DOCTORAL DISSERTATION SUMMARY

Growth and Diversification Trajectories of Natural Resource Exporters

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1. Research Background

The current state of the subject literature is highly inconclusive with regard to the growth mechanisms of resource-rich countries. As emphasized by Auty (2001), there exists no reason as to why resource abundance should be detrimental. Furthermore, no substantial, theory-supported explanation clarifies why growth led by deposits in resource-rich countries should be less beneficial than growth led by manufacturing in resource-poor countries (Mellor, 1995). At the same time, research results vary significantly depending on numerous factors, and a universal explanation as to why some countries are blessed with natural resources while others are not has yet to be determined.

At the beginning of the twentieth century, primary products were perceived as a driver of accelerated economic growth. The positive effect of natural resources was reinforced by the example of the Golden Age of Economic Growth (1870-1913). During this period, countries with abundant natural resources experienced rapid development and often outperformed those with fewer resources (David and Wright, 1997; Findlay and Lundahl, 2001; Lewis, 2009; Álvarez and Prado, 2022). The Second Industrial Revolution further promoted resource-endowed states by creating a dynamic demand for primary products, particularly those used in steel and fuel production (Badia-Miró et al., 2015).

However, despite a few periods of skyrocketing resource prices and substantial windfalls in the mid-twentieth century, economists began to recognize the negative aspects of resource dependence and started investigating the causes of poor growth in resource-based economies (see among many: Prebisch, 1950; Singer, 1950; Roemer, 1970; Lewis, 1989; Corden and Neary, 1982; Corden, 1984; Neary and van Wijnbergen, 1986; Krugman, 1987; Gelb, 1988; Auty, 1990). One of the first post-war theories to address this issue was the Prebisch-Singer hypothesis (Prebisch, 1950; Singer, 1950). It states that, due to prolonged and unsustainable dependence on raw materials, the price of primary products deteriorates in line with the price of manufactured goods imported by developing resource-rich states.

Another branch of resource literature emerged following the discovery of a large natural gas field in the Netherlands in the late 1960s. This discovery was accompanied by deteriorating economic growth and led to a number of characteristic symptoms, including a rise in the currency value, a worsening of the economy's competitiveness, and an increase in the volume of imports. This phenomenon, known today as "Dutch Disease", was first described by Corden and Neary (1982), and to this very day serves as an example of the negative effects of sudden resource blessing.

The modern discussion regarding the economics of natural resources was shaped by Sachs and Warner's seminal paper from 1995 (Sachs and Warner, 1995). This work presented evidence that economies with a high ratio of primary exports to GDP tend to experience lower growth rates in the future. This direct, negative effect of natural resource intensity was found to be significant even when controlling for important economic growth determinants and introducing alternative measures of resource abundance. The conclusions formulated by Sachs and Warner (1995, 2001) reignited the "natural resources – economic growth" debate in the late twentieth century. The situation in which resource-rich countries are unable to benefit fully from their abundance, performing notably worse than economies without an abundance of primary products, has since become known as the "resource curse" phenomenon (see, among many, Sachs and Warner, 2001; Atkinson and Hamilton, 2003; Mehlum et al., 2006; Torvik, 2009; Arezki and Van der Ploeg, 2010; Horvath and Zeynalov, 2014; Ross, 2015; Farhadi et al., 2015; Sharma and Pal, 2021; Inuwa et al., 2022).

One major objection to the methodology of Sachs and Warner (1995) concerns the selection of the proxy for natural resource abundance. As Brunnschweiler (2008) stressed, choosing between resource abundance and resource dependence can lead to entirely different estimation results. Indeed, the definitions of resource abundance and resource dependence describe two distinct relationships. While resource abundance is directly associated with the quantity of a country's specific resource deposits, resource dependence describes how deeply a country's functioning is subordinated to natural resources. Researchers more frequently choose proxies for resource dependence, since these are relatively easier to obtain or calculate (see, for example: Atkinson and Hamilton, 2003; Bond and Malik, 2009; Elbadawi and Soto, 2012; Boschini et al., 2013; Farhadi et al., 2015; Bahar and Santos, 2018; Destek et al., 2023). However, these indicators are often inadequately assigned as measures of resource abundance. Consequently, they are used to prejudge the occurrence or non-occurrence of the resource curse phenomenon (Crutzen and Holton, 2011; Satti et al., 2014; Gerelmaa and Kotani, 2016; Kim and Lin, 2017; Redmond and Nasir, 2020; Ghecham, 2021; Ridzuan et al., 2021).

When compared simultaneously, natural resource abundance usually exhibits a positive effect on economic growth, while the effect of natural resource dependence is negative (Ding and Field, 2004; Brunnschweiler and Bulte, 2008; Kropf, 2010; Moshiri and Hayati, 2017; Berisha et al., 2021; Ertimi et al., 2022). However, when studied separately, both resource dependence and resource abundance may affect growth positively as well as negatively (Gylfason, 2000; Papyrakis and Gerlagh, 2007; Cavalcanti et al., 2011a; Ben-Salha et al., 2021; Sharma and Paramati, 2022; Khan and Khan, 2023).

