income-demand elasticity and the deteriorating terms of trade in natural resources. Demand for exports from natural resource industries is less elastic than for manufactured goods. This means that as world income grows demand for commodities for natural resources will grow less than that for manufactured products. Therefore, countries exporting natural resource-based commodities and importing manufactured products will

face price to import increases at a faster rate than the price of exports (Bontadini and Savona, 2019). The Structuralists (Singer, 1949; Prebisch, 1950; Hirschmann, 1958) argue that natural resource intensive industries are problematic for economic development mainly because they create little opportunities for learning and innovation, and because they generate fewer backward linkages to other sectors compared to manufacturing, with lower diversification opportunities of productive activities (Szirmai, 2012).

We argue that the extreme negative consequence for a developing country specialised in natural resources production is to run into the resource curse. James (2015) states that a large literature documents a negative relationship between resource dependence and economic growth. Resource curse concerns the systematic tendency for resource dependence to impede economic growth and development by creating market or institutional failures. However, natural resource-based specialisation is a multifaceted phenomenon which may have different consequences on economic development according to specific national experiences and according to the historical circumstances under observation.

Hence, the relationship between natural resource specialisation and development can be described as a relatively complex one characterised by a variety of challenges and opportunities, which may well lead to the extreme condition identified as "resource curse". Besides, being characterised by a resource curse may per se be a highly variegated condition, so that one would better talk about "degree" of resource curse, rather than identifying a single, punctual level of resource curse. Discussing the circumstances that may determine such different outcomes of natural resource-based specialisation is the purpose of this paper. We will argue that natural resource-based specialisation tends to favour, and is hence associated with, the emergence of structural weaknesses that may hinder development (labour market fragilities, financial instability, low quality of institutions, lack of innovation, lack of diversification, and the degree of dependence of an economy on natural resources as captured for instance by the concentration of inward foreign direct investments in the extractive sector). Countering these impoverishing effects of natural resource specialisation effects is not an easy task. However, several successful experiences exist which highlight that investing in innovation (Perez, 2015; Pietrobelli et al., 2018) and coupling natural resource specialisation with wider portfolios of specialisations through the attraction of foreign direct investments (FDIs) in different sectors may be a way out of the poverty trap (Nomaler and Verspagen, 2021; UNCTAD, 2022).

In this paper, we consider sector specialisation as a dynamic concept, suggesting that diversification of productive activities and specialisation are not opposites, because a country may specialise in the products in which it has a comparative advantage, but also develop new specialisations over time thus implying some degree of diversification (Imbs and Wacziarg, 2003; Nomaler and Verspagen, 2021). Indeed, a more diversified productive structure provides greater capacity to absorb more severe shocks in the short term and larger adaptability in the long term, by increasing the opportunities to develop new growth paths (Martin, 2012). Economic development opportunities of countries are intimately linked to the amount of knowledge and productive capabilities they are equipped with, where the latter can be measured by the diversity and ubiquity of products they produce (and export). Additionally, – next to the diversification in terms of industry products or sectors – greater attention should be given to the functional diversification of countries, i.e. the ability of national economies to develop a wider range of value added functions along global value chains, with higher innovation and technological content (Coveri and Zanfei, 2023).

The paper is organised as follows. Section 2 defines the conceptual framework. Section 3 describes challenges and opportunities in specialising in natural resource production, according to different streams of literature. Section 4 provides variegated examples of countries where natural resources have been a blessing, a curse or something in between. Section 5 illustrates the structural weaknesses that, whether associated with specialisation in natural resources, lead to resource curse. Section 6 discusses a possible strategy for developing countries to avoid the curse and achieve natural resource-based industrialisation. Section 7 concludes.

2. Conceptual framework

One of the main problems for (developing) countries with large endowments in natural products is that primary sectors often generate very low employment opportunities (McMillan and Rodrik, 2011). Inter-sectoral comparative advantages are thus misleading drivers of development, and the positive impact of structural change is found to be higher for countries that manage to reallocate a large share of employment to manufacturing activities. The key point is that sheer acceptance of comparative advantages might not be sufficient to achieve satisfactory competitiveness levels (Dosi and Tranchero, 2021). Dosi, Riccio and Virgillito (2021) state that the process of economic development historically can be seen as an upgrading path over technological capabilities and learning regimes. If the textile sector has typically represented the opportunity to discipline and organise a previously unstructured labour force, steel and heavy metal industries often have been the chance to accumulate massive productive capacity and capital equipment. Finally, information and communication technologies, fine chemical and pharmaceuticals entailed a tighter connection between basic and applied research. Thus, the productive structure and the ensuing specialisation and diversification patterns at any stage of development strongly influence the development process itself (Fagerberg, 1987). When a country experiences a resource boom, its economy may suffer from the "Dutch disease" effects associated with dramatic appreciation in domestic currency which may damage agriculture and manufacturing activities that compete in international markets (Corden, 1982; Narula, 2018). As these sectors are key drivers of economic development, GDP growth will be pensalised by their shrinkage (Davis and Tilton, 2008). Moreover, the Dutch disease contributes to undermine the diversification of productive activities (Venables, 2016). Additionally, the inter-country diversity in terms of production specialisation ought to emerge by opening up the black box of technological attributes of the different sectors. In other words, the diversification and specialisation in productive activities of different countries should be disentangled studying the role that innovation and technological change play in each sector. In this respect, the Pavitt (1984) taxonomy reveals to be a quite useful lens of analysis to classify sectors according to their technological content, position in the supply chain and overall quality of specialisation. According to Pavitt (1984), the natural resources sector is a supplier-dominated industry, where innovation is mainly driven by exogenous change in intermediate capital inputs and learning largely entails learning by using. Relatedly, Dosi, Riccio and Virgillito (2021) find that although supplier dominated industrial sectors (e.g. the natural resources sector) are the ones absorbing the highest fraction of the labour force in the manufacturing sector, they are also the first ones losing shares in terms of both employment and value added when facing crises.

Resource-abundant countries on average have experienced lower economic growth than resource-poor countries over the last four decades. However, there is large variation in the experiences. In many countries, a heavy reliance on natural resources has contributed to political instability, corruption and

some cases also warfare. It is the case of countries such as the Central African Republic, the Democratic Republic of Congo, Guinea, Liberia, Nigeria and Sierra Leone (Davis and Tilton, 2008). In other countries (e.g. Australia and Norway), the resource endowment has been used to the benefit of the country, leading to higher growth and income than in neighbouring countries (Holden (2013). Calzada Olvera and Foster-McGregor (2018; p. 2) point out that the experience of Norway and Australia, in successfully moving from natural resources to knowledge-based economies has also strengthened the idea that the so-called resource curse is not necessarily a curse but potentially a blessing. In the case of Australia and Norway, Smith (2007) and Fagerberg, Mowery and Verspagen (2009) argue that successful long-term economic growth of these countries is closely linked to dynamics within resource-based sectors of the economy. A central aspect for innovation resource-based sectors depends on the degree to which these sectors interact and cooperate with other parts of the economy (Ville and Wicken, 2013). Norway's resource-based sectors have displayed considerable dynamism in developing knowledge and adapting to new challenges (Fagerberg, Mowery and Verspagen, 2015). The Norwegian innovation system has been dominated by resource-based innovation that has played a key role in Norway's economic performance[1]. This also helped the country to avoid the resource curse. It is worth adding that not only developed countries have the chance to escape from the resource curse. Indeed, there are intermediate cases of developing countries that have escaped (or are escaping) the resource curse such as Botswana, which handles its natural resources (i.e. diamonds) in a relatively balanced way to achieve development opportunities through them (Pegg, 2010). However, cases similar to the Botswanan risk to remain isolate considering that developing resource abundant countries lag behind the international technological frontier in mining, situation that reduces the likelihood of achieving development opportunities through mining activities (Alessandri, 2023).

Reacting to the resource curse literature, also, an important body of historical studies has argued that natural resources have usually been the locus of learning, innovation and linkages, and that the relevant question is not so much whether or not resources are bad for growth and development and why, but under which conditions they might contribute to development and growth (see for instance Smith, 2007; Andersen, 2012; Ville and Wicken, 2013; Marin, Navas-Aleman and Perez, 2015). A recent stream of literature – adopting a Global Value Chain (GVC) approach - has suggested that natural resource-based development is achievable if developing resource-abundant countries (e.g. Latin America) enhance innovation in the natural resources sector (Marin, Navas-Aleman and Perez, 2015; Perez, 2015). In fact, innovation helps to generate spillovers and linkages between the extractive industry and other sectors such as manufacturing and the services sector, increasing the current and potential range of industries into which a country is specialised in terms of production, encouraging diversification of economic structures (see for example the experience of Australia and Norway) (Andersen et al., 2015; Bjornland and Thorsrud, 2015). In this manner, a developing resource-abundant country may enter a horizon of dynamic competition (built on innovation-based Schumpeterian efficiency (Dosi and Tranchero, 2021) that is better for development than a specialisation based on a few productive activities related to natural resources, which have the feature of impoverishing the nation and where competition is only (or mainly) based on price (Cimoli et al., 2006). More precisely, Schumpeterian efficiency is a dynamic concept that pertains technological change and the specialisation in sectors that create more technological externalities, have higher technological

[1] Specifically, Norway's innovative performance has been the ability of Norwegian entrepreneurs, firms and public sector actors to recognise opportunities, mobilize resources, adapt existing capabilities and develop new ones, and develop appropriate institutions and policies. The system's adaptability thus appears to be one of the important factors contributing to Norway's successful technological and economic development (Fagerberg, Mowery and Verspagen, 2009).

opportunities and exhibit higher rates of innovation (Dosi and Tranchero, 2021). The paramount importance of technical change in shaping the possibilities of economic growth clarifies why Schumpeterian adjustments are fundamental: specialisation in the most innovative sectors dominates over the short-term gains induced by Ricardian comparative advantages[2] (Dosi, Riccio and Virgillito, 2021). Nevertheless, the possibility of building a platform for development by innovating across the value network around natural resources exists in the modern market conditions and that the sources of the natural resource curse can be addressed through strategic policies (Marin, Navas-Aleman and Perez, 2015; Pietrobelli, Marin and Olivari, 2018). The networks of natural resources production and their multiple linkages upstream, downstream and laterally present an innovation space of higher profitability that the probable trends in the global economy will do nothing but expand (Perez, 2010; Andersen et al., 2015).

Given the above discussion, we suggest that the most severe and intertwined negative factors associated to specialisation in natural resources production are the lack of innovation in the natural resources sector (Perez, 2015; Pietrobelli et al., 2018) and the lack of diversification of productive activities (Hidalgo and Hausmann, 2009). The latter is a means to reduce the volatility of markets and to increase linkage creation opportunities (Hausmann, Hwang and Rodrik, 2007). Deller and Schreiber (2012) point out that localities that "settle" on being dependent upon a single industry, e.g. mining, and do not seek to diversify from that industry, expose the local economy to unnecessary risks[3]. Indeed, specialising in some products will bring higher growth than specialising in others (Hidalgo et al., 2007). Everything else being the same, countries that specialise in the types of goods that rich countries export are likely to grow faster than countries that specialise in other goods. Rich countries are those that have latched on to "rich-country products", while countries that continue to produce "poor-country" goods remain poor (Hausmann, Hwang and Rodrik, 2007; Hidalgo and Hausmann, 2009; Bontadini and Savona, 2019).

3. Is natural resource-based specialisation a problem?

This section highlights that specialisation in natural resources is multifaceted because it has been conceived differently over time. Perez (2015) argues that the prevailing notions about the potential contributions of natural resources to development have changed radically over time, depending on the dominant technologies and the windows of opportunity available[4]. We provide a review of the principal

[2] In this context, Dosi, Riccio and Virgillito (2021) argue that, for a country, producing "microchips" is not the same as producing "potato chips". Dosi, Riccio and Virgillito (2021) find that, during the phase of globalization, the probability for low-income countries to produce "potato chips" has increased while the transition probability towards the production of "microchips" has been reducing. This suggests that developing resource-abundant countries increase their specialisation in natural resources, which is a type of specialisation that may impoverish the country especially if strategic and intelligent policies such as encouraging innovation and diversification are not adopted (Coveri and Zanfei, 2023).

[3]Advanced countries are found to also export products for which they do not possess a comparative advantage, contrarily to what Ricardo (1817) would have predicted. In general, comparative advantage theory is found working only for developing countries, whose export basket is limited to a handful of products. This asymmetry shows the relevance of diversification (Hidalgo and Hausmann, 2009) and its advantage over Ricardian specialisation (Tacchella et al., 2013). However, diversification is only available for countries that possess the necessary productive capabilities (Dosi and Tranchero, 2021).

[4] Archibugi and Pianta (1992) argue that a variety of factors rooted in the structure of a country's economy affects its comparative advantages in technology. These include:

(i) The sectoral specialisation of production and trade shown by the country's industries;
(ii) The existence of natural resources and of a domestic industry based on their exploitation;
(iii) A particular national demand structure and consumer tastes which may lead to specific technological developments.

streams of literature concerning challenges and opportunities of specialising in natural resources production. Section 3.5 summarises pros (opportunities) and cons (challenges) of specialisation in natural resources production in achieving natural resource-based development.

3.1 Classical and Neo-classical trade theory

Prior to the era of mass production, during the period that can be recognized as the first globalization (from the 1870s to 1914), natural resources were seen as key to development (Adam Smith's (1776) view). The technological revolution that was then taking place, in the age of steel and heavy engineering, was about chemistry and electricity, transcontinental railways and world-trading steamships, metallurgy and major engineering projects. Such global infrastructure enabled counter-seasonal world markets for meat, wheat and other agricultural products. Natural resources were considered a blessing by classical economists (Smith, 1776), not a curse, with Australia, New Zeland, Canada, Sweden, the United States and others partly owing their 'catching up' successes for their resource endowment.

The Ricardian trade theories (Ricardo, 1817) and the Heckscher-Ohlin model (Leamer, 1995) suggest that countries should produce and export goods, no matter their quality, using the resources that they have in abundance, i.e. specialising in "what one does best". By becoming more specialised, the allocation of resources becomes more efficient, allowing for mutual welfare increases (Krugman and Obstfeld, 2006). It is supposed to be cheaper to produce these goods for the countries that adopt this strategy. It is worth stressing that classical and neo-classical trade theories consider natural resources a blessing for economic development. The main difference between classical and neo-classical economists is that the latter do not contemplate technological progress in the production function.

There is a branch of (mainstream) literature that finds that the effect of a large endowment of oil and other mineral resources on a country's economic growth has been on balance positive (Alexeev and Conrad, 2009; Davis and Tilton, 2008; Smith, 2015). In particular, Smith (2015) finds that positive GDP effects of natural resources wealth are concentrated in developing countries, with small and insignificant effects when the sample is limited to OECD countries.

3.2 The Structuralists

It was not until the 1950s, during the successful post-war deployment of the mass production paradigm in the West, that criticism grew towards natural resources. The neoclassical prescription about taking advantage of resource abundance did not convince the Structuralists, worried about the poor economic performance of Latin American and African countries. Marin, Navas-Aleman and Perez (2015) state that Structuralists, reacting to the neoclassical prescriptions for these countries to specialise in NRs (natural resources) to take advantage of their resource abundance, argued that there were some main objections to specialisation in natural resources.

Relatedly, Prebisch (1950) and Singer (1949) emphasised several types of demand and supply rigidities, all of which would explain a continuous downward trend in the relative price of primary commodities relative to manufacturing (the so called 'price scissors'). On the demand side, Prebisch and Singer highlighted that:

(i) NRs face relatively low income elasticity, so countries with NRs would not benefit from increases in world demand associated with world income growth;

(ii) NRs demand growth was slower than that for manufacturers, because of the technical change, in particular the capacity to displace natural materials by developing synthetic alternatives.

On the supply side they identified that:
(i) NRs were not favoured by technological progress, which was mostly concentrated in manufacturing, 'they do not provide the growing points for increased technological knowledge, urban education, the dynamism and resilience that goes with urban civilisation, as well as the direct Marshallian external economies' (Singer, 1949);

(ii) The little technological progress they experienced did not translate into larger demand or greater profits but in reduced prices, benefited consumers in foreign countries and not producers in developing countries supplying the NRs.

Furthermore, Singer (1949) and Prebisch (1959) saw development of the primary sector as an inferior specialisation strategy, notably with respect to manufacturing, because of the difference in income-demand elasticity between the two sectors and the deteriorating terms of trade of natural resources. Bontadini and Savona (2019) state that development of the primary sector was deemed beneficial only conditionally on the development of the manufacturing sector (Prebisch, 1959), within a balanced development strategy a la Nurkse (1952).

The scepticism around economic development ensuing from a large natural resource sector became a dominant view from the 1980s to the end of the 1990s, with the formulation of the Dutch Disease thesis (Corden, 1982). The Dutch Disease is a resource curse "symptom" that is based upon the conception that a large, capital intensive, high-productivity and export-oriented natural resource sector would have a range of negative effects on the rest of the economy, hindering its overall performance:

(i) By concentrating all the revenue in one sector, the country would become exposed to price volatility of the exported commodity (Bontadini and Savona, 2019);

(ii) Because of the export of the commodity the country's currency would appreciate making other sectors' export less competitive (Harding and Venables (2016). Moreover, the commodity sector would also draw investment and other resources away from other sectors (Sachs and Warner, 1997; Matsuyama, 1992).

(iii) The commodity sector is perceived as an enclave, extracting resources from the country for export, with little linkages with the rest of the domestic economy and most of the profits being shipped away (Weisskoff and Wolff, 1977; Bontadini and Savona, 2019).

It is worth stressing that Singer (1949) and Prebisch (1975) emphasised problems arising due to the domination of NR activities in developing countries by Multinational Corporations (MNCs). Not only were profits repatriated, but also local investment and the instigation of backward and forward linkages were very limited, preventing future development. The assumption thus arose that only manufacturing led to development, with natural resources being a dead end (Bontadini and Savona, 2019). For instance, in the case of the mining sector, Molina, Olivari and Pietrobelli (2016) state that the country of origin of the mining company was the one that benefited from the technological spillovers related to the mining activity.

The above discussion may lead to the conclusion that countries should not specialise in natural resources.

3.3 The Evolutionary economists

The Evolutionary economists belong to a more recent stream of literature than the Structuralists. Both groups of economists have a similar view regarding specialisation in natural resources, i.e. countries should not specialise in producing products of the extractive sector for the following reasons.

In the long run and in contrast to the Ricardian trade theories, income elasticity ratio depends on the diversification of the periphery (the case of developing resource-abundant countries, e.g. Latin America) towards high-tech sectors (Cimoli and Porcile, 2011). The relative growth of the periphery will thus depend on the relative weight of technology-intensive sectors in the periphery as compared to the centre (e.g. developed countries). According to the Evolutionary perspective, competitiveness based on abundant natural resources or raw labour cannot be sustained and is bound to decline. Only competitiveness based on technological capabilities would allow the periphery to have a presence in markets whose demand grows at higher rates. A higher share of technology-intensive sectors gives rise to externalities and increasing returns, spill-over effects, backward and forward linkages, and technological externalities which boost exports, capital accumulation and growth (Gerschenkron, 1962; Hirschman, 1977). In other words, catching-up and convergence require transformation of the production structure towards rents generated by knowledge and learning, rather than by the availability of natural resources or cheap labour (ECLAC, 2010).

Cimoli et al. (2006) argue that according to international specialisation patterns and technological efforts countries can be classified in terms of a growth strategy based on taking advantage of the economic rents conferred by a privileged access to abundant factors of production, namely cheap labour or natural resources endowment. Countries that follow this strategy will tend to concentrate their efforts in maintaining or extending their participation in natural resource intensive sectors. In some cases, especially when natural resources are abundant but labour is scarce, significant technological efforts may be required to boost labour productivity (the case of Latin America). Some production linkages can arise spontaneously, but if those countries fail to actively encourage structural change it is likely that their specialisation pattern will not automatically create the incentives to shift towards more sophisticated technological production stages and activities. Cimoli et al. (2006) add that abundance of resources can sustain growth without significant efforts for learning during a relatively short period, but in the long term economic rents derived from these resources tend to be eroded. Growth is sustainable only if backward and forward linkages are created, as it was anticipated by Hirschman (1977) and by the "staples theory", and if the initial advantage is used to build up technological advantages.

Dosi and Tranchero (2021) state that, contrarily to what conventional wisdom takes for granted, large resource endowments often turn out to be a comparative dis-advantage in practice. It is worth noting that resource-based economic activities suffer from a drawback (among others), namely diminishing returns (Reinert, 1996). Output increases in resource-based activities will eventually lead to reach a point after which the crucial resource is no longer available, or it is left only in lower quality (extractive activities provide a straightforward example of such a situation). This is what Reinert (1996) dubbed "double trap of resource-based nations": the resource-based nation is locked into an economic activity

which yields less and less as its specialisation according to its comparative advantage deepens. This relates to an "impoverishing" specialisation in natural resources.

Cimoli and Porcile (2011) stress that the higher the share of goods intensive in natural resources in total exports, the less dynamic will the export structure be, to the extent that the international demand for goods intensive in natural resources grew at lower rates than the demand for industrial goods, particularly those of medium and high technology (ECLAC, 2008). Cimoli and Porcile (2011; p. 13) show that this share is much higher in Latin America than in other groups of countries. This seems to point to the existence of some curse associated with natural resources. Nonetheless, Ricardian trade theories are rather agnostic on the quality of goods traded, implicitly assuming that trade is good for everyone no matter the kind of goods effectively traded (Kemp and Van Long, 1984). Both common sense and economic research show that this is not the case (Reinert, 1996; Hausmann et al., 2007), and specialisation patterns are highly predictive of economic performances of countries (Tacchella et al., 2013).

A few scholars provided new evidence on the classic hypothesis of manufacturing as the "engine of growth" (Haraguchi et al., 2017; Szirmai, 2012; Szirmai and Verspagen, 2015). Rodrik (2012) shows that the manufacturing sector exhibits unconditional convergence in labour productivity: the poorer a country is the faster the productivity in its manufacturing sector will increase towards the technological frontier. Relative to other sectors, manufacturing has a higher potential for technological progress without being dependent on other country-specific conditions (Haraguchi et al., 2017) and it has traditionally absorbed significant quantities of labour, unlike mining activities (Rodrik, 2016). Furthermore, spillovers from learning associated with one technology are not automatically diffused to the whole economy but tend to improve only similar technologies because of localised technological change (Atkinson and Stiglitz, 1969). Linkages between natural resource production and other sectors have historically been weaker than between manufacturing and the rest of the economy (Greenwald and Stiglitz, 2013), helping to explain the persistent large gap between the state of technology in the natural resource sector (mainly mining) and other sectors (Dosi and Tranchero, 2021).

Dosi and Tranchero (2021; p. 27) point out that intra-country inter-sectoral differences in productivity and profitability trigger Ricardian adjustment processes that are comparative advantage performing. This is what happened during the last three decades of globalisation: international demand for primary commodities has pushed resource-abundant countries toward increasing specialisation in their comparative advantages, as showed by the increasing weight of commodities in the production for foreign markets. On the technological front, innovative capabilities remain highly concentrated in the leading "technology club", with less developed (resource-abundant) countries still lagging behind (e.g. Latin America). Relatedly, Alessandri (2023) finds that developing resource abundant countries lag behind the international technological frontier in the mining industry, with companies originating in developed economies (United States) that concentrate in their hands the crucial innovation activities in this field. Instead of simply conforming to the comparative advantage stemming from their given endowments, developing countries should put in place a wide array of trade and industrial policies that would foster the accumulation of technological capabilities. This should be done even to contrast the risk of contracting the resource curse in developing resource abundant countries.

Murshed and Serino (2011) investigated the relationship between the pattern of specialisation and economic growth, demonstrating that the so-called resource curse occurs in countries that do not manage to diversify their tradable sectors; something that is often asserted but rarely empirically

confirmed. Moreover, a starting point towards developing manufacturing exports can be an industrialisation strategy based upon processed natural resource-based products. This, however, may not be achievable only through market forces, but may require policies to improve competitiveness, education, infrastructure and even some Research & Development (R&D). Murshed and Serino (2011) found that it is only the specialisation in unprocessed natural resource products that hampers economic growth, because it impedes the emergence of more dynamic patterns of trade specialisation. Thus, diversification into natural resource processing can be seen as a way of avoiding the resource curse (low growth) in the presence of abundant natural resources. The above discussion links to the inability of primary commodity exporters to develop more dynamic patterns of trade specialisation.

To sum up, the existence of abundant natural resources or cheap labour can sustain high rates of growth during a relatively short period without requiring high R&D investments. However, changes in the international economy and demand patterns are likely to expose countries pursuing this strategy to vulnerabilities, because, in the long term, this behaviour reduces the structural capacities of capturing the opportunities of technological progress. Actually, rents derived from knowledge, which are cumulative by nature, can be continuously recreated, redefining the conditions for allowing entrance in new markets. On the other hand, when rents are purely based on the relative abundance of resources, the capacities to induce or respond to shocks and changes is reduced, since the country lacks the technological capabilities necessary to readapt the production system to changing contexts (Cimoli et al., 2006).

For instance, in the case of a developing resource abundant region as Latin America, the widening of the technology gap displayed by Latin America in the last decades reflects a hysteresis state which could only be overcome by means of a thorough redefinition of the industrial and technology policies in the coming years. These policies should challenge the various forces that hamper the accumulation of technological capabilities (Cimoli and Porcile, 2011), which are an important tool to avoid the resource curse.

3.4 Global Value Chain (GVC) approach

The huge transformation that the mining industry has experienced during the last 10-15 years has contributed to reinforce the idea that it is possible for economies to grow and diversify through natural resource specialisation (Marin, Navas-Aleman and Perez, 2015). Perez (2015; p. 12) points out that it is not that authors such as Auty (1993), Gyfalson (2001), Prebisch (1950, 1975), Singer (1949), Sachs and Warner (1997) were wrong. It is that the contexts were different and they therefore provided different conditions for development and led to different views. Therefore, during the 2000s a new literature has emerged challenging the existence of such a curse, putting forward historical examples (see e.g. Wright and Czelusta, 2004), as well as raising a range of issues questioning the empirical soundness of the evidence on which the resource curse was based (Stijns, 2000; Brunnschweiler and Bulte, 2008; Lederman and Maloney, 2016). In particular:

(i) The original studies looking at the resource curse (Sachs and Warner, 1997) are based on cross sections, which cannot capture causal links, e.g. the evolution over time of both institutions and technology (Van der Ploeg and Poelhekke, 2017).

(ii) Natural resource abundance is often confused with natural resource dependence[5] (Brunnschweiler and Bulte, 2008) and when this is disentangled from natural resource rents, the latter can have a positive impact on economic growth (Ding and Field, 2005).

(iii) The main problem with natural resource dependent countries is a lack of export diversification rather than something inherent to natural resources (Bontadini and Savona, 2019). In other words, the key issue is not of specialising in natural resources, but of "over-specialising" and "mono-specialising" in the natural resources sector.

The changing global market and technological and economic conditions are creating a new context in which developing countries can take advantage of NRs, e.g. of higher value added activities along the mining value chain. Recently, Morris, Kaplinsky and Kaplan (2012), Marin, Navas-Aleman and Perez (2015) and Perez (2015) argued that mining activity has become more knowledge intensive and increasingly involved in technological improvements in the different stages of the mining process. Mining activities are increasingly carried out following a GVC perspective. Multinationals in NRs have changed their usual behaviour of acting as enclave towards adopting a more decentralized way of operating, mainly because mining companies have strong incentives to increase the level of outsourcing and near sourcing in their non-core activities (Morris, Kaplinsky and Kaplan, 2012). Due to this recent transformation, a wide literature has emerged trying to understand and explain the linkages and the learning and innovation processes in natural resources industries that can encourage structural change and economic diversification (Marin, Navas-Aleman and Perez, 2015; Marin and Stubrin, 2015; Ville and Wicken, 2013).

Hence, recently, a large body of literature underlines the fact that a resource-abundant developing country specialised in natural resources production might have chances to develop. The necessary condition to achieve natural resource-based development is to rely on innovation, e.g. the local production of higher value-added products along the mining value chain such as mining equipment (Alessandri, 2021; Molina, Olivari and Pietrobelli, 2016; Perez, 2015). In this paper, we argue that this strategy of fostering innovation in the natural resources sector should be accompanied by the presence of a diffuse specialisation in many or several sectors of the economy, without neglecting the manufacturing and the services sector (Andersen et al., 2015; Hidalgo and Hausmann, 2009).

3.5 Pros and cons in production specialisation in natural resources

Based on the different approaches adopted by diverse streams of literature to examine the relationship between specialisation in natural resources production and natural resource-based development, we summarise pros (opportunities) and cons (challenges) of production specialisation in the natural resources sector (Table 1).

[5] Hailu and Kipgen (2017) state that resource abundance refers to resource endowments or stocks, which to a large extent are endogenously determined, while resource dependence refers to the importance of the resource sector to an economy in generating tax revenues, foreign exchange, growth and employment. Thus, resource-dependence becomes applicable once extraction takes place, while being resource abundant does not necessarily imply extraction of the resources. These two terms are used interchangeably in misleading ways when evaluating various resource curse hypotheses. It is worth highlighting that a nation that is resource abundant may not be resource dependent if it diversifies its production structure.

Table 1 – Pros and cons of Natural Resource (NR) production specialisation in achieving natural resource-based economic development from a country perspective

Pros		**Cons**	
Stream of literature	**Arguments**	**Stream of literature**	**Arguments**
Classical and Neo-Classical trade theory	Specialising in "what a country does best" (e.g. natural resources production) may be cheaper and more efficient in the allocation of resources nationally, with positive effects on GDP (Ricardian trade theory of comparative advantage)	Structuralists	NRs face relatively low-income elasticity, so countries with NRs would not benefit from increases in world demand associated with world income growth
GVC approach	Specialisation in the natural resources production may be beneficial for development only if it is accompanied by specialisation in innovation in the natural resources sector and by diversification of productive structures, i.e. developing a diffuse specialisation pattern of productive activities, as a means of being more reactive to adverse shocks and less dependent on a single sector	Structuralists	NRs demand growth may be slower than that for the manufacturing sector, because of the technical change, in particular the capacity to displace natural materials by developing synthetic alternatives
GVC approach	In some contexts, specialisation in mineral production could encourage the local production of higher value-added products along the mining value chain such as mining equipment and technology, avoiding to import all mining technologies from abroad. This promotes technological upgrading and catching-up along the GVC, with greater possibilities of diversification through establishing linkages with non-mining sectors, e.g. suppliers of equipment and technologies	Structuralists	NRs are not historically favoured by technological upgrading, which was mostly concentrated in manufacturing
		The Evolutionary economists	Low level of flexibility of reacting to external shocks. When rents are purely based on the relative abundance of resources, the capacities to induce or respond to shocks and changes is reduced, since the country lacks the technological capabilities necessary to readapt the production system to changing contexts

		The Evolutionary economists	Large extractive multinational corporations have the capacity to dominate their host economy, especially the smaller and less developed countries with a single-sector focus, i.e. a "mono-specialisation" in the extractive sector.
		The Evolutionary economists	The higher the share of goods intensive in natural resources, the less dynamic will the export structure be, to the extent that the international demand for goods intensive in natural resources grows at lower rates than the demand for industrial goods, particularly those of medium-high technology
		The Evolutionary economists	The existence of abundant natural resources can sustain high rates of growth only in the short period. Indeed, in the long-term this reduces the structural capacities of capturing the opportunities of technological progress and to respond to shocks flexibly
		The Evolutionary economists	Innovative capabilities remain highly concentrated in the leading "technology club", with less developed (resource abundant) regions and countries still lagging behind (e.g. Latin America and Sub-Saharan Africa).

Source: Author's elaboration.

4. The experiences of countries specialising in natural resources

Specialisation in natural resources is a multifaceted phenomenon not only depending upon different perspectives related to streams of literature that developed during time, but also depending on the experiences of countries. There is a wide heterogeneity of examples of countries whose specialisation (dependence) on natural resource-intensive industries has been associated with different "symptoms" such as weaknesses of institutions, lack of innovation and of diversification and financial instability; relatedly, different resource-abundant countries may exhibit positive or negative effects on economic development. When the specialisation in natural resources production is accompanied by structural weaknesses of countries, we have the extreme case of a resource cursed country.

A large body of empirical work establishes a relationship between resource abundance and poor economic performance of countries. For the most part this evidence appears to support the "resource curse" hypothesis (Stevens, 2003). James (2015; p. 55) states that this remarkably robust phenomenon is commonly attributed to the so-called "resource curse", the systematic tendency for resource

dependence to impede economic growth and development by creating market or institutional failures. It is not surprise that the "resource curse" in resource abundant states refers primarily to socio-economic development and to phenomena such as poverty and general economic decline (Basedau (2005; p. 9).

The resource curse represents for a (developing) country the extreme case in which the negative effects of a specialisation in natural resources manifest. Some literature associates the presence of the resource curse only to low GDP growth (Sachs and Warner, 1997). Certainly, low GDP growth is a negative factor that, associated with specialisation in natural resources, might lead a country to resource curse. Dubé and Polèse (2015) state that, for national economies, rich natural resource endowments become a "curse" when they distort the allocation of resources (i.e., away from knowledge-rich industries) and undermine the efficient functioning of political institutions. As such, Dam and Scholtens (2012) reveal that the dependence (specialisation) in natural resources cannot only be associated with a negative factor, i.e. low or declining GDP growth, but also to corruption and regulatory quality. A resource-abundant region experiences a "resource curse" if the way that it uses its resource wealth detracts from the economic well-being of its people. A substantial, though controversial, empirical literature suggests that people residing in many resource-abundant regions do in fact experience lower incomes and slower income growth rates than people in otherwise comparable resource-poor regions. There are many possible explanations for this phenomenon, including disincentives to human capital formation, negative interactions between extractive industries and social institutions, adverse real exchange rate effects, and economic damage from resource price volatility[6] (Douglas and Walker, 2017). The just listed factors are different structural weaknesses associated with specialisation in natural resources (together with low GDP growth), which are illustrated in Section 5.

We have learnt that, traditionally, the resource curse is presented in terms of reduced (GDP) economic growth (Sachs and Warner, 1997). Low GDP growth is a very broad negative effect that can be directly or indirectly associated to specialisation in natural resources. Indeed, many scholars claim that the lower growth experienced by resource abundant countries also results from poor institutional quality (Baland and Francois, 2000; Torvik, 2002; Dam and Scholtens, 2012). Dam and Scholtens (2012) illustrate the differences in institutional quality. Specifically, Dam and Scholtens (2012) compare the means of five different indicators for oil abundant and oil poor countries, as well as for resource abundant and resource poor countries (where resources are: mineral resources, oil, and ores). The five computed indicators are Regulatory Quality, Government Effectiveness, Control of Corruption, Political Stability, and Voice and Accountability. The results represented in Table 2 concern different groups of countries, distinguished in oil/resource abundant countries and oil/resource poor countries.

[6] Van Der Ploeg and Poelhekke (2008) show that the resource curse is foremost a problem of volatility. The high volatility of world prices of natural resources causes severe volatility of output per capita growth in countries that depend heavily on them. The resulting volatility of unanticipated output growth has a robust negative effect on long-run growth itself and is a curse. This is not limited to oil-exporters, but also applies to exporters of copper, coffee, foods, etc. which include many of the world's worst performing countries.

Table 2 – Differences in institutional quality

Indicator	Oil poor countries (mean)	Oil rich countries (mean)	Difference	Resource poor countries (mean)	Resource rich countries (mean)	Difference
Regulatory quality	0.26	−0.37	0.63	0.26	−0.04	0.31
Government effectiveness	0.32	−0.33	0.64	0.32	0.01	0.31
Control of corruption	0.29	−0.39	0.67	0.32	−0.10	0.42
Political stability	0.05	−0.74	0.79	0.08	−0.38	0.46
Voice and accountability	0.25	−0.39	0.65	0.26	−0.06	0.32

All differences are significantly different from zero at the 1% level, using a standard one-sided t-test for equality of means. We assume equal variances. Resource Rich means abundant in mineral resources, oil and/or ores.

Note: for a list of the countries included to compute these indicators of institutional quality, see Dam and Scholtens (2012; pp. 154-155).

Source: Dam and Scholtens (2012; p. 151).

On the basis of Table 2, for all five indicators the mean is smaller for oil and resource poor countries. Dam and Scholtens (2012; p. 150) conducted one-sided t-tests for the differences in means. For all indicators, they reject the hypothesis that the difference of the means is zero, at the 1% level, both for the subdivision in oil abundant and oil poor and resource abundant and resource poor. Of course, it is not possible to jump to conclusions based on a simple t-test, but it is evident that these indicators are correlated to institutional quality. This is an example which shows that low GDP growth is only one negative factor that can be associated to specialisation in extractive industries and it only captures part of the story. Nonetheless, low GDP growth may be the outcome of several countries' structural weaknesses associated with specialisation in natural resources.
We provide examples of countries for which specialising in natural resources production has been an opportunity for development (Section 4.1) and countries for which it turned out to be detrimental for economic progress, leading to resource curse (Section 4.2). Finally, Section 4.3 summarises key information on the country examples.

4.1 Positive experiences of countries specialising in natural resources

Blomstrom and Kokko (2007), Bravo-Ortega and de Gregorio (2002), Dubé and Polèse (2015) and Gylfason (2001) all make the same point: natural resources have not been a "curse" for nations such as Australia, Canada, Finland and Sweden. Specifically, several single country studies have also sought to learn lessons for avoiding the resource curse by focusing on resource abundant nations that have avoided it (see e.g. Papyrakis and Gerlagh (2007) for the United States; Pegg (2010) for Botswana; Gylfason (2011) for Norway; Parlee (2015) for Canada. Taking the case of Norway as an example, its strong national institutions, effective public policy in general, prudential resource management policy, and establishment of a petroleum savings fund are identified as key features of its success (Badeeb, Lean and Clark, 2017).

Some resource-based economies have avoided the curse altogether, and this includes those which have done so through a long period of economic development, although little has been written about them within this context. It is worthwhile to remember the involvement of some of the countries that avoided the resource curse in the extractive sector and, within this, in the mining sector, which represents an important component of the natural resource sector.

Calzada Olvera and Foster-McGregor (2018; p. 10) state that, on average, the importance of mining in high-income countries is comparable to that of Latin America, with the notorious exception of Norway where it is much higher. The share of mining in GDP moved from 9% to 17% in Norway,

4% to 6% in Australia, and 3% to 7% in Canada. There were no significant changes in the US, the Netherlands, or Great Britain. Mining exports went from 30 to 44% in Norway, 16% to 45% in Australia, and 7% to 20% in Canada. It remained virtually the same in the US (1% to 2%), the Netherlands (3% to 4%) and Great Britain (5%).

Economic development, by its nature, is a longitudinal process, and yet history has had little to say on this issue of contemporary interest, besides an implicit assumption that truly successful nations will transit from natural resource to manufacturing industries. For instance, Australia and Norway have continued to heavily rely on their resource-based industries (Ville and Wicken (2013; p. 2)). These two economies have continually renewed and extended their resource base by drawing upon the role of learning and knowledge creation to facilitate innovation in these industries and spill-overs into other sectors.

Recent analyses involving both Australia and Norway, combine historical studies and innovation systems approaches (Smith, 2007; Fagerberg, Mowery and Verspagen, 2009; Ville and Wicken, 2013). Smith (2007) and Fagerberg, Mowery and Verspagen (2009) argue that successful long-term economic growth of these countries is closely linked to dynamics within resource-based sectors of the economy. A central aspect for innovation in resource-based sectors depends on the degree to which these sectors interact and cooperate with other parts of the economy. An example could be that of Knowledge Intensive Mining Services (KIMS). Hence, one of the reasons of Australia and Norway resource-based industrialization's success is that they focused on innovation. Innovation plays a key role in fostering resource-based development (see for instance Perez, 2015; Marin, Navas-Aleman and Perez, 2015; Molina, Olivari and Pietrobelli, 2016).

Narula (2018; p. 90) stresses the fact that countries that avoided the resource curse carefully nurtured inter-industry linkages, and deliberately sought to avoid over-specialisation. Marin, Navas-Aleman and Perez (2015) point to the recent success of Argentina and Chile in leveraging their natural resources to build up new industries that are more "future-proof". The idea that economic development is dependent on linkages between sectors in the economy goes back to Hirschman (1958). Hirschman (1958) emphasised specifically the role of backward linkages, and argued that resource-based industries created fewer backward linkages compared with manufacturing. This explained slow development in many resource-based economies. However, resource-based industries have created strong backward (and forward) linkages in Australia and Norway.

Calzada Olvera and Foster-McGregor (2018; p. 2) point out that the experience of Norway and Australia, in successfully moving from natural resources to knowledge-based economies has also strengthened the idea that the so-called resource curse is not necessarily a curse but potentially a blessing. A central aspect of the economic dynamics of Australia and Norway has been the strong linkages between resource-based sectors and other parts of the economy. This reflects how innovation processes most often take place within the resource-based sectors: problem solving occurs mainly through the search for knowledge and competency in other parts of the economy (Ville and Wicken, 2013). Therefore, the interaction between the resource-based industries and the enabling sectors explains how Australia and Norway remained specialised in natural resources production, but they avoided the resource curse because these countries averted structural weaknesses (e.g. weaknesses of institutions and of national innovation systems) that often associate with specialisation in extractive industries. Ville and Wicken (2013) state that the main argument is that in both nations the resources sector expanded and diversified by developing new technologies that draw upon and contribute to

learning and knowledge broadly across the economy.

Another relevant factor associated to resource-abundant countries is the quality of the political institutions (Holden, 2013). In countries with producer friendly institutions, with good protection of property rights, reliable public bureaucracy, and little corruption, natural resources are more likely to lead to economic growth (Mehlum et al., 2006). When oil was discovered in Norway, it already had a long and stable tradition of democratic rule. It had a well-functioning state bureaucracy.

Switching attention to Australia, the mining boom has undoubtedly been a key foundation of Australia's recent economic growth. Nonetheless, how far should it be welcomed? It is essential to focus on the impact of the resource boom in Australia, arguing that we should be willing to discuss whether this presumed blessing is, for many, in fact a "curse" in disguise. For the modernizers Australia is said to have combined minerals dependency with prosperity and is cited as a key example of what can be achieved by an expanding minerals sector (Wright and Czelusta, 2007). The Australian Economy has traditionally run a surplus on its primary commodities (agriculture and mining) to fund a deficit in its manufacturing trade (Goodman and Worth (2008; p. 203)). It is this presumed complementarity between mining and prosperity that is cited as Australia's great lesson. Indeed, the experience since the 1970s mining boom, with rising GDP and transition to an information economy, "demonstrates that expansion of a country's mineral base can go hand-in-hand with economic growth and technological progress" (Wright and Czelusta, 2007).

However, some assessments of the 1970s minerals boom emphasized the extent to which mining would displace other activities (Goodman and Worth, 2008). In an early intervention, in 1976, Bob Gregory (1976) predicted that the process in Australia would disadvantage non-mining sectors, especially the rural sector (Gregory, 1976; Goodman and Worth, 2008). The principal mechanism for this Australian version of the "Dutch disease" was the exchange rate, which would appreciate with the mining boom, leaving non-mining sectors disadvantaged. Resources would flow to the mining sector, undermining economic diversification, and leading to macro mal-development. The minerals boom was seen as directly undermining Australian efforts to strengthen its manufacturing base and, far from promoting prosperity in the medium term, it was seen as undermining growth prospects. With the onset of a resources boom that in many respects out-booms the 1970s experience, these concerns should be revisited and revised in the light of the now much more clearly defined socio-economic, political and ecological dimensions of the process. Thus, considering the above discussion, there are some studies according to which the resources boom in Australia has not only been a blessing.

In addition, there is a further lodging of literature that believes that the natural resources sector has not exclusively been a blessing for economies like Canada and the United States. Regarding this, Douglas and Walker (2017) find that one of the channels for the resource curse is through disincentives to education. Young people have an incentive to drop out of school when relatively well-paying unskilled employment opportunities are available in the resource sector. Furthermore, Papyrakis and Gerlagh (2007) find that schooling is the most important transmission channel of the resource curse in their cross-sectional study of the U.S. states.

Boom and bust swings associated with resource extraction are also in part industry specific with oil and gas the clearest example in Canada. Dubé and Polèse (2015) discover that communities in oil-abundant Alberta showed the clearest signs of booms and busts with growth coefficients reversing between periods. The uncertainty generated by industries prone to violent demand swings creates a

disincentive for long-term investment in non-resource sectors. Nevertheless, Dubé and Polèse' (2015) results do not allow to make such an inference. Over the (long-run) 35-year period examined, growth variable coefficients are systematically positive for Alberta-based communities. To sum up, the findings of Dubé and Polèse (2015) point to the absence of a generalizable resource curse valid for all resource industries and for all communities. A corollary of the above is that the possible solutions for mitigating the negative side effects of resource-led growth will vary between communities within countries. The challenges facing a remote community whose fate has been tied for the last 30 years to a single large paper mill providing well-paying jobs for an established blue-collar population are not the same as those of a centrally located community with a number of oilrigs at various stages of development, staffed largely by transient engineers, geologists, and drillers.

The discussion concerning resource-abundant developed countries such as Australia, Canada, Norway and the US have pointed out that economies, which avoided the resource curse, underwent small negative repercussions from the presence and expansion of the natural resources sector (with the exception of Norway).

4.2 Negative experiences of countries specialising in natural resources

This section provides examples of countries where specialisation in natural resources associates with structural weaknesses that lead to the extreme case of resource curse. One dimension of the presence of resource curse apart from a negative growth impact is the prevalence of poverty and the observation that oil, gas and mineral abundant economies have a poor record in poverty alleviation (Stevens, 2003). Stiglitz (2005; p. 14) writes that extraction in itself makes the country poorer because resources such as oil, gas or minerals are not renewable. Once they are out of the ground and sold, they cannot be replaced. It is only the subsequent reinvestment into capital (physical or natural) that can offset the loss of this natural wealth and make the country richer.

Based on the experiences of countries such as Norway, the United States and Australia (in the nineteenth and early twentieth centuries), some studies (e.g. Smith, 2007; Andersen, 2012; Ville and Wicken, 2013) have emphasized the importance of issues such as previous industrialization, institutions and learning to explain why some resource abundant countries have succeeded while others not (e.g. Nigeria or Venezuela). Most of the literature on the resource curse has regarded Nigeria as a quintessential example of a resource cursed country (see for instance Auty, 1993; Collier and Hoeffler, 2001; Sachs and Warner, 2001). Nigeria is an archetypical 'oil nation', a mono-economy in which oil dwarfs every other economic sector (Amundsen, 2017). The sale of crude oil totalled 77 billion USD in 2014 and made up about 75 per cent of Nigeria's government revenues. Since the 1970s, oil has accounted for 90-95 per cent of all foreign exports and 70-85 per cent of all government revenues. Nigeria has been bedevilled by the natural resource curse and has witnessed a significant decrease of living standards, unfathomable corruption, and societal strife' (Humphreys et al. (2007; p. 94). Shaxson (2007) argues that the 'crowding out' effect in Nigeria during the oil-boom years produced a 60 per cent decline in agricultural output and 'plunged tens of millions of people into poverty'. The economic indicators of the resource curse in Nigeria are, first, the fact that the people of Nigeria remain as poor today as before oil (that is, before the early 1970s and a production of over 2 million barrels of crude oil a day). In 2014, almost 100 million Nigerians (60.9 per cent) were living on less than USD 1 a day (that is, in 'absolute poverty'). In 1980, the figures were only 17.1 million (and 30 per cent) (Amundsen (2017; p. 19)). In other words, the level of poverty has risen substantially in both absolute and relative

terms. A second indicator is the low level of economic diversification, which is an important tool to combat the resource curse. In the wake of the oil boom of the 1970s, agriculture and manufacturing fell from 44.2 and 12.4 to 24.7 and 4.8 per cent of GDP, respectively (Amundsen, 2017). Although Nigeria has been among the ten fastest growing countries in the world in the 2000s, a recent report on economic transformation argues that Nigeria is among the least transformed countries in Africa. It scores zero on a combined index of diversification, export competitiveness, productivity, technology upgrading, and this poor showing reflects its extreme dependence on producing and exporting oil' (ACET (2014; pp. 32-33)). This reflects the fact that it is misleading to associate resource curse only to low GDP (economic) growth. Moreover, low GDP growth may also be the outcome of many kinds of structural weaknesses of a country specialised in the extractive industry. The political indicators of the resource curse in Nigeria are the civil war and the many dictatorships the country has seen since independence. However, Nigeria made a remarkable democratic transition with the March 2015 general elections, but there is still a long way to go before escaping the resource curse.

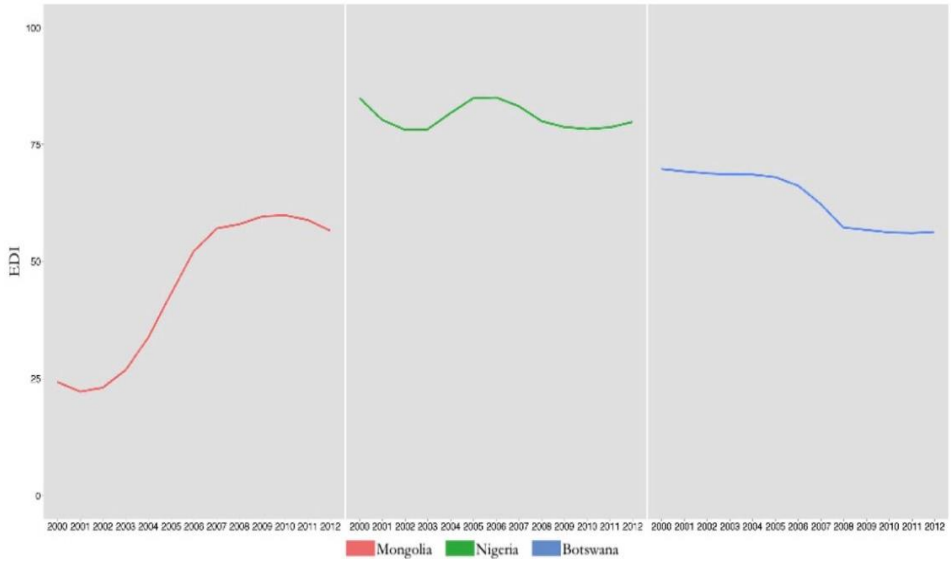
To examine whether a developing country is resource cursed, first, it needs to quantify how countries are dependent on oil, gas and mineral extraction at a given point in time and under prevailing economic conditions. This is possible through the computation of an index, called EDI[7] (Extractive Dependence Index), which measures pathological resource dependence that can be associated to the presence of resource curse. Thus, the EDI index augments the probability to find countries that are subject to that problem. This is built on Auty's (1990) proposed measure of mineral dependence, which takes the mean contribution of minerals to GDP, exports and revenues. The EDI improves on Auty's (1990) measure and fills a gap in the literature by considering the productive structure of economies and widening the country coverage (Hailu and Kipgen, 2017).

Economic diversification remains a challenge for resource-dependent countries, particularly since market forces tend to pull output toward the more efficient sector (the extractive sector) and away from the less efficient sectors (e.g. manufacturing). However, diversification into non-resource sectors from a strong resource base is both "feasible and historically common" (Lederman and Maloney, 2006). A high level of dependence on the mining sector does not necessarily imply dependence that has to be avoided; rather it is an indication of the need to adopt strategies for future diversification of economic activity within GDP. Policymakers need to worry about persistent, not transient, dependence on resources (Hailu and Kipgen, 2017). The EDI indicator attempts to measure this changing (or stagnant) dependence on resources.
Figure 2 portrays the EDI scores regarding three countries, i.e. Mongolia, Nigeria and Botswana, illustrating the different extractive dependence trajectories. Figure 3 shows the EDI scores in 2000 against scores in 2011. Figure 3 further demonstrates the examples of the different trajectories of dependence on the extractive sector concerning Mongolia, Nigeria and Botswana.

[7] $$EDI_{ct} = \sqrt{[EIX_{ct} \times (1 - HTM_{ct})]^* \quad [Rev_{ct} \times (1 - NIPC_{ct})] \; ^*[EVA_{ct} \times (1 - MVA_{ct})]}$$

Where:
EDI is Extractive Dependence Index for country *c* in time *t*.
EIX is export revenue from oil, gas and minerals as a share of total export revenue.
HTM is export revenue from high-skill and technology-intensive manufactures as a share of global HTM exported in year *t*.
Rev is revenue generated by the extractive industry as a share of total fiscal revenue.
NIPC is the total tax revenue collected from non-resource income, profits and capital gains as a share of GDP.
EVA is extractive industries value added as a share of GDP.
MVA is the per capita manufacturing value added used as proxy for domestic industrial capability.

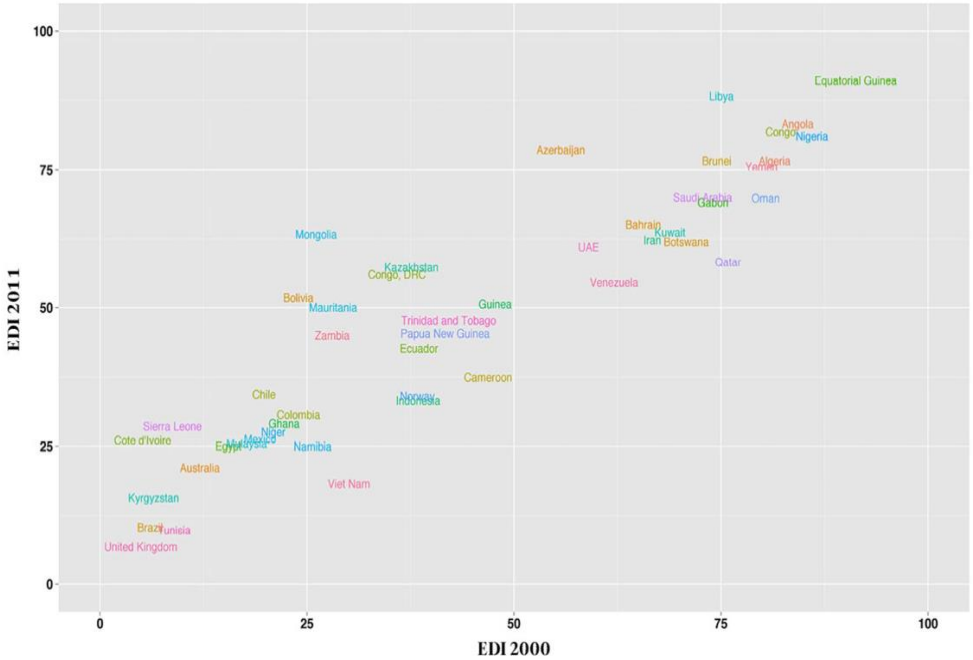
Figure 2 – The EDI for Mongolia, Nigeria and Botswana, 2000-2011



Note: the EDI score is measured as the outcome of three ways identified by Hailu and Kipgen (2017) in which a country's dependence on the resource sector manifests itself, namely through its contribution to export revenues, fiscal revenues and through its ability to add value in GDP. Together, these variables also reveal the transmission mechanisms by which the resource curse has been found to operate and reflect the specialised production structure that results from resource dependence. See footnote n. 7 on how the EDI score is calculated.

Source: Hailu and Kipgen (2017; p. 260).

Figure 3 – Scatterplot of the EDI[8] scores (years 2000 and 2011)



Source: Hailu and Kipgen (2017; p. 261).

[8] Largely, the EDI reflects the prevailing trends in global commodity prices and does not differentiate between changes in the level of dependence resulting from short-term external shocks or long-term trends. Lower dependence, for instance, could reflect low global prices, as was the case for countries including Angola, Norway, Kuwait and Nigeria during the economic and financial crisis that started in 2008 (Hailu and Kipgen, 2017).

Discussing Figures 2 and 3, Mongolia's EDI value in year 2000 was about 26.11. In 2011, the value increased to about 63. Hence, Mongolia is becoming more dependent on its minerals. Despite over 60 years of resource extraction, Nigeria has not undergone the structural transformation required to decrease dependence on the sector and has maintained an EDI score greater than 80 in both 2000 and 2011. Nigeria has a pathological dependence on natural resources and is subject to resource curse. In the case of Botswana, the EDI score declined from 71 to 62 between 2000 and 2011. Botswana may represent an intermediate case of a developing country where natural resources became more a blessing than a curse for the local economy (Pegg, 2010).

A possible solution to the problems created by a dominant oil, gas or mineral sector is to reduce the importance of the sector in the economy by developing other sources of value added, promoting diversification (UNCTAD, 2022). Indeed, this is also one of the recommended solutions in the Oxfam Report (Ross, 2001).

Economies that rely heavily on oil, gas and mineral sectors embark on a completely different model of development than economies that depend on agricultural, service and manufacturing sectors (Loayza and Raddatz, 2010). In particular, extractive sectors – especially those of oil, gas and minerals – are primarily capital intensive and use little, if any, unskilled or semi-skilled labour, offering little or no labour opportunities to the poor. Apergis and Katsaiti (2018) investigate the relationship between resource dependence and poverty. Their data covered 28 major oil-exporting countries, 36 major natural gas exporters, and 15 major coal exporters, spanning the period 1992-2014. After establishing cross-sectional dependence, unit roots and co-integration in their panel, Apergis and Katsaiti (2018) established that all the three resources exacerbated poverty. The results were significant at the 1% level, while they remained robust across a number of robustness checks. One of the main issues facing economies that rely heavily on revenues from energy resource exports is the diversification of the economy and the re-investment of those revenues into sectors of the economy where the poor can benefit from, providing a positive structural change for the economy. Two main avenues of getting the poor out of the poverty trap could be the provision of child welfare, in the form of health care, nutrition and education, and the provision of jobs. For younger generations, providing this combination of childcare will facilitate the escape from the poverty trap. According to a recent study by Loayza and Raddatz (2010), poverty alleviation depends not just on the size of economic growth, but also on the contributions from unskilled labour-intensive sectors, that is agriculture, construction and manufacturing. One way this could occur is through the investment of resource revenues into the development of "upstream" – i.e. industries that supply goods to the extractive sector – and "downstream" industries, which process and add value to the products of the extractive sector (Apergis and Katsaiti, 2018).

4.3 Summary information on the country experiences

This section summarises key information on the relationship between specialisation in natural resources production and economic development for the examples (experiences) of countries illustrated in Section 4.1 (positive experiences) and Section 4.2 (negative experiences). In particular, Table 3 reports this summary information distinguishing between developed and developing countries and providing – before and after natural resource production specialisation – key comparative features of the countries analysed in terms of level of industrialisation, level of diversification of productive activities, national innovation system, quality of institutions and level of education. The goal is to show

that developing resource-abundant countries may show greater structural weaknesses in terms of the key comparative features mentioned above than developed resource-abundant countries, especially after increasing their specialisation in natural resources production.

Table 3 – Summary characteristics of countries specialising in natural resources

		Positive experiences of countries			**Negative experiences of countries**		
Type of countries	Country names	Characteristics of the country **before** natural resource production specialisation	Characteristics of the country **after** natural resource production specialisation	Key literature	Characteristics of the country **before** natural resource production specialisation	Characteristics of the country **after** natural resource production specialisation	Key literature
Developed countries	Australia	Medium level of industrialisation ; medium level of diversification of the productive structure; strong national innovation system; strong institutions; medium-high level of education	High level of industrialisation ; high level of diversification of the productive structure; very strong national innovation system; strong institutions; medium-high level of education	Goodman and Worth (2008); Ville and Wicken (2013); Wright and Czelusta (2007)			
	Norway	High level of industrialisation ; high level of diversification of the productive structure; strong national innovation system; strong institutions; medium-high level of education	Very high level of industrialisation ; high level of diversification of the productive structure; very strong national innovation system; strong institutions; high level of education	Fagerberg , Mowery and Verspagen (2009); Gylfason (2011); Ville and Wicken (2013)			
	Canada	High level of industrialisation ; high level of diversification of the productive structure; very strong national innovation system; strong institutions; medium-high level of education	High level of industrialisation ; high level of diversification of the productive structure; very strong national innovation system; strong institutions; medium level of education	Parlee (2015)			
	United States	High level of industrialisation ; high level of diversification of the productive structure; very strong national innovation system; strong	High level of industrialisation ; high level of diversification of the productive structure; very strong national innovation system; strong	Papyrakis and Gerlagh (2007)			

		institutions; medium-high level of education	institutions; medium level of education				
Developing countries	Botswana	Low level of industrialisation; low level of diversification of the productive structure; weak national innovation system; moderately strong institutions; low level of education	Medium level of industrialisation; medium level of diversification of the productive structure; moderately strong national innovation system; moderately strong institutions; medium level of education	Pegg (2010)			
	Nigeria				Low level of industrialisation; Low level of diversification of the productive structure; weak national innovation system; weak institutions; low level of education	Very low level of industrialisation; Very low level of diversification of the productive structure; very weak national innovation system; very weak institutions; low level of education	Amundsen (2017); Auty (1993); Sachs and Warner (2001)
	Other Sub-Saharan African countries (e.g. Central African Republic, Democratic Republic of Congo, Guinea, Liberia, Sierra Leone)				Low level of industrialisation; Low level of diversification of the productive structure; weak national innovation system; weak institutions; low level of education	Very low level of industrialisation; Very low level of diversification of the productive structure; weak national innovation system; weak institutions; low level of education	Apergis and Katsaiti (2018); Davis and Tilton (2008)
	Mongolia				Medium level of industrialisation; Medium level of diversification of the productive structure; weak national innovation system; weak institutions; low level of education	Low level of industrialisation; Low level of diversification of the productive structure; weak national innovation system; very weak institutions; low level of education	Hailu and Kipgen (2017)

Note:
a) The time span of the analysis is approximately from mid XX century to the most recent period. It is worth stressing that it is very tricky to fix the exact year(s) when a country becomes dependent on natural resources. Thus, our approach refers to analysing a resource-abundant country from an historical and longitudinal perspective over a relatively long period of time, to capture changing relationships between natural resource dependence (specialisation) and economic development, based on extant literature mentioned in this table.
b) Characteristics of the country before and after natural resource production specialisation range from very high to very low in the case of level of industrialisation, level of diversification of productive activities and level of education; whereas, the national innovation system and the institutions may range from very strong to very weak.

Source: Author's elaboration.

Table 3 indicates that countries considered as positive examples of specialisation in natural resources production and economic development – i.e. Australia, Norway, The United States and Canada - were already advanced economies before becoming specialised in producing natural resources, with a relatively high level of diversification of productive activities, strong institutions and national innovation systems. In some cases, e.g. Norway and Australia the level of development further improved when increasing specialisation in natural resources production, mainly due to a high capacity of these countries in establishing linkages between mining and non-mining activities (i.e. the manufacturing and services sector), with the beneficial result of incrementing the level of diversification of productive structures that allowed the countries to better reacting to external shocks. As already illustrated in the previous section, Botswana represents an isolate case of a developing resource-abundant country which improved the level of diversification of productive activities – through linkages between mining and other sectors beyond mining - after increasing specialisation in mineral (diamonds) production, mostly thanks to strong institutions and a moderately strong innovation system. When considering positive experiences of countries specialising in natural resources, Table 3 also depicts that there appears to be a "path dependence" in terms of being a highly structured and advanced country before becoming specialised (dependent) in (on) natural resources. Conversely, Table 3 also shows there seems to be a "path dependence" even when considering negative experiences of countries specialising in natural resources, in the sense that weakly structured and less advanced countries (e.g. Mongolia, Nigeria and other Sub-Saharan African countries) are those showing a negative relationship between increasing specialisation in natural resources and economic development. Indeed, developing resource-abundant countries, after becoming (or increasing) specialised (specialisation) in natural resources worsen their conditions and increase structural weaknesses in terms of lower levels of industrialisation and diversification of productive activities, weaker institutions and weaker national innovation systems, with detrimental effects for the whole economy.

5. When does natural resource specialisation lead to resource curse?

Considering the heterogeneity of experiences of countries illustrated in Section 4, this section examines which mix of factors associated to natural resource-based specialisation can lead a country to experiment the most negative and intricate effect of resource curse. It is worth remembering that, being characterised by a resource curse may per se be a highly variegated condition, so that one would better talk about "degree" of resource curse, rather than identifying a single, punctual level of resource curse. Discussing the factors (i.e. structural weaknesses) that may determine such different outcomes of natural resource-based specialisation, and therefore different degrees of resource curse is the purpose of this section.

If a country exhibits structural weaknesses associated to specialisation in natural resources production, it is most likely to be resource cursed. The related resource curse degree will vary depending on the number and the severity of structural weaknesses (e.g. weaknesses of institutions, labour market fragilities, lack of innovation and of diversification) that associate with specialisation in extractive industries. Additionally, we will dig deeper into two major structural weaknesses, i.e. the lack of innovation in the extractive sector and lack of diversification of productive activities.

5.1 Concentration of inward FDI in the extractive sector

At the heart of the vitality (or its lack) of the extractive sector as an engine for sustainable development is the Multinational Corporation (MNC). The MNC and the resource sector have a strange and convoluted history (Narula, 2018). The MNC has been much derided in the dependency theory literature as generating too few benefits for the host, and causing structural distortions in the local economy, as well negatively influencing its political processes (Moran, 1978; UNCTAD, 2007). MNCs had a habit of internalising the complete value chain and creating enclaves around their facilities that had few linkages or spillovers locally (Prebish, 1950; Girvan, 1970). This buttressed the view that the MNC in the extractive sector was an obstacle to development and positive structural change (Narula, 2018).

Asiedu and Lien (2011) state that FDI in natural resource-abundant countries tend to be concentrated in the natural resource sector. The concentration of inward FDI in extractive industries is also a proxy for measuring natural resource dependence, among other indicators (Demir, 2016). Specifically, inward FDIs in the extractive sector become a structural weakness when there is an "over-concentration" or a "mono-concentration" of inward FDIs in the extractive sector, neglecting FDI inflows in other non-resource sectors. This reveals a worrisome dependence (specialisation) on (in) the extractive sector (Narula, 2018). It is more likely that this structural weakness, i.e. the almost exclusive concentration of inward FDIs in the natural resources sector is shown by developing resource abundant economies such as Sub-Saharan African (SSA) countries and Latin America (Asiedu, 2013; World Investment Report, 2018). MNCs dominate the oil industry (Asiedu, Dzigbede and Nti-Addae's, 2015). For example, in 2005, the share of oil production by MNCs was about 19 percent for all developing countries, 18 percent in Latin America, 11 percent in transition countries, and 57 percent in SSA.

Relatedly, we provide a Revealed Comparative Advantage (RCA) index based on inward FDI per

industry sector (Zanfei, Coveri and Pianta, 2019), regarding selected groups of countries worldwide in the fDi Markets Database[9] between 2003 and 2017. The goal is to identify whether and to what extent selected groups of countries at the global level are "over-specialised" or "mono-specialised" in the extractive sector, and whether this specialisation is accompanied by various specialisations in other non-resource-intensive industry sectors, such as the manufacturing and the services sector. In other terms, we identify if geographical regions that are "over-specialised" in the extractive sector have a relatively diversified set of specialisations in non-resource intensive industry sectors.

The RCA indicator constructed using inward FDIs mirrors Balassa index (Balassa, 1965), with Zanfei, Coveri and Pianta (2019) stating that the FDI specialisation indices are computed in a given industry for a given economy as the share of Inward Foreign Direct Investments (IFDIs) drawn in that industry by such economy over the share of total inward FDIs attracted by such economy in all industries worldwide. Values greater than 1 indicate specialisation. Having an extractive industry FDI specialisation indicates that a country has the ability to attract FDI in the extractive industry that is greater than other areas, which in turn may have a substantial effect on the host economy in terms of structural change, agglomeration economies and potential technological spillovers accruing to local firms and institutions, for example (Antonietti et al., 2015; Baldwin and Venables, 2013).
The RCA of inward FDI ($IFDI$) for industry i in economy k is thus computed as:

$$RCA_k^i = \frac{IFDI_k^i \Big/ \sum_k IFDI_k^i}{\sum_i IFDI_k^i \Big/ \sum_k \sum_i IFDI_k^i}$$

If the RCA is greater than one, the economy is specialised in attracting inward FDI in that particular product or industry sector; otherwise not. See Figure A1, Appendix A.

Results show that developing resource abundant-countries – i.e. Latin America and especially Sub-Saharan Africa – are "over-specialised" in the extractive industry. This "over-specialisation" seems to crowd-out specialisations in other non-resource intensive sectors, such as the manufacturing and the service sector; in fact, Latin America and Sub-Saharan Africa developed specialisations in very few other industry sectors different from the extractive one, revealing a low level of diversification. Instead, developed countries – i.e. the European Union (19 countries) and North America – that have no specialisation (the European Union) or weak/partial specialisation (North America) in the extractive industry are specialised in attracting inward FDI in many or several industry sectors, beyond the extractive one. Hence, these developed countries show a more diversified productive structure than developing resource abundant countries such as Latin America and especially Sub-Saharan Africa.
However, moving away from natural resource-based FDIs might not translate into certain development opportunities. Indeed, even an increase in FDI in the manufacturing industry does not necessarily translate into higher economic growth. Relatedly, several studies have found that FDI

[9] fDi Markets Database is an online database provided by fDi Intelligence – a specialist division of Financial Times Ltd – that monitors cross-border investments covering all sectors and countries worldwide from 2003 onwards. fDi Markets is an event-based (or deal-based) database, i.e. each entry is a project, which collects detailed information on announced cross-border greenfield investments (i.e. new wholly-owned subsidiaries, including joint ventures whether they lead to a new physical operation) from several publicly available information sources, including nearly 9000 media sources, over 1000 industry organizations and investment agencies, and data purchased from market research and publication companies. The time span covered by this database covers the period 2003-2018 (for further details regarding fDi Markets dataset see Zanfei, Coveri and Pianta, 2019).

enhances growth only under certain conditions:

- When the host country's education level exceeds a certain threshold (Borensztein et al., 1998);
- When domestic and foreign capital are complements (de Mello, 1999);
- When the country has achieved a certain level of income (Blomstrom et al., 1994);
- When the country is open (Balasubramanyam et al., 1996);
- When the host country has a well-developed financial sector (Alfaro et al., 2004).

5.2 Weakness of institutions and local governments

The resource curse literature lists several different channels, i.e. structural weaknesses through which resource dependence might negatively affect growth. Much of the recent resource curse literature focuses on institutions as the primary mechanism associated to specialisation (dependence) on natural resources production (Douglas and Walker, 2017). For example, Mehlum et al. (2006) find that poor institutional quality is a necessary precondition for resource dependence to retard economic growth. Nonetheless, it is worthwhile to be aware that Kaffine and Davis (2017) ascertained that Mehlum et al. (2006) have results that are not robust to sample. Nevertheless, Alexeev and Conrad (2009) show that large natural resource endowments appear to increase per capita GDP without a simultaneous improvement of the country's institutions; hence, Alexeev and Conrad (2009) have results that identify a neutral effect of natural resources on institutions. Furthermore, Acemoglu et al. (2003), Collier (2010) and Corrigan (2014) find that resource dependence may also cause poor institutions. In this last case, weak institutions act as a facilitating factor of the resource curse.

As anticipated in the first part of Section 4, there exist variables to measure the quality of institutions. Some of them reflect: the level of political and civil rights, the level of bureaucracy, the level of corruption, and the impartiality of the legal system in host countries (Asiedu, Dzigbede and Nti-Addae's, 2015). For instance, a developing resource-abundant region such as Sub-Saharan Africa (SSA) fares poorly on all the measures of institutional quality with respect to non-SSA countries within the African continent, and the top eight oil-exporting countries in the region fare even worse (Asiedu, 2013; Asiedu, Dzigbede and Nti-Addae (2015). Indeed, this observation is consistent with several studies that find a negative relationship between natural resource dependence and institutional quality, human capital, and physical capital (Gylfason and Zoega, 2006). In addition, the dependence of natural resources is driving the lack of transparency in most developing countries' governments, because without the large revenues being earned from these resources there is less reason for the government to hide anything from its citizens (Corrigan, 2014; Williams, 2009; Williams, 2011).
The availability of natural resources in the developing world is often seen as a hindrance to economic development. In most cases, institutional failure (e.g. conflict, mismanagement or corruption) is at the heart of this inability to transform natural wealth into better standards of living (Deller and Schreiber, 2012). However, in the presence of strong enough backward linkages natural resources can be more a blessing than a curse (Aragòn and Rud, 2009). Institutions play a key role in fostering these linkages between the natural resources sector and other sectors of the economy, contributing to diversification purposes.

5.3 Volatility of the financial system

Countries with poorly developed financial systems are more volatile. Van Der Ploeg and Poelhekke (2009) argue that resource-abundant and landlocked economies have less developed financial systems than resource-poor countries. This is a structural weakness that may contribute to lead to the resource curse for a country specialised in natural resources production.

Volatility can be fortunately reduced if countries have a sound financial system to cope with large and sudden fluctuations in resource income. Fewer capital account restrictions, openness and physical access to world trade also lower volatility. Van Der Ploeg and Poelhekke (2009) argue that countries can turn the curse even into a blessing, because they find evidence for a positive direct effect of natural resource dependence on growth after controlling for volatility. The key to a turn-around for many resource-abundant countries is financial development, ensuring openness and mitigating the effect of being landlocked, because the indirect negative effect of resource dependence on growth, via volatility, is much larger than any direct positive effect. While it may be difficult to lower price volatility of resources themselves, it should be feasible to deal with volatility in a more efficient way. It is increasingly realised that large external shocks, volatile macroeconomic policies, microeconomic rigidities and weak institutions induce substantial income volatility in many developing countries, which imposes significant welfare losses for risk-averse individuals (see e.g. Loyaza et al., 2007).

5.4 Pitfalls concerning local employment

Marchand and Weber (2017) argue that the presence of natural resources in a local labour market may also provide incentive for individuals to accumulate less human capital than they would otherwise. This is due to the availability of relatively high-paying, low-skill jobs, which increases the opportunity cost of education and lowers its return. Less human capital could (in turn) depress the growth of resource-dependent areas over the longer term.

Another important factor that may affect employment is mining FDI. It is worth noting that the impact of FDI on host economies depends on the type of FDI that the country receives (Asiedu, 2002; Asiedu, 2013). MNCs employment increases domestic employment, boosts domestic wages, enhance the productivity of the labour force and it fosters the transfer of technology between foreign and domestic firms (Asiedu, 2002). However, extractive industry FDI generates very limited local employment. This point is noted in UNCTAD (2007; p. 92): "mineral extraction is primarily an export-oriented activity, with significant revenue creation, but limited opportunities for employment creation and local linkages". For instance, the employment effects of FDI are important to SSA, because in most African countries unemployment is prevalent. High unemployment rate countries in SSA include South Africa, 23%; Kenya, 40%; Senegal, 48%; Zambia, 50% (Asiedu (2013; p. 20)).

To sum up, there can be troubles with the creation of local employment in the extractive sector in (developing) resource-abundant countries (Castillo et al., 2001). Pitfalls concerning local employment creation might represent a negative factor of a country specialised in natural resources. Reasons put forward relate to the fact that extractive industry FDI may generate very limited local employment, especially in SSA (Asiedu, 2013); moreover, when mining FDIs create employment, this employment often consists in low-skilled activities (Marchand and Weber, 2017).

5.5 Environmental regulations

Extractive activity also leads to environmental degradation which most often affects the poor (Apergis and Katsaiti (2018; p. 211)). The Pollution Haven Hypothesis (PHH) states that because of increased environmental regulation, multinationals shift their production to countries with poor environmental and social standards (see e.g. Cole and Elliot, 2003; Ross et al., 2011). The PHH concerns the concentration of pollution-intensive industries in poor and developing countries. As stated by the PHH, the migration of dirty industries from advanced to developing countries takes place through the trade of goods and FDI (Gill, Viswanathan and Karim, 2018; Rezza, 2013). However, the advanced countries are clean because they have shifted their pollution-intensive industries to the developing countries. As a result, the developed countries tend to specialise in clean goods while developing countries tend to specialise and export pollution-intensive goods (Gill, Viswanathan and Karim (2018; p. 172)).

Less stringent environmental regulations represent a structural weakness of a resource-abundant economy that - along with other structural weaknesses - may lead a country to the extreme and variegated negative phenomenon of resource curse.

5.6 Level of education

Education stimulates economic growth and improves people's lives through many channels: by increasing the efficiency of the labour force, by fostering democracy and thus creating better conditions for good governance, by improving health, and by enhancing equality (Aghion et al., 1999).
We point out that natural resource abundance seems likely to deter economic growth not only through the Dutch Disease, rent seeking, and overconfidence that tends to reduce the quality of economic policy and structure as suggested by Sachs and Warner (1997) among others, but also by weakening public and private incentives to accumulate human capital (Gylfason, 2001; Gylfason et al., 1999). In line with these statements, we argue that the neglect of education associated with dependence (specialisation) in natural resources may be a structural weakness that contributes to lead a country to resource curse.

Nations that are confident that their natural resources are their most important asset may inadvertently – and perhaps deliberately – neglect the development of their human resources, by devoting inadequate attention and expenditure to education (Bravo-Ortega, 1999). Bravo-Ortega and De Gregorio (2002) show that abundance of human capital is important in determining whether natural resources are a curse or a blessing to economic growth. Bravo-Ortega and De Gregorio (2002) state that there are many reasons why regions that more than a hundred years ago were similar in terms of income per capita and abundance of natural resources had very different patterns of development and economic growth, but clearly a salient difference was the level of human capital. More precisely, Bravo-Ortega and De Gregorio's (2002) evidence suggests that human capital not only partially compensates the negative effects of increasing natural resources on economic growth, but it can more than offset these negative effects. Precisely, a high level of human capital diminishes the growth-reducing effect of the reallocation of resources from a dynamic sector, such as industry, to the exploitation of natural resources.

Gylfason (2001; p. 856) believes that, insofar as high-skill labour and high-quality capital are less common in primary production than elsewhere, this may help explain why natural resource abundance

and the associated preponderance of primary production and primary exports tend to impede learning by doing, technological advance and economic growth. More and better education tends to shift comparative advantage away from primary production towards manufacturing and services, and thus to accelerate learning by doing and growth providing structural change and diversification of national economies. Summing up, a low level of education in a resource-abundant economy can represent one of the factors that contributes to increase the risk of contracting the resource curse.

5.7 The Dutch disease and the risks of low diversification

Named after the decline in the tradable sector that was caused by the discovery of natural gas in the Netherlands (Stijns, 2000), an economy suffers from a Dutch Disease when natural-resource industries "crowd out" other growth-promoting industries such as manufacturing (Matsuyama, 1992; Sachs and Warner, 1997; James, 2015). Precisely, the term "Dutch disease" was coined in 1977 by The Economist to describe the experience in The Netherlands, an industrialised country that from the 1960s became dependent on exports of newly discovered natural gas reserves (Corden, 1982).

The Dutch Disease is one possible channel for the resource curse. This refers to a decline in a country's non-resource traded goods sector caused by resource-driven appreciation of real exchange rates. At a sub-national level, this might manifest as high wages in resource industries crowding out growth in the non-resource traded goods sector. In other words, the economic mechanism behind the Dutch disease is the following: higher domestic demand increases demand for non-traded and traded goods. Traded goods can be bought from other countries, but non-traded goods must be produced at home. The increased demand for non-traded goods pushes up non-traded prices, leading to a real appreciation of the currency, via either nominal appreciation or higher domestic inflation (Corden, 1982; Holden, 2013).

Basedau (2005; p. 10) affirms that the manufacturing sector exhibits important positive side effects ("externalities"), such as learning-by-doing effects or "economies of scale" (i.e. techniques once learned can be used in other sectors) in production. Resource-dependent economies, however, specialise in sectors such as agriculture and mining without these externalities and with a negative impact on growth. Matsuyama (1992) illustrates this effect in an endogenous growth model with externalities in the manufacturing sector. In Matsuyama's (1992) model, an increase in resource technology in a small and open economy pulls labour out of a non-resource industry that benefits from learning by doing and into a resource industry that does not. A resource discovery decreases the level of technology in the non-resource industry and decreases total economic growth (James (2015; p. 56)).

Related to Dutch Disease effects, in the case of Peru, Ticci and Escobal (2015) find that the recent mining boom in Peru has created labour opportunities in the extractive sector and affected internal migration flows, but it has generated negligible spillovers for non-mining activities.
According to Auty and Warhurst (1993), the key dimension of the Dutch disease is the process of displacing or crowding-out non-mining goods from the export profile. The primary driver is a raising exchange rate that makes the exports from local manufacturing industries less competitive[10] (Goodman and Worth (2008; p. 204)).

[10] Davis (2011) finds some evidence of the Dutch disease using international data. Precisely, Davis (2011) argues that most slow growth in resource-abundant economies is attributable to optimally slow growth rates in the resource sector itself.

The Dutch disease is a phenomenon that may appear in countries specialised in producing natural resources, whose consequence can be a lack of diversification of the productive activities in the long-run (Narula, 2018). Indeed, the Dutch disease can accentuate natural resource dependence over time reducing diversification and linkage creation opportunities. Diversification is often advanced as a countermeasure directed against the Dutch Disease and its consequences in terms of resource curse (Andersen et al., 2015). As a matter of fact, diversification can be expected to improve the productivity of the economy, thus counterbalancing the detrimental impacts on productivity offset by the Dutch disease. The focus is often on diversification of the bundle of export products (Hesse, 2008). Diversifying the export bundle allows to better handle external shocks; it is also an occasion for countries to tap into fast-growing and high value-added segments of global markets (UNCTAD, 2022; UNECA, 2007). It is worth adding that export diversity most often reflects industrial diversity in the domestic economy. Industrial diversity is, in turn, strongly related to the level and depth of technological diversity of the economy, which largely reflects the strength and specialisation of the national innovation system and particularly in the business sector (Andersen et al., 2015; Perez, 2015). Hence, the diversification of the productive activities also relates to the diversification of technological activities and innovation.

Nomaler and Verspagen (2021) argue that the acquisition of technological capabilities, both by means of imitation and innovation, provides opportunities for diversification. The theoretical angle also raises questions about the conceptualization of diversification and specialisation of production (export) activities. A part of the (mainstream) literature sees specialisation and diversification as opposites on a scale. While this may have some intuitive appeal, this view is based much more on (casual) empiricism than on theory. From the point of view of Revealed Comparative Advantage (RCA) and the Ricardian trade theory (Ricardo, 1817) that underlies it, diversification increases if the number of products that a country specialises in increases. This makes specialisation rather similar to diversification, rather than its opposite (Imbs and Wacziarg, 2003; Kaulich, 2012; Nomaler and Verspagen, 2021). Regarding natural resources specialisation, Nomaler and Verspagen (2021) find that the countries specialised in natural resources production are the less diversified in their large sample of countries, and that low diversification of productive structure is exclusively associated with low levels of development. It seems that natural resources play a role in inhibiting diversification and thus development. Perez (2015) states that, particularly in the case of developing resource-abundant countries, policies should be able to transform static comparative advantages in natural resources into dynamic advantages, fostering diversification of production in knowledge-intensive activities that are horizontally, vertically and laterally related to the natural resources sector each country chooses to develop. An appropriate policy strategy would promote technical change and would entail creating conditions for learning and innovating that would result in new value-adding processes and in more specialised products with higher and more stable prices and markets. This means that the current opportunity opens the possibility of adding some of the key characteristics of manufacturing to natural resources industries in a process of resource-intensive industrialisation.

5.8 Lack of innovation in the natural resources sector

An extensive literature during the '50s and '60s argued that natural resource-abundant countries needed to encourage a structural change away from the exploitation of natural resources (Prebisch, 1950; Singer, 1950). Authors argued that due to the enclave nature of commodities production, countries would not benefit from the forward and backward linkages between the primary export sector and the

rest of the economy. According to Singer (1950), low-income economies would not be able to handle the technological complexity involved in the extraction and production of minerals. Instead, the country of origin of the mining company was the one that benefited from the technological spillovers from the mining activity. Relatedly, it is worth stressing that Multinational Corporations (MNCs) behaviour provides a key example of changes in the global market context that may affect innovation in the natural resource industry. In the last decades, many MNCs have changed their usual behaviour of acting as an enclave (typically in extractive industries) (Singer, 1949) towards adopting a more decentralised way of operating and taking advantage of local specialised capabilities in host economies (Cantwell, 2001; Dunning, 1994). Natural resource intensive economies can profit from the MNCs' new behaviour and even encourage it. Nonetheless, (developing) resource-abundant countries can also be threatened by multinationals. Narula (2018) argues that large extractive MNCs have the capacity to dominate their host economy, especially the smaller and less developed countries with a single-sector focus. A typical extractive multinational may have global revenues that are equivalent to the GDP (Gross Domestic Product) of many a host economy. They therefore have a natural capacity for regulatory capture and this allows for uneven distribution of rents that favoured the MNC (Girvan, 1970). Moreover, MNCs have the technological capability to access resources in locations that were previously difficult to access, and/or to explore and extract more value from subsoil assets that weaker counterparts would have abandoned[11] (Kraemer and van Tulder, 2009). These technological assets are more about process technologies and are a key source of competitiveness (Narula, 2018).

We describe a set of factors which are creating new opportunities for innovation, dynamism and linkages in the natural resources sector generally (Andersen et al., 2015). Alexandratos and Bruinsma (2012) state that the rise of Asia and the incorporation of the so-called second world to the market system have accelerated the rhythm of growth in the demand for energy, food and raw materials. This increase in the volume of demand has provided opportunities to increase production via innovation. It is worth remembering that the expansion in the production of natural resources can only come from a more efficient and productive use of existing resources, the incorporation of new land or the exploration of new mines that generally demand higher costs due to distance and are less productive, the discovery of new uses of natural resources (Andersen, 2012). Relatedly, the opening of rich but remote mineral deposits became economically possible thanks to developments in transportation technologies linked to mining activities (Alessandri, 2021). The iron ore deposits of the Pilbara in Western Australia and those in Amazonia in Brazil stand as examples of this (Humphreys, 2019). All these possibilities require different types of innovation. In addition, expectations of rising prices and profitability have encouraged such innovations throughout the 2000s.

Another important factor that creates new opportunities for innovation in the natural resources sector relates to changes in science and technology[12]. Some important innovations based on biotechnological advances have been the use of market-assisted selection in plant breeding, using bacteria in mining (mineral processing technologies) and the development of new vaccines for livestock and fish. Natural resource producers are incorporating these new technologies in the production of natural resources and this is questioning the "low-tech" notion of natural resource intensive industries, as well as forming

[11] This is the case of some Latin American countries, e.g. Peru where mining activities are often carried out by foreign MNCs, and at high altitudes and/or remote locations (Molina, Olivari and Pietrobelli, 2016).

[12] Recent advances in Information and Communication Technologies (ICTs) between producers, suppliers and users located in different parts of the world are key to the possibility of innovation to materialise. Local innovations can reach global markets, the needs and demands of users concerned by very specific issues can be attended from all over the globe (Andersen et al., 2015).

and deepening of linkages towards other industries creating new opportunities for diversification (Andersen et al., 2015).

Andersen et al. (2015) believe that innovation-based natural resource intensive development also regards strengthening learning and competence building in natural resource producers to participate in interactive learning and to take advantage of new opportunities emerging for these industries, including cost reduction, product enhancement and mitigating environmental spillovers.

Providing information about new technological opportunities in natural resource intensive activities and building domestic capacity for accessing and utilising international technology and scientific knowledge bases are of utmost importance, especially in developing resource-abundant countries.

Based on this, the lack of innovation in the natural resources sector is the most important resource curse symptom (structural weakness), especially in developing resource-abundant countries. In effect, other structural weaknesses of countries specialising in natural resources production depend on the lack of innovation, e.g. the lack of diversification and linkage creation opportunities (Perez, 2015). Andersen et al. (2015) argue that linkage building is enabled or blocked by development, diffusion and use of new knowledge and capabilities within and around the natural resource activities. It is not enough to have access to abundant natural resources. Nevertheless, if you can build an institutional framework for the utilisation of specific natural resources, which supports development of new knowledge and competences, which may again be applied in a range of different activities, innovation-based natural resource development may be possible. Therefore, the resource curse is not really about natural resources, but about learning (or the absence of it). Natural resources do not make countries poor, but weak innovation systems do. In this context, the lack of innovation in the natural resources sector can also be interpreted as a facilitating factor that worsens the resource curse, when present. Fagerberg (1992) states that export diversification begins with learning and capability building in domestic resource-abundant countries. In this regard, having access to a home market than can serve as a "learning arena" via local-user producer interaction can be an important factor for successful diversification. Innovation in the natural resources sector is paramount to achieve natural resource-based development.

Innovation is an interactive phenomenon and success depends on the ability of firms to cooperate with other parties, e.g. suppliers and customers (Lundvall, 1988). Kuramoto and Sagasti (2006) argue that it often happens that natural resource intensive technology suppliers build competences within rather generic knowledge bases such as automation, ICTs or chemical science. For instance, technology suppliers to the mining industry are heavily engaged in developing software systems in Australia (Smith, 2007). The development of competences with wide applicability enables firms to enter many other industrial activities, thereby promoting diversification. A lack of innovation in the natural resources sector would have undermined this chance in Australia. Innovation in the natural resources sector supports linkage dynamics, including backward (with suppliers) and forward linkages (Hirschmann, 1977; Kuznets, 1971). In regard to backward linkages, we may think of networks of supplier companies that in natural resource intensive industry dynamics play an important role in overcoming the knowledge barriers for linkage formation and deepening (Dietrichs, 1995). In the case of the mining industry, innovation is supplier-dominated according to the Pavitt taxonomy (Pavitt, 1984).

However, in some developing resource-abundant countries, backward linkages do not exist (or are very weak) because machinery purchase and service is likely to be imported from abroad. The reason

why is that the host country does not have an advanced secondary sector (Andersen et al., 2015) and mining companies prefer to rely on foreign suppliers instead of local suppliers, e.g. in Latin America (Alessandri, 2021; Pietrobelli, Marin and Olivari, 2018).

Innovation in the extractive sector is the result of a complex business ecosystem conformed by machinery equipment manufacturers, service providers, mining and junior firms, academia and other organizations. In the case of developing resource-abundant countries (e.g. Latin America), such ecosystem is still underdeveloped despite the importance of the industry. Suppliers in these developing countries are quite heterogeneous in terms of their technological and organizational capacities and most of the interactions between mining firms and suppliers can be described as transactional rather than collaborative (Calzada Olvera, 2021).

The relationship between the pattern of economic specialisation and a country's innovation system is pivotal for economic growth (Fagerberg, Mowery and Verspagen, 2009). Indeed, one view of the role of technology in economic growth holds that a strong high-technology industrial base (consisting in ICTs, biotechnologies, new materials and selected other industries) is necessary for prosperity. However, in the case of Norway (a resource-abundant country that avoided the resource curse), the Norwegian resource-based sectors, i.e. aluminium, oil and gas and fish-farming have for decades been highly innovative, drawing on domestic sources of innovation, technology transfer from foreign sources[13] and Norway's universities and research institutes (Fagerberg, Mowery and Verspagen, 2009). This suggests that fostering innovation in the natural resources sector (and removing this major structural weakness) helps to broaden the range of specialisation patterns of a country's productive activities, thus encouraging diversification[14] (Hidalgo and Hausmann, 2009). Therefore, it allows a country to enter in a condition of dynamic competition based on innovation in a Schumpeterian way (Schumpeter, 1934); it also allows to avert the risks associated to competition only (or mainly) based on prices in a single (or a few) sector(s).

Given the above discussion, we argue that fostering innovation and technological change in the extractive industry is a necessary, but not sufficient condition to achieve natural resource-based development in developing countries. Indeed, a complementary factor is the presence of a relatively high degree of diversification of the productive structure of developing resource-abundant economies.

6. Discussion on resource-based development in developing countries

Section 5 has illustrated a set of structural weaknesses that may appear jointly with a specialisation in natural resources production. When several or many structural weaknesses, (often) caused by natural resources, are present at the same time in a country specialised in extractive industries, that country exhibits the most negative effect on the overall economy, i.e. the resource curse. This section provides possible strategies to avoid the risk of contracting the resource curse and to achieve natural resource-based industrialisation.

There is a stream of literature (see e.g. Marin, Navas-Aleman and Perez, 2015; Perez, 2015) which

[13] The success of this relied on substantial indigenous Norwegian "absorptive capacity".
[14] In this sense, diversification and specialisation are not opposites (Nomaler and Verspagen, 2021).

believes that the changing global market and technological and economic conditions are creating a new context in which developing countries can take advantage of natural resources. Recently, several authors have discussed and identified these transformations (Molina, Olivari and Pietrobelli, 2016). Authors acquaint that, in general, mining activity has become more knowledge intensive and increasingly involved in technological improvements in the different stages of the mining process. Multinationals in natural resources have changed their usual behaviour of acting as enclave towards adopting a more decentralized way of operating, mainly because mining companies have strong incentives to increase the level of outsourcing and near-sourcing in their non-core activities (Molina, Olivari and Pietrobelli (2016; p. 4)). Moreover, mining companies are increasingly re-directing their extraction activities to developing countries, where there are under-exploited resources and less labour and environmental restrictions. This has led to the emergence of specialised suppliers locally.

Due to this recent transformation, a wide literature has emerged trying to understand and explain the linkages and the learning and innovation processes in natural resource industries that can encourage structural change and economic diversification (Ville and Wicken, 2013; Marin, Navas-Aleman and Perez; 2015). This literature challenges the view that natural resource-abundant countries should encourage structural change away from natural resources, and argues that structural change and production diversification should be achieved by working with the resources that countries possess. Thus, natural resource intensive industries may stimulate wider diversification by financing investments in other industries, by setting up infrastructure such as transport, ICT (Information and Communication Technology) and energy with positive externalities for many other activities. Diversification is also possible through the promotion of technical and organisational competence in firms and governments (from participation in global value chains), which could benefit other industries[15] (Andersen et al., 2015).

In the current global context and under the new structure of the extractive sector, new opportunities are emerging for the development of local suppliers associated to mining activities. It is worth stressing that the expansion of the natural resource sector may also enhance the diversification of productive activities through the development of domestic and knowledge intensive industries, which are suppliers and users to the natural resource intensive industries. This is equivalent to promoting the quantity and quality of backward and forward linkages (Hirschmann, 1977) around natural resource production including both manufacturing and service firms, as it happened in Norway (Andersen et al., 2015). Therefore, it is also important that the knowledge developed in relation to natural resources intensive industries "migrates" to other areas of application that are not linked directly to resource production (Lorentzen, 2006). These "lateral" knowledge migration linkages are thus key vehicles of technological diversification induced by activities related to natural resources. It is only rather recently that this has received attention in relation to natural resource intensive economies, especially in developing countries (Andersen et al., 2015). Studies on spillover effects have mainly focused on spillovers between different manufacturing industries rather than between manufacturing, services and the natural resources sector (Castellacci, 2008). Consequently, such spillovers are not well understood nor have they been empirically well explored. Thus, recently, a relatively large body of literature argues

[15] Bjornland and Thorsrud (2015) state that it is paramount to consider the productivity spillovers between the natural resources sector and the rest of the economy. Experience in Australia and Norway suggests that this could be important. Specifically, Bjornland and Thorsrud (2015) found that a booming resource sector has substantial productivity spillovers on non-resource sectors in the two countries examined, i.e. Australia and Norway. Nevertheless, it must be highlighted that the picture is gloomier for Australia, considering that there is evidence of a Dutch disease effect with crowding out and an eventual decline in manufacturing.

that a resource-abundant developing country can remain specialised in the natural resources sector (with a comparative advantage in this sector) and develop at the same time, but under the conditions expressed above. Specifically, one of the most important conditions is to rely on innovation to generate spillovers to other sectors of the economy (Marin, Navas-Aleman and Perez, 2015; Perez, 2015) and benefitting from the local production of higher value-added products along the mining value chain (e.g. mining equipment). However, this does not seem to happen in some developing resource-abundant economies, e.g. Latin America (see Alessandri, 2021; Pietrobelli, Marin and Olivari, 2018). Especially in the case of developing resource-abundant countries, the key to success in progressing beyond the mere export of raw materials is innovation capacity, and that depends on education and continuous learning (Bell, 2006). Perez (2015) states that, whether natural resources are to lead to development, they will have to encompass a very wide network of participants and activities, all with an innovative approach. Without a strong shift towards science and engineering in the education system and without intense and persistent learning efforts on the part of companies and the public sector, success is simply not possible, whatever the strategy (Marin, Navas-Aleman and Perez, 2015). In addition, the countries that first attract the investors and allies who bring the technologies related to natural resource activities, and those that more intensively engage in learning and innovating, acquire dynamic advantages that put them in a better competitive position.

To achieve these goals in developing resource-abundant countries, it would be wiser to adopt a diffuse specialisation pattern of productive activities, avoiding "mono-specialising" and "over-specialising" in natural resources as suggested by Hidalgo and Hausmann (2009). One of the main risks for a developing resource-abundant country is to run into resource curse, a variegated phenomenon which is widely illustrated in Sections 4.2 and 5 as the most negative consequence of a specialisation in natural resources. The adoption of a diffuse specialisation pattern in terms of production is aimed at reducing risks associated to volatility of markets, and increasing diversification/linkage creation opportunities (Hwang, Hausmann and Rodrik, 2007). Indeed, adopting a diffuse specialisation pattern means increasing the level of diversification of productive activities. Relatedly, we consider sector specialisation as a dynamic concept, suggesting that diversification of productive activities and specialisation are not opposites, because a country may specialise in the products in which it has a comparative advantage, but also develop new specialisations over time thus implying some degree of diversification (Imbs and Wacziarg, 2003; Nomaler and Verspagen, 2021). Hausmann, Hwang and Rodrik (2007) stress that specialising in some products will bring higher growth than specialising in others. Everything else being the same, countries that specialise in the types of goods that rich countries export are likely to grow faster than countries that specialise in other goods. Rich countries are those that have latched on to "rich-country products", while countries that continue to produce "poor-country" goods (e.g. natural resources) remain poor. Countries become what they produce and – thus- quality of specialisation matters. Export diversification seems particularly important for countries rich in natural resources (Hausmann, Hwang and Rodrik, 2007). As already mentioned, the influential work of Sachs and Warner (1997) and Auty (1993) has put forward the idea of a natural resource curse, pointing out the fact that countries rich in natural resources usually experience poor economic performance. Consistently with this view, export diversification has often been a stated policy goal of many commodity-dependent countries (Bontadini and Savona, 2019).

Economic development is associated with shifts in economic structure and the source of these shifts is predominantly innovation activities (Kuznets, 1971). Development block dynamics are most likely to emerge from industries with most innovation opportunities. This implies that at any point in time some individual industries are growing more and innovating more than others, and they can therefore

be characterised as "better" for development than others (Andersen et al., 2015). In this context, the possibility of development based on natural resources in both the short and longer run should be seen as complementary to, rather than in competition with, development strategies addressing other aspects of the economy such as manufacturing and services unrelated to natural resources. Innovation based natural resource intensive development should be seen primarily as a sometimes-important element of economic development and not as a development strategy for the national economy as a whole (Marin, Navas-Aleman and Perez, 2015). Thus, innovation is an essential factor to achieve natural resource-based development (Perez, 2015). Andersen et al. (2015) argue that, to understand the development impact, we should be concerned about whether the expansion of the natural resources sector is associated with innovation-driven knowledge intensification of production activities and beyond to enhance productivity, employment and diversification[16].

In this framework, economic development can be understood as a process of accumulation of capabilities that leads to the emergence of new and more complex sectors, which require a larger set of capabilities and higher levels of productivity (Hidalgo et al., 2007; Bontadini and Savona, 2019). Within the product space, natural resources are shown to be among the least complex and, most importantly, among the least connected goods. Consequently, policies encouraging export diversification through beneficiation, i.e. fostering forward linkages and trying to move from natural resources to more downstream manufacturing processing activities, are argued to be ill-advised.

Furthermore, diversification should not only entail productive activities, but also innovation and value-added activities (Andersen et al., 2015; Coveri and Zanfei, 2023; Hidalgo and Hausmann, 2009). A country's diversity of capabilities tends to influence its ability to develop new capabilities, and the speed with which this process unfolds. Thus, an economy with low diversity (as is the case with many developing countries) will, ceteris paribus, have larger challenges in diversifying further and initiating longer term growth (Hidalgo et al., 2007). It is well-known that innovation most often arises from new combinations of existing items of knowledge (Schumpeter, 1934) and that in turn generates novelty and increased diversity. Hence, diversity strengthens innovation potential. When seen from a linkages perspective, the more diversity an economy contains, the larger is the potential for the emergence of new linkages and for innovation. Countries able to develop and retain the capacity to perform a relatively large range of products and particularly of value adding activities are likely to be in a better position to pursue at least two key objectives: (i) fostering the pace of process and product innovation through the interaction between different functions along the GVC; (ii) increasing the resilience of the productive structure in face of both domestic and external shocks by favouring the deployment and recombination of larger sets of competencies and abilities needed to promptly adapt to changed conditions (Coveri and Zanfei, 2023).

The strategies to achieve natural resource-based development, i.e. fostering innovation in the natural resources sector and adopting a diffuse specialisation pattern in many or several sectors of the economy (increasing diversification), must be adopted jointly by developing resource-abundant countries. It is worth adding that encouraging innovation in the natural resources sector and the adoption of a diffuse

[16] Besides strong growth in the demand for natural resources, other changes in the world economy have been radically transforming some of the conditions under which all sectors operate. There is tendency that several manufacturing industries, which were dynamic and high-tech in the past, are now experiencing becoming standardised commodities with low technology content and market dynamism (e.g. some electronic goods, textiles and so on). At the same time many natural resources intensive industries, which were low-tech and with low dynamism in the past, are now dynamic (Perez, 2010). Some key examples are the agricultural, oil and mining industries that have all become high-tech because of massive investments in knowledge by different types of actors.

specialisation pattern are paramount factors to escape from (or to reduce the risk of contracting) the resource curse.

7. Conclusion

According to extant literature, specialising in natural resources production may be a blessing (Classical and Neo-classical economic theory), a curse (Structuralists and Evolutionary economists) or lead to different outcomes in terms of economic development according to the position occupied by a country in the production and commercialisation of mining (Global value chain approach).

Regarding the strengths of specialising in natural resources, the Ricardian trade theories (Ricardo, 1817) and the Heckscher-Ohlin model (Leamer, 1995) suggest that countries should produce and export goods, no matter their quality, using the resources that they have in abundance. It is supposed to be cheaper to produce these goods for the countries that adopt this strategy. However, there are many potential drawbacks of specialising in natural resources production. According to the Evolutionary economists, the higher the share of goods intensive in natural resources, the less dynamic will the export structure be, to the extent that the international demand for goods intensive in natural resources grows at lower rates than the demand for industrial goods, particularly those of medium-high technology (ECLAC, 2008; Cimoli and Porcile, 2011). Moreover, the existence of abundant natural resources can sustain high rates of growth only in the short period. Indeed, in the long-term this reduces the structural capacities of capturing the opportunities of technological progress and to respond to shocks flexibly (Cimoli et al., 2006). It is worth noting that specialising in the manufacturing sector has a higher potential than mining for technological progress (Haraguchi et al., 2017) and it has traditionally absorbed significant quantities of labour, unlike mining activities (Rodrik, 2016). Furthermore, linkages between natural resource production and other sectors have historically been weaker than between manufacturing and the rest of the economy (Greenwald and Stiglitz, 2013). A higher share of technology-intensive sectors gives rise to externalities and increasing returns, spillover effects which boosts growth (Hirschmann, 1977) and allows the transformation of the productive structure towards rents generated by knowledge and learning, rather than by the availability of natural resources (ECLAC, 2010).

In addition, our descriptive evidence suggests that the geographical regions over-specialised in the extractive sector have a less diversified productive structure, e.g. Latin America and especially Sub-Saharan Africa. It seems that this "over-specialisation" or "mono-specialisation" in the production of natural resources has a lock-in effect for developing countries, discouraging these countries in developing new specialisations (which would mean promoting diversification) in other non-resource intensive sectors, such as the manufacturing and the service sector. Contrarily, developed regions that are not overly specialised in the extractive sector (e.g. the European Union and North America) have a more diversified specialisation pattern than developing resource-abundant regions such as Sub-Saharan Africa (see Appendix A).

Specialisation in natural resources is a multifaceted phenomenon not only by considering different streams of literature - with different approaches to this issue - that developed during time, but also depending on the experience of countries. Specifically, the outcome of a natural resource-based industrialization strategy concerns positive experiences (the case of some developed countries such as

Australia, Norway and Canada), intermediate cases (for instance the case of the developing country Botswana) or negative experiences that lead to the resource curse (the case of some developing countries, e.g. Nigeria, Mongolia and Sierra Leone). The most negative effect for a developing country that specialises in producing natural resources is to run into the resource curse, which is the systematic tendency for resource dependence to impede economic growth and development by creating market or institutional failures (James, 2015). However, being characterised by a resource curse may per se be a highly variegated phenomenon, so that one would better talk about "degree" of resource curse, rather than identifying a single level of resource curse. Relatedly, in Section 5, we argue that natural resource specialisation tends to favour, and is hence associated with, the emergence of structural weaknesses (i.e. the neglect of education, weakness of institutions, pitfalls concerning local employment creation, lack of diversification and of innovation) that may hinder development and lead to resource curse. Certainly, if a country shows all (or many) of the structural weaknesses associated to specialisation in natural resources production illustrated in Section 5, that country is resource cursed.

Nonetheless, highlighting the risks of hyper-specialisation in the extractive sector does not necessarily mean that a developing resource-abundant country must diversify away from natural resources. Nevertheless, the specialisation in natural resources production must be accompanied by the adoption of strategies for future diversification of economic activities within GDP (Stevens, 2003; Dam and Scholtens, 2012). Indeed, a potential solution to the problems created by a dominant oil, gas or mineral sector (e.g. the resource curse) is to reduce the importance of the sector in the economy by developing other sources of value added, and avoiding "over-specialising" and "mono-specialising" in the extractive industry (Hausmann, Hwang and Rodrik, 2007; Rodrik, 2016; Dosi and Tranchero, 2021). The lack of diversification of productive activities is one of the main negative factors associated to specialisation (dependence) in (on) natural resources that may be "healed" by adopting a diffuse specialisation pattern in many or several sectors of the economy, as a means to reduce risks associated to the volatility of markets and to increase linkage creation opportunities (Hidalgo and Hausmann, 2009; Narula, 2018). In this paper, we have considered sector specialisation as a dynamic concept, suggesting that diversification of productive activities and specialisation are not opposites, because a country may specialise in the products in which it has a comparative advantage, but also develop new specialisations over time thus implying some degree of diversification (Imbs and Wacziarg, 2003; Nomaler and Verspagen, 2021). Moreover, "mono-specialisation" and "over-specialisation" of countries may hinder their innovation rate, reduce resilience to adverse shocks and changes in global conditions; whereas, countries showing a higher diversification in terms of industry products (Hidalgo and Hausmann, 2009; UNCTAD, 2022) and particularly in terms of global value chain activities (Coveri and Zanfei, 2023) can be better positioned in regards to both these dimensions. Indeed, some degree of functional diversification – i.e. the capacity of countries to carry out a wider range of (high) value adding activities – can be associated with a broader and increasingly diverse set of skills, favours a better exploitation of backward and forward linkages between GVC stages and encourages greater innovation and learning opportunities (Coveri and Zanfei, 2023).

A complementary strategy to reduce the risk of contracting the resource curse that is underpinned in this paper and by economists who can be ascribed to the "Global Value Chain approach" (Marin, Navas-Aleman and Perez, 2015; Pietrobelli et al., 2018) - but also to achieve natural resource-based development - is to foster innovation in the natural resources sector, benefitting from the local production of higher-value added activities along the mining value chain (e.g. mining equipment) and of mining knowledge (Alessandri, 2021; Alessandri, 2023; Marin, Navas-Aleman and Perez, 2015; Perez, 2015). It is worth remembering that the lack of innovation is one of the main structural

weaknesses associated to specialisation in natural resources for developing countries (together with the lack of diversification). Indeed, innovation-based natural resource development has the potential to generate spillovers to other sectors of the economy contributing to the diversification of productive activities (Bjornland and Thorsrud, 2015) and the creation of backward and forward linkages (Hirschmann, 1977; Andersen et al., 2015), as it happened in the case of Australia and Norway[17] (Fagerberg, Mowery and Verspagen, 2015).

Future research addressing the issue of "mono-specialisation" and "over-specialisation" in natural resources production could consider the size of the countries analysed in terms of population and/or extension and their demography. When studies are focused on geographical regions (i.e. groups of countries), it is advised to consider country heterogeneity because there could be different relationships between specialisation in natural resources production and resource-based development across countries. Hence, analyses on this topic can be developed for a geographical region as a whole, but it is also important to separately analyse single countries within the geographical region. In terms of policy recommendations, successful policy requires that industrial and technology policy are both aligned and complementary. This is particularly recommended for developing resource abundant regions such as Latin America and Sub-Saharan Africa. As a matter of fact, resource-based development is not the result of the mere extraction of natural resource commodities itself but rather of the development of productive linkages - especially with medium-high knowledge intensive sectors – which are the basis for diversification of productive activities.

[17] Bjornland and Thorsrud (2015) argue that, for instance, as the development of offshore oil often demands complicated technical solutions, this could generate positive knowledge externalities that benefit other sectors. Moreover, since these sectors trade with other industries in the economy, there may be learning by doing spillovers to the overall economy. This could be an important explanation for the high growth rates observed in the domestic economies (i.e. Australia and Norway).

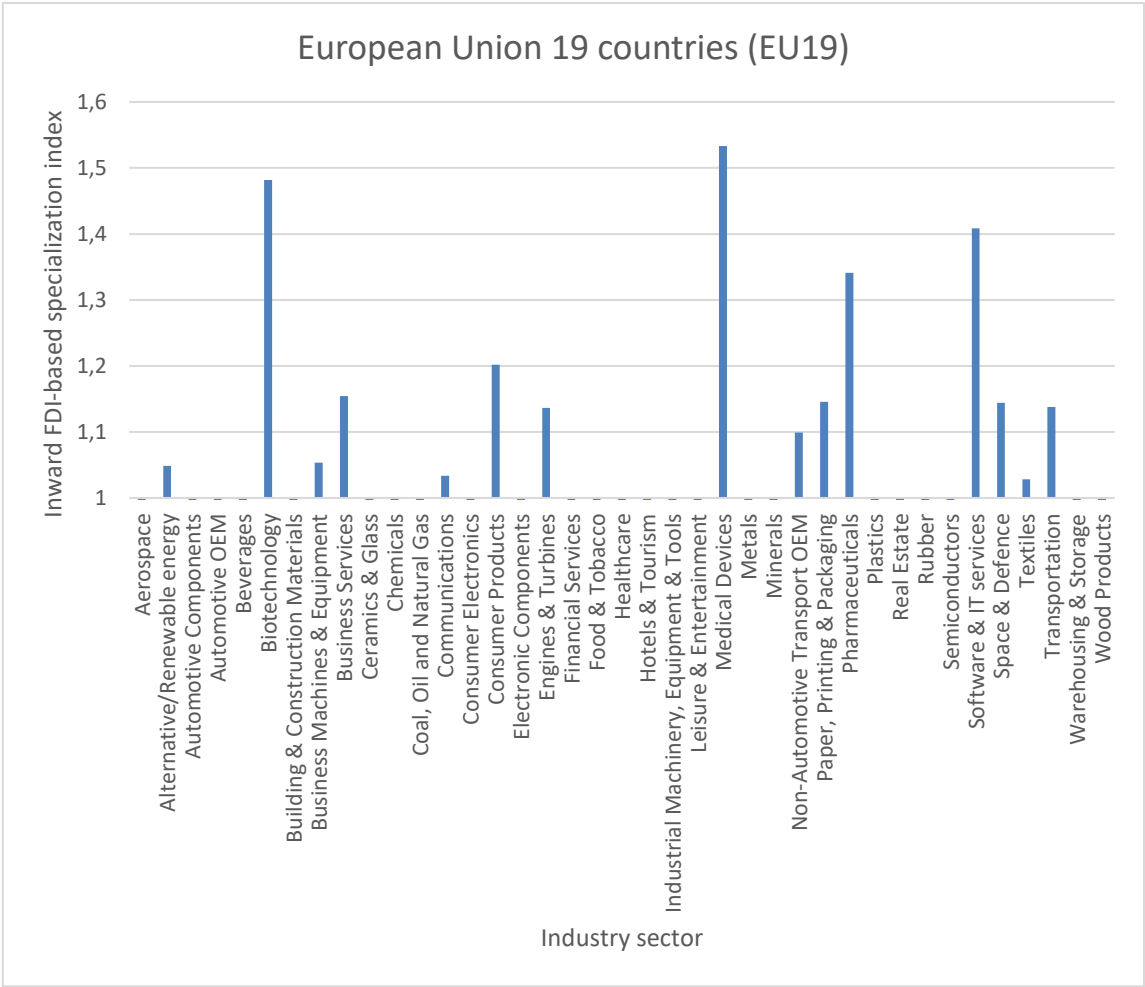
Appendix A

Revealed Comparative Advantage (RCA) based on inward FDI per industry sector, 2003-2017 (average)

Figure A1 portrays the RCA based on inward FDI – measured in terms of number of FDI projects - per industry sector for selected groups of countries worldwide between 2003 and 2017. In Figure A1, bars referring to specialisation in the extractive industry are highlighted in red. Precisely, in fDi Markets Database, the extractive industry is represented by three industry sectors, i.e. "Coal, oil and natural gas", "Metals" and "Minerals".

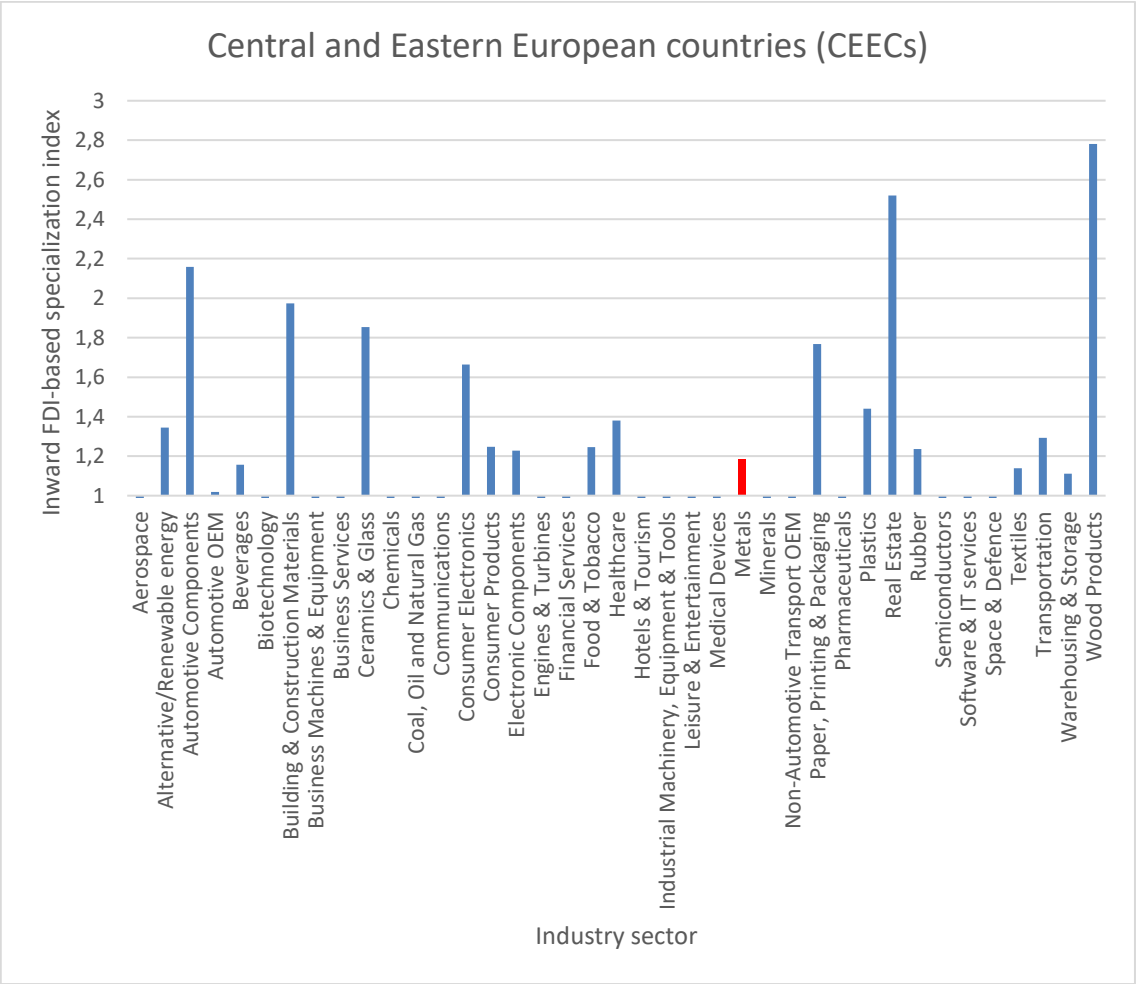
Figure A1 – RCA based on Inward FDI[18] per industry sector for selected groups of countries worldwide, 2003 – 2017

a) European Union 19 countries (EU19)

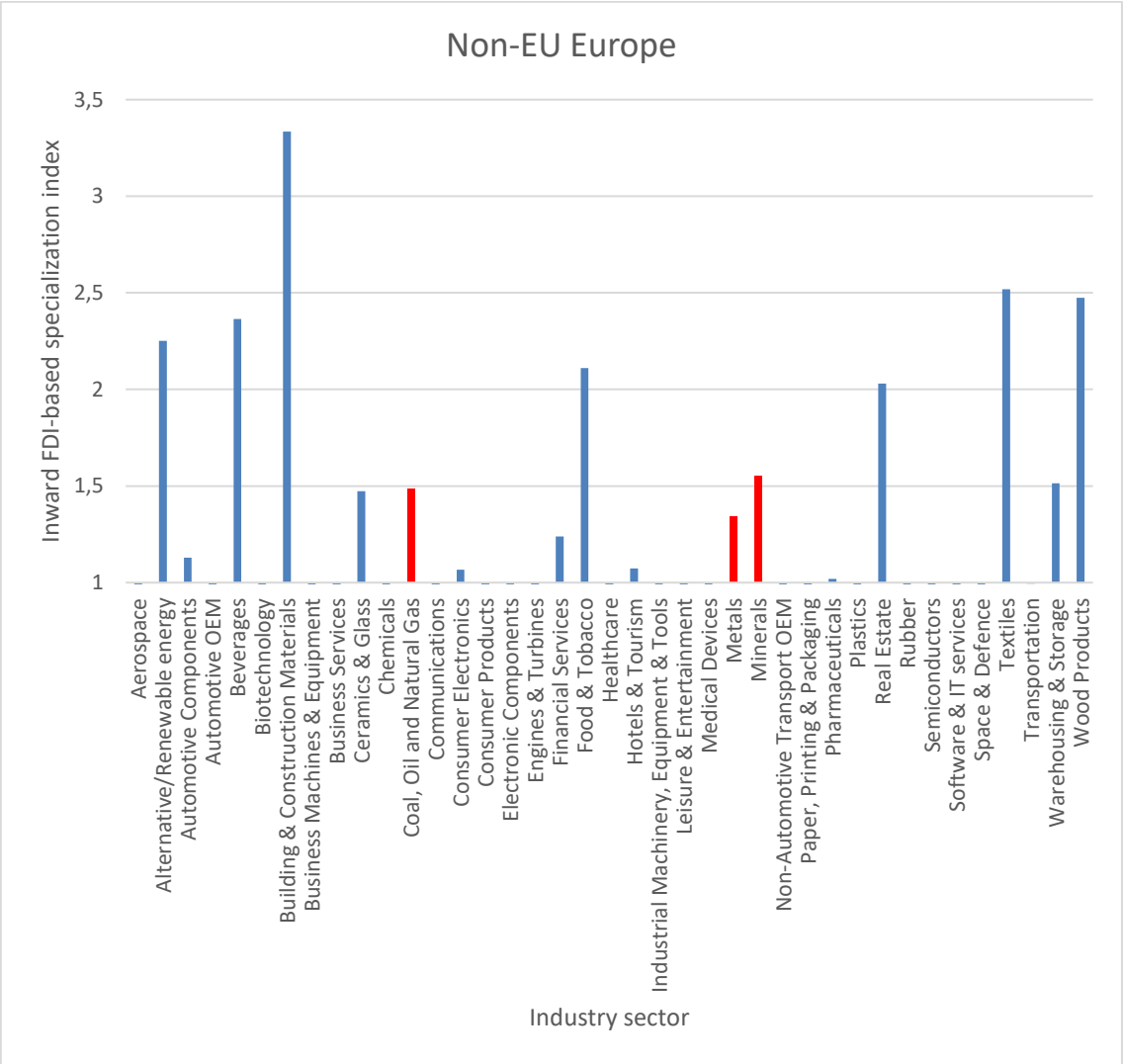


[18] In terms of number of FDI projects.

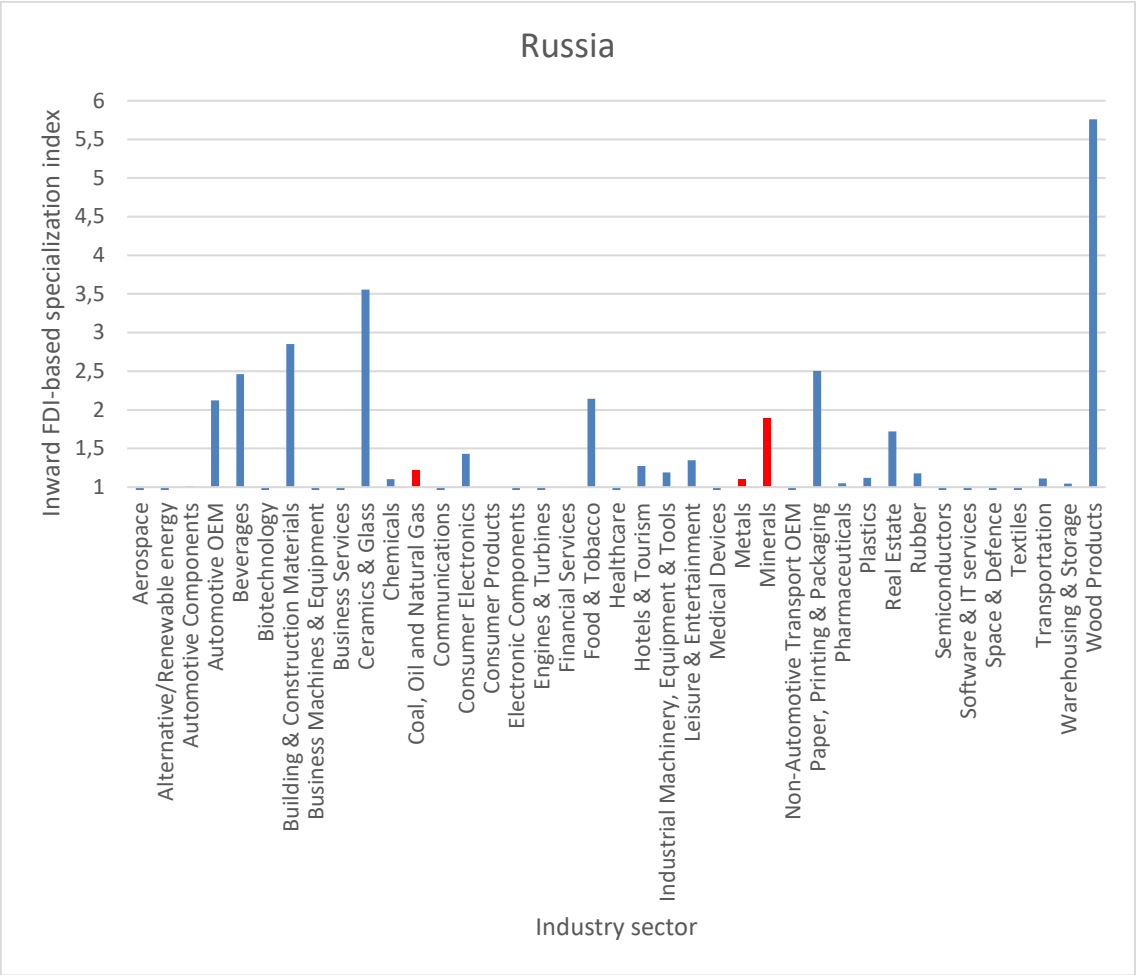
b) Central and Eastern European countries (CEECs)



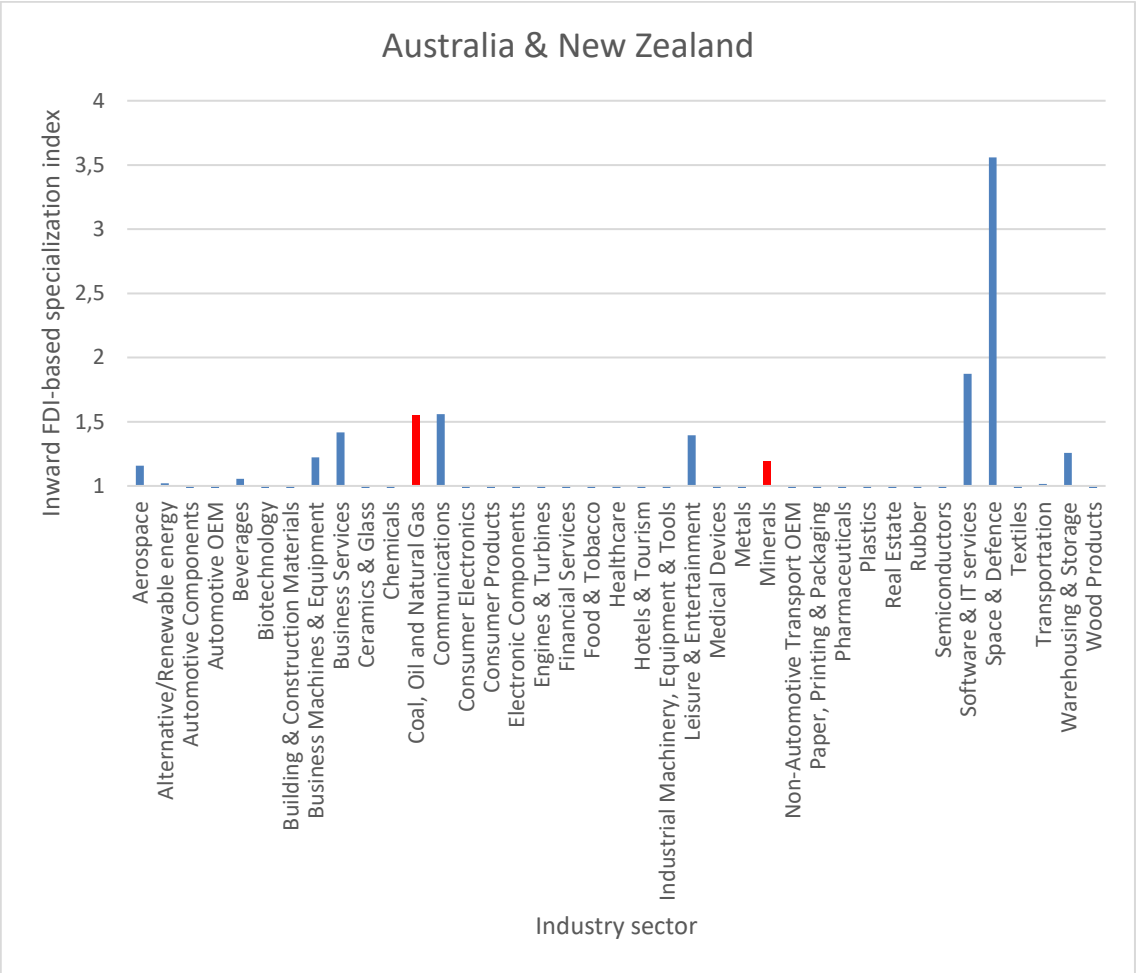
c) Non-EU Europe



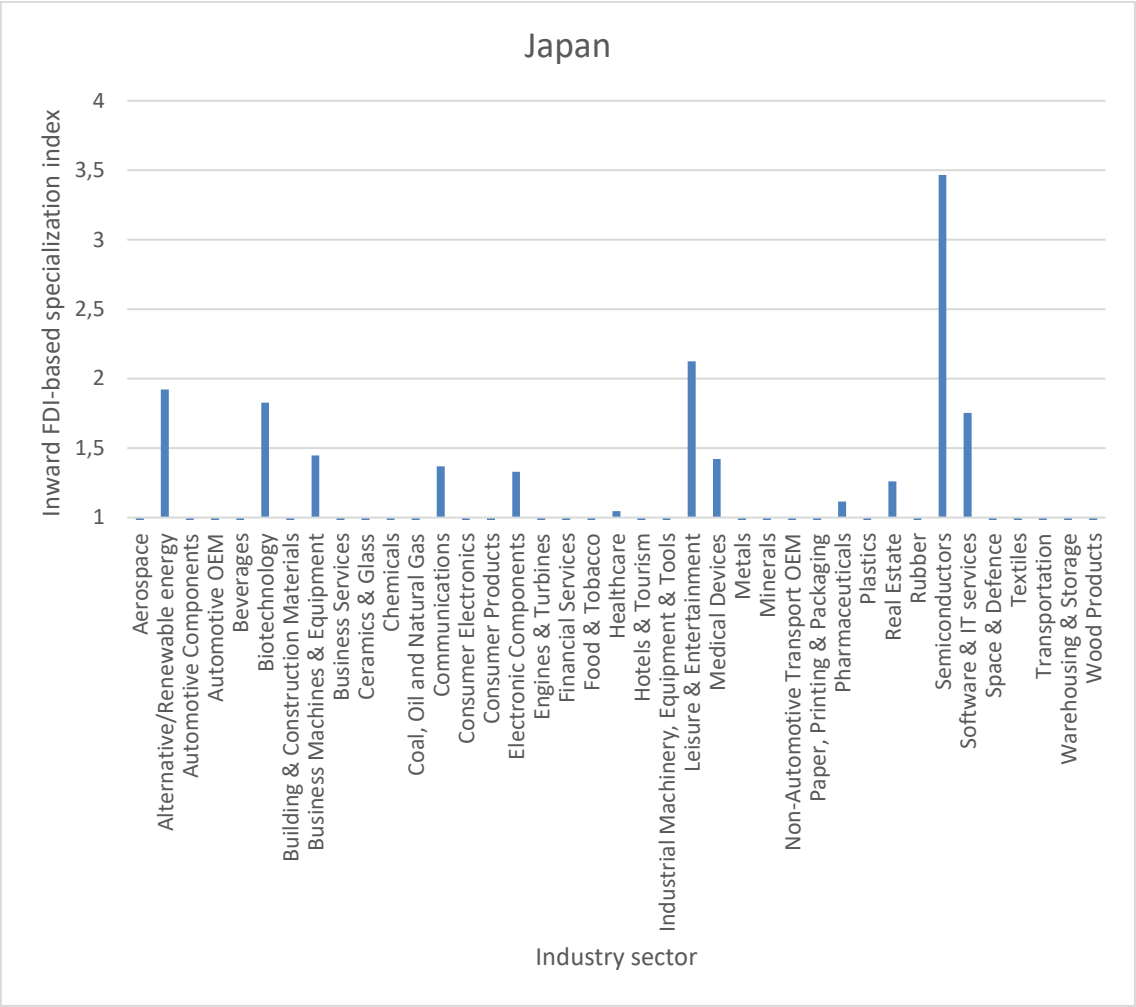
d) Russia


Russia
Inward FDI-based specialization index
6
5,5
5
4,5
4
3,5
3
2,5
2
1,5
1
Aerospace
Alternative/Renewable energy
Automotive Components
Automotive OEM
Beverages
Biotechnology
Building & Construction Materials
Business Machines & Equipment
Business Services
Ceramics & Glass
Chemicals
Coal, Oil and Natural Gas
Communications
Consumer Electronics
Consumer Products
Electronic Components
Engines & Turbines
Financial Services
Food & Tobacco
Healthcare
Hotels & Tourism
Industrial Machinery, Equipment & Tools
Leisure & Entertainment
Medical Devices
Metals
Minerals
Non-Automotive Transport OEM
Paper, Printing & Packaging
Pharmaceuticals
Plastics
Real Estate
Rubber
Semiconductors
Software & IT services
Space & Defence
Textiles
Transportation
Warehousing & Storage
Wood Products
Industry sector

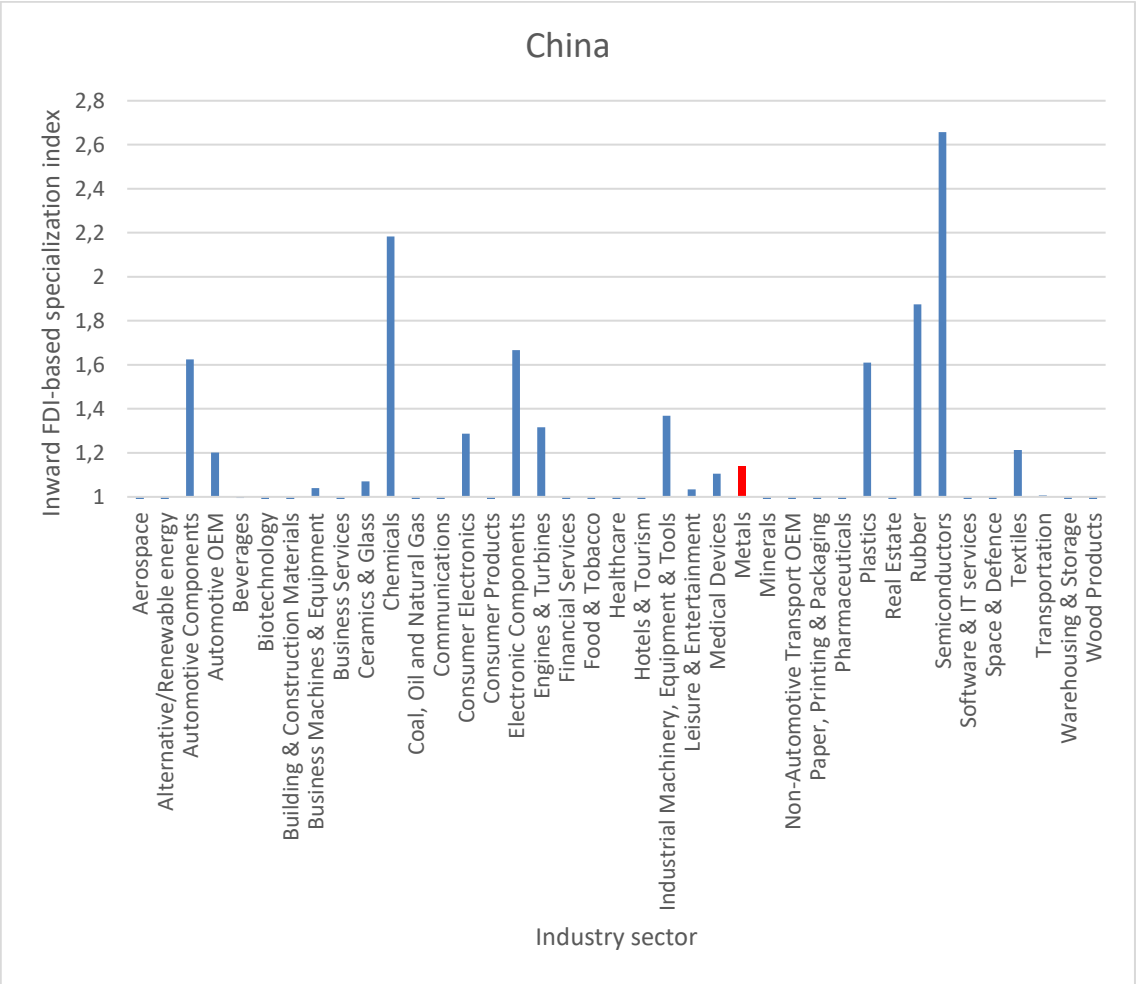
e) Australia & New Zealand



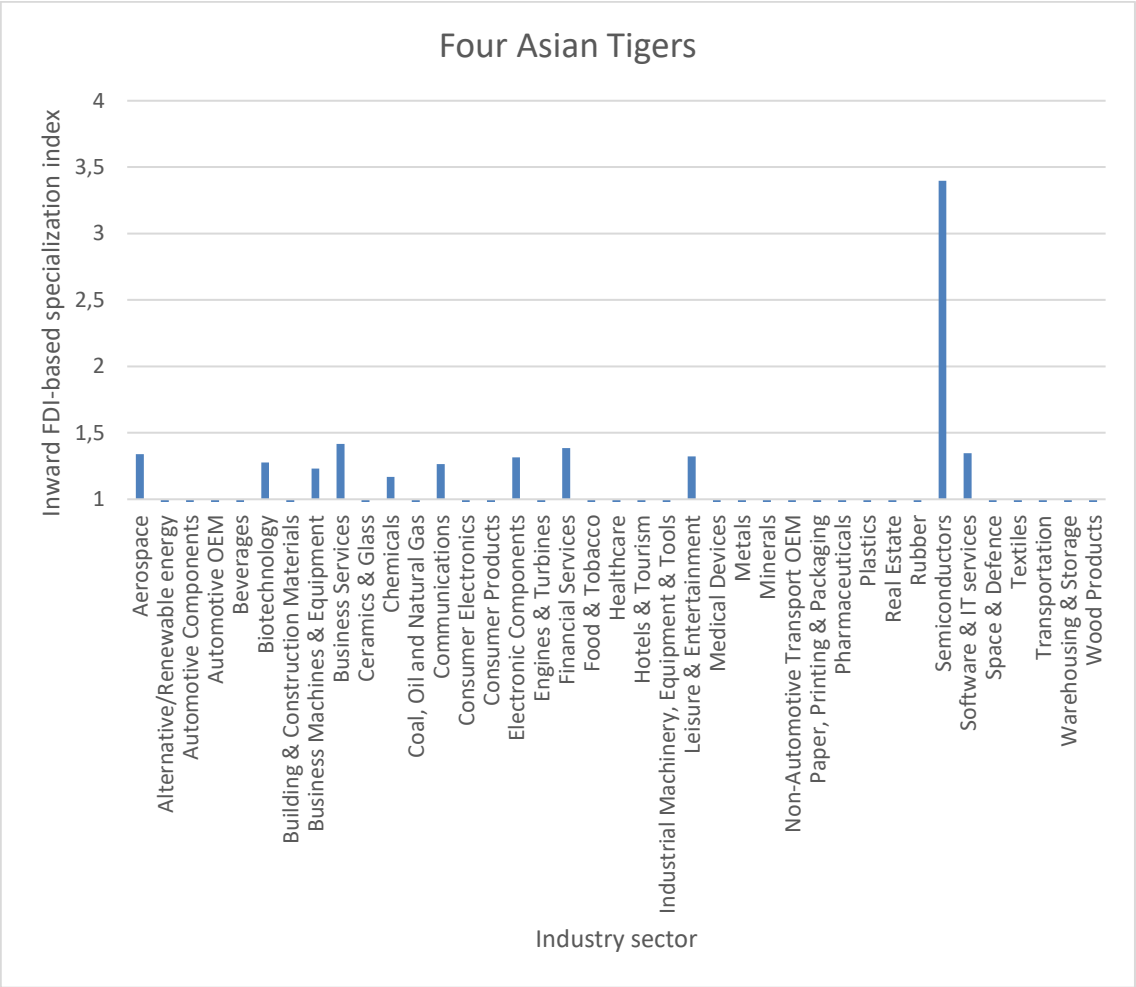
f) Japan


Japan
Inward FDI-based specialization index
4
3,5
3
2,5
2
1,5
1
Aerospace
Alternative/Renewable energy
Automotive Components
Automotive OEM
Beverages
Biotechnology
Building & Construction Materials
Business Machines & Equipment
Business Services
Ceramics & Glass
Chemicals
Coal, Oil and Natural Gas
Communications
Consumer Electronics
Consumer Products
Electronic Components
Engines & Turbines
Financial Services
Food & Tobacco
Healthcare
Hotels & Tourism
Industrial Machinery, Equipment & Tools
Leisure & Entertainment
Medical Devices
Metals
Minerals
Non-Automotive Transport OEM
Paper, Printing & Packaging
Pharmaceuticals
Plastics
Real Estate
Rubber
Semiconductors
Software & IT services
Space & Defence
Textiles
Transportation
Warehousing & Storage
Wood Products
Industry sector

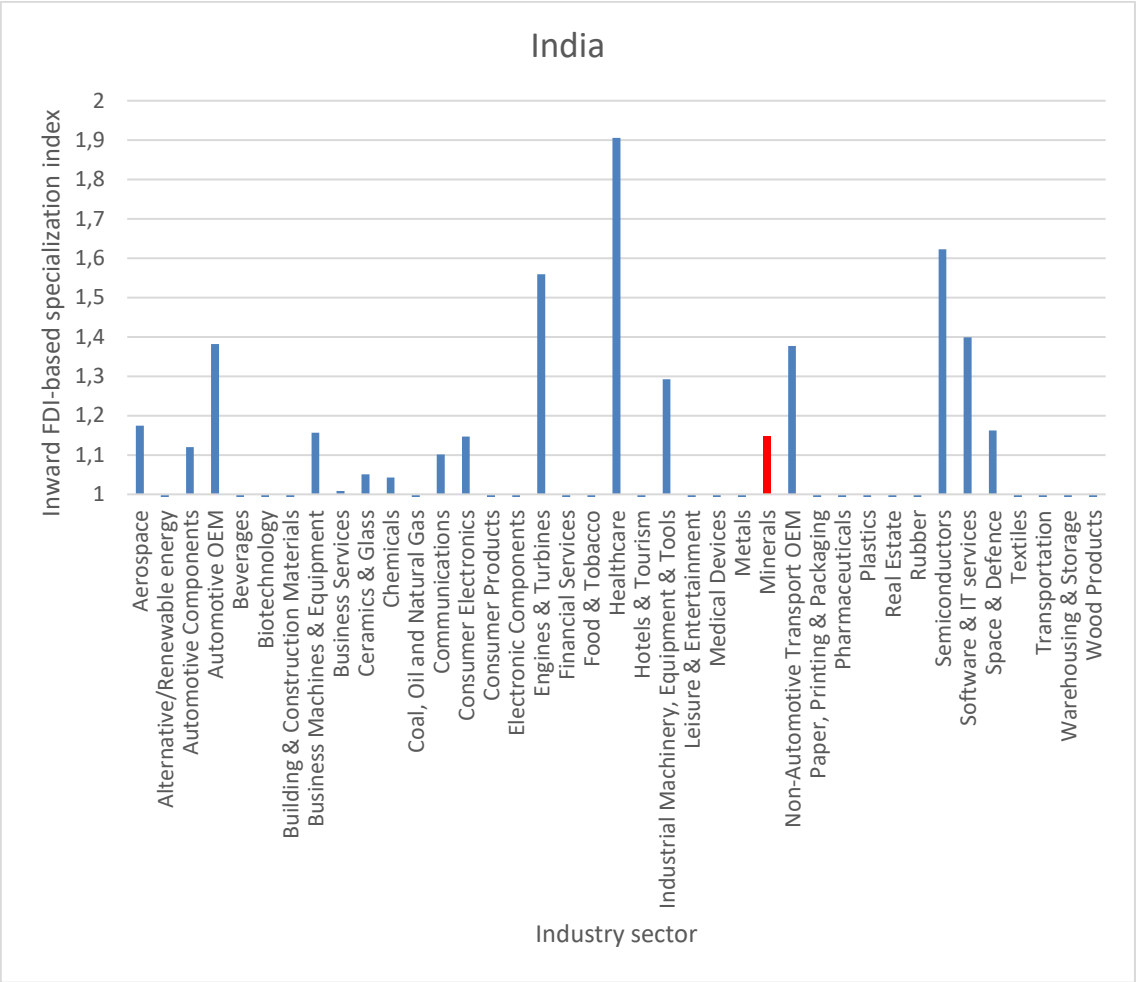
g) China


China
Inward FDI-based specialization index
2,8
2,6
2,4
2,2
2
1,8
1,6
1,4
1,2
1
Aerospace
Alternative/Renewable energy
Automotive Components
Automotive OEM
Beverages
Biotechnology
Building & Construction Materials
Business Machines & Equipment
Business Services
Ceramics & Glass
Chemicals
Coal, Oil and Natural Gas
Communications
Consumer Electronics
Consumer Products
Electronic Components
Engines & Turbines
Financial Services
Food & Tobacco
Healthcare
Hotels & Tourism
Industrial Machinery, Equipment & Tools
Leisure & Entertainment
Medical Devices
Metals
Minerals
Non-Automotive Transport OEM
Paper, Printing & Packaging
Pharmaceuticals
Plastics
Real Estate
Rubber
Semiconductors
Software & IT services
Space & Defence
Textiles
Transportation
Warehousing & Storage
Wood Products
Industry sector

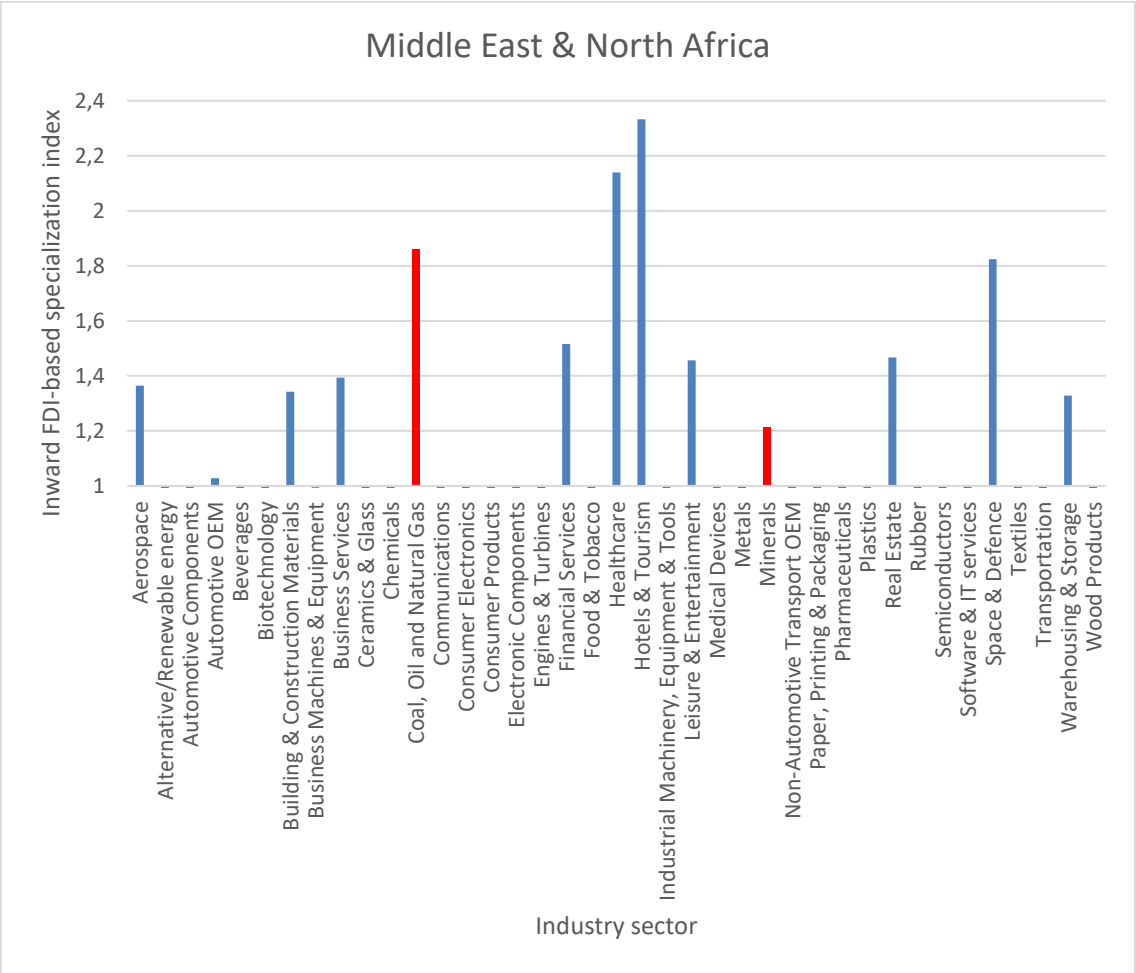
h) Four Asian Tigers



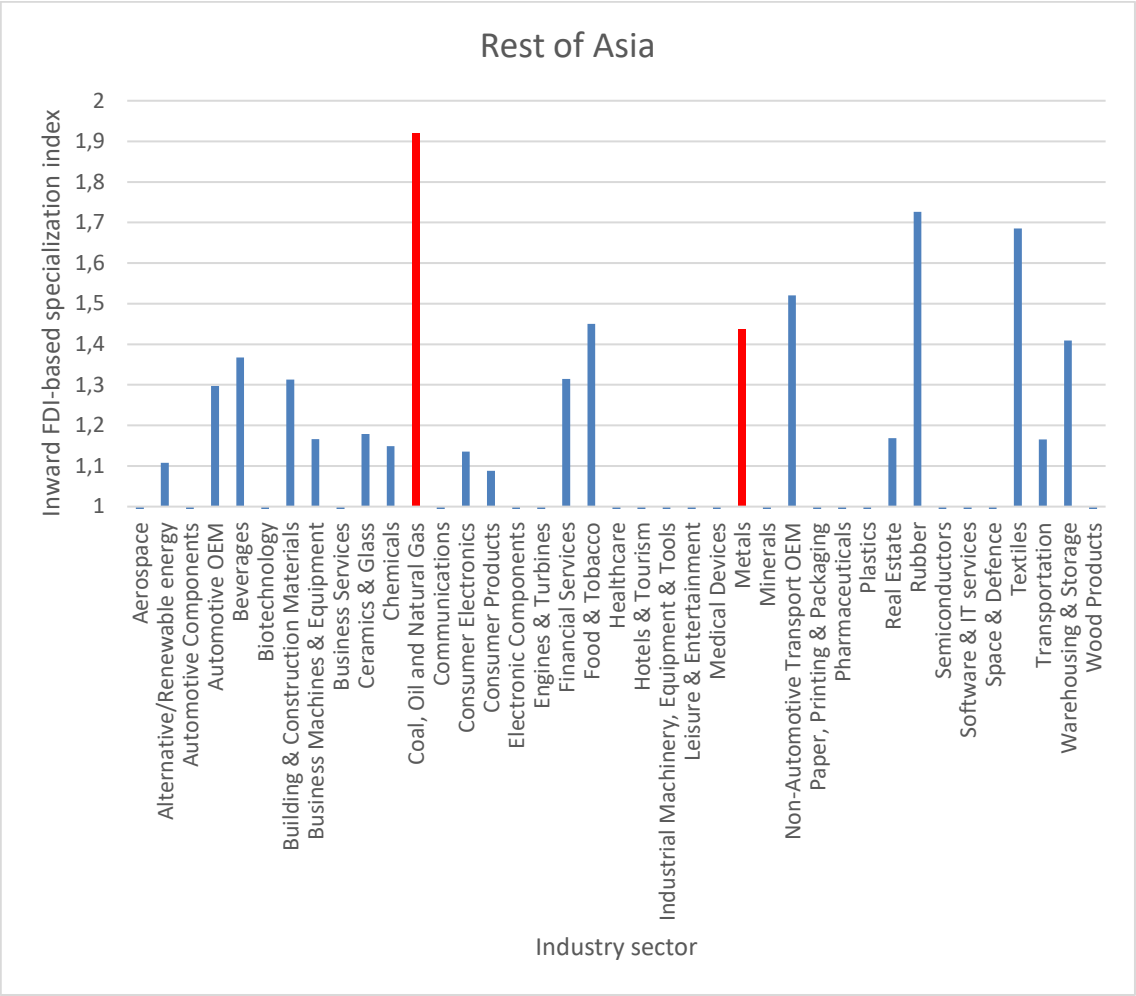
i) India


India
Inward FDI-based specialization index
2
1,9
1,8
1,7
1,6
1,5
1,4
1,3
1,2
1,1
1
Aerospace
Alternative/Renewable energy
Automotive Components
Automotive OEM
Beverages
Biotechnology
Building & Construction Materials
Business Machines & Equipment
Business Services
Ceramics & Glass
Chemicals
Coal, Oil and Natural Gas
Communications
Consumer Electronics
Consumer Products
Electronic Components
Engines & Turbines
Financial Services
Food & Tobacco
Healthcare
Hotels & Tourism
Industrial Machinery, Equipment & Tools
Leisure & Entertainment
Medical Devices
Metals
Minerals
Non-Automotive Transport OEM
Paper, Printing & Packaging
Pharmaceuticals
Plastics
Real Estate
Rubber
Semiconductors
Software & IT services
Space & Defence
Textiles
Transportation
Warehousing & Storage
Wood Products
Industry sector

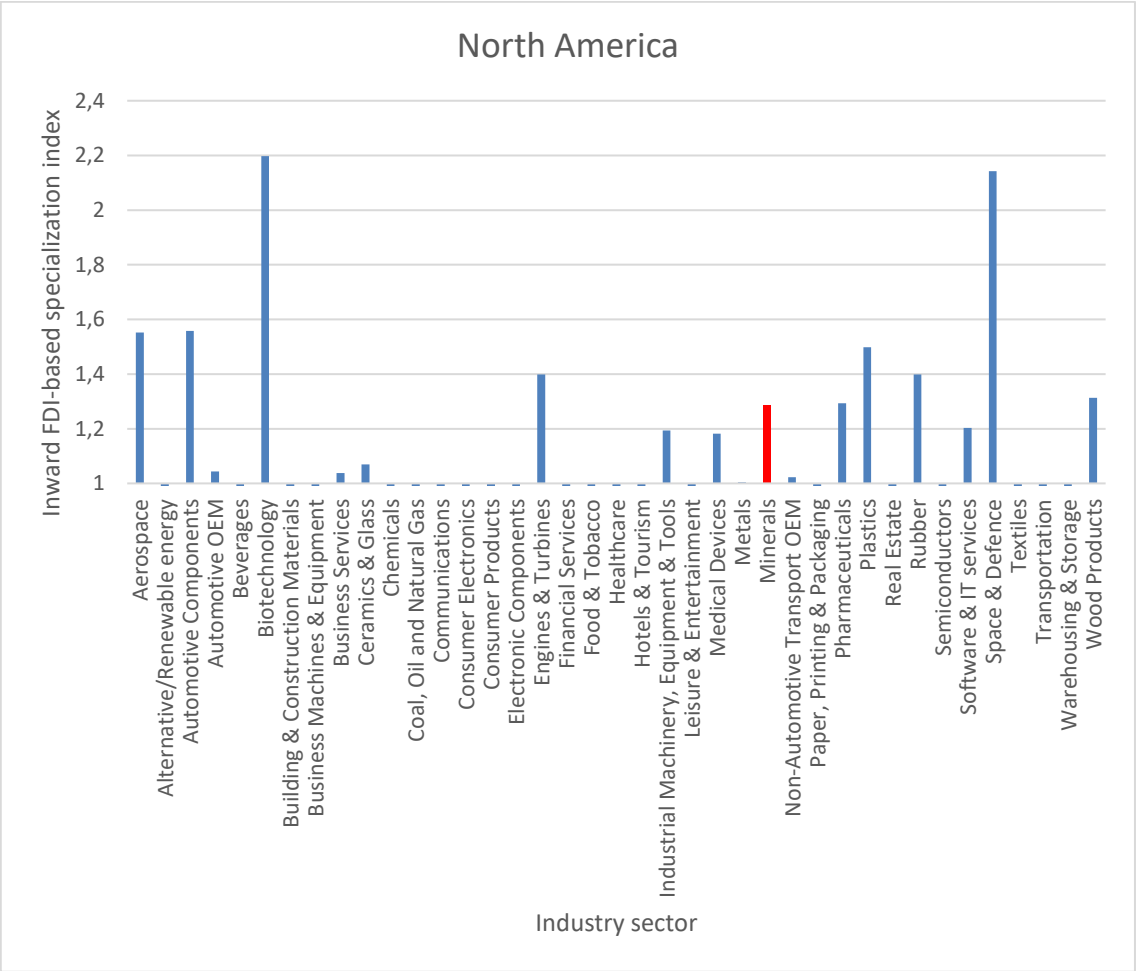
j) Middle East & North Africa



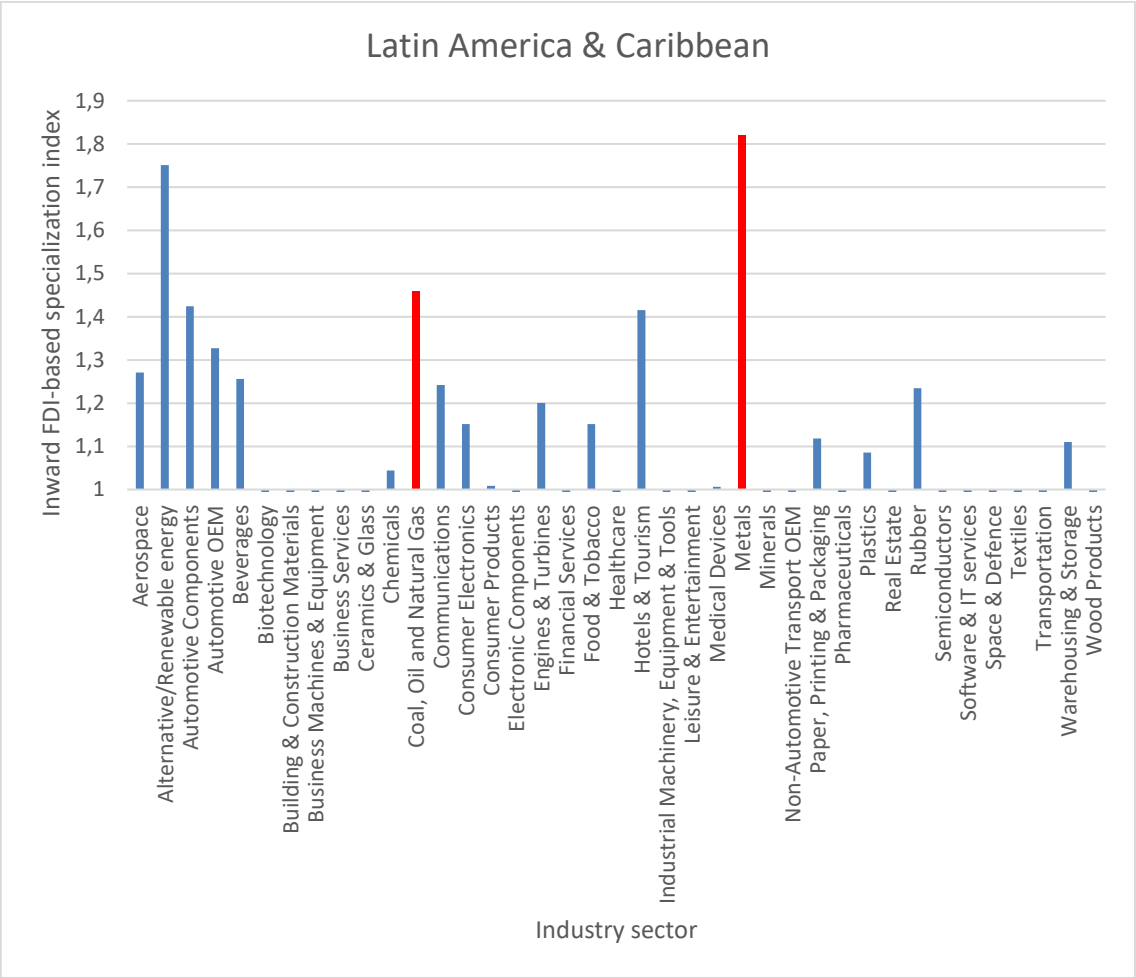
k) Rest of Asia



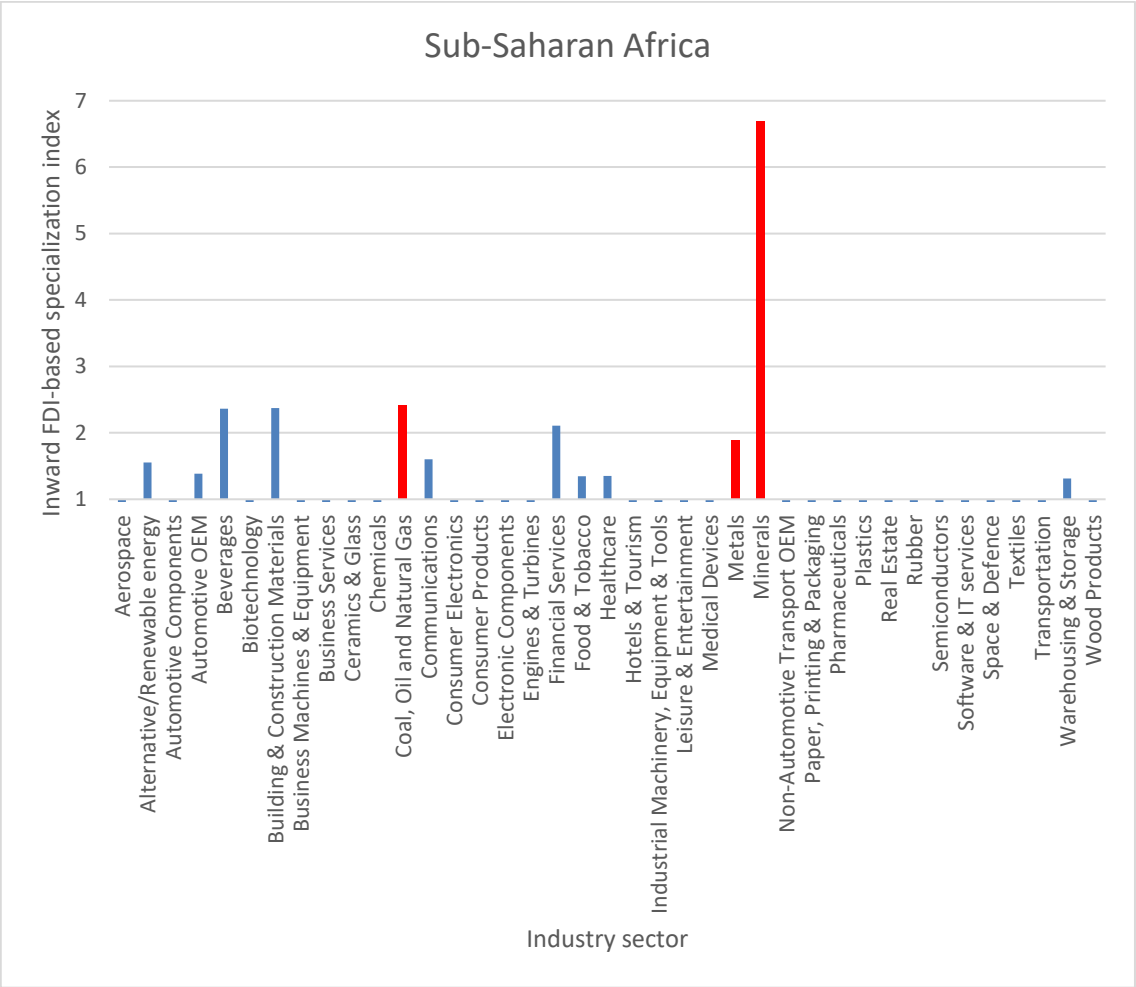
l) North America



m) Latin America & Caribbean



n) Sub-Saharan Africa



Note: the extractive sector includes the following industry sectors:

- Coal, Oil and Natural Gas
- Metals
- Minerals

Source: Author's elaboration based on fDi Markets Database

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