While seeking a universal explanation as to why some countries are blessed with natural resources while others are not, researchers have proposed answers that seem to bring us closer to the truth. The most common one is the quality of institutions and governing bodies (see, among many: Atkinson and Hamilton, 2003; Isham et al., 2005; Mehlum et al., 2006; Boschini et al., 2007; Torvik, 2009; Boschini et al., 2013; Farhadi et al., 2015; Shittu et al., 2022). Other studies have suggested that discrepancies between resource-rich and resource-poor countries are due to the level of trade openness and financial development (see, for example: Lederman and Maloney, 2009; Van der Ploeg and Poelhekke, 2009; Satti et al., 2014; Destek et al., 2023; Mesagan and Vo, 2024).

Additionally, resource economists emphasize that the paradox of plenty is more likely to occur with certain types of primary commodities, such as precious minerals (e.g. diamonds) (Papyrakis and Gerlagh, 2004; Olsson, 2007; Butkiewicz and Yanikkaya, 2010; Van der Ploeg, 2011; Belarbi et al., 2016) as well as fossil fuels (Isham et al., 2005; Tsui, 2011; Badeeb and Lean, 2017; Cuevas Ahumada and Calderón Villarreal, 2022; Ertimi et al., 2023). Nevertheless, and in line with the inconclusiveness of research mentioned earlier, the literature provides several examples of the beneficial effects of oil on economic growth (Alexeev and Conrad, 2009; Cavalcanti et al., 2011a; Cotet and Tsui, 2013; Altaee et al., 2022). Interestingly, forestry rents have also been found to exhibit a positive effect on economic growth compared to oil and mineral rents (Naidoo, 2004; Ofori and Grechyna, 2021; Nkemgha et al., 2022; Zarach and Parteka, 2023). This finding aligns with the concept of successful forestry-based economies such as Canada, Latvia, New Zealand, Sweden and Finland (De Ferranti et al., 2002).

Throughout the decades, the role of natural resources in growth mechanisms has undergone a gradual transformation. In the era of classical growth theories, which focused on the agents that promoted or hindered societal development (Harris, 2007), land and raw natural resources were considered as the most essential factors of production and the most important forms of wealth. (Weil, 2014). However, due to their fixed supply, natural resources imposed strict limits on long-term economic growth (Eltis, 1984).

Neoclassical growth models usually disregarded natural resources as a contributor to economic growth in their basic form. Nevertheless, incorporating restrictions on exhaustible natural resources and land could provide a more accurate understanding of the prerequisites for growth (Nordhaus, 1974; Stiglitz, 1974a & 1974b; Nordhaus et al., 1992; Cavalcanti et al., 2011b). In the Solow-Swan model, higher rates of resource extraction result in lower rates of long-term steady-state growth as the economy converges to a balanced growth path (Zhang et al., 2022). Therefore, the greater the dependence on natural resources in the production process, the greater the drag on growth (Gylfason and Zoega, 2006). Nonetheless, once exogenous technological progress outpaces the limitations imposed by scarce natural resources, sustainable growth in output per worker may be possible (Romer, 2010; Maris and Holmes, 2023). Incorporating endogenous technological change into growth theory enables us to examine the relationship between natural resources and economic growth from a different perspective. This approach emphasizes renewable resources and introduces the concepts of environmental constraints and environmentally friendly innovations. It simultaneously analyzes the impact of these factors on economic development as well as the regulatory role of directed technological change in promoting the more efficient use of non-renewable resources (Maris and Holmes, 2023).

The literature also highlights the role of natural resources in the process of structural change in the patterns of export diversification. In fact, natural resources are among the most frequently cited negative factors influencing export diversification (Jetter and Ramírez Hassan, 2015; Giri et al., 2019; Vogel, 2022). Concerns about the relationship between the specialization of resource exports, deteriorating terms of trade and slow growth date back to the works of Singer (1950) and Prebisch (1950), but have also been confirmed by modern studies (Harvey et al., 2010; Arezki et al., 2014). However, the development issue, which trade theory associates with resource abundance, may not be rooted in abundance itself, but rather in the strong specialization (or in other words dependence) of only a few types of primary commodities. In this scenario, as emphasized by Badeeb et al. (2017) and Karl (2005), the diversification in the basket of exported natural resources is insufficient to sustain general growth. Indeed, low-income, resource-dependent countries typically struggle with excessive export specialization (Bond and Malik, 2009; Bacchetta et al., 2010; Hattendorff, 2014; Bahar and Santos, 2018). Over time, this inhibits export diversification (Newfamer et al., 2009; Handoyo and Ibrahim, 2021).

Some studies on patterns of specialization and resource dependence also address the question of whether some countries, particularly those rich in natural resources, are excluded from the technological race. According to Fagerberg and Verspagen (2021), there is a significant disparity between economies that specialize in advanced technological production and those that depend almost exclusively on natural resources. Resource exporters lag in technology and income. Furthermore, Foster-McGregor et al. (2019) argue that only the most developed countries can specialize in 4IR technologies. However, Zarach and Parteka (2023) analyzed a large sample of 160 countries and found that some resource-dependent countries - specifically high-income oil exporters - can transition from complete resource dependence to producing technologically advanced products.

2. Research Gap and Objectives

The conclusions from the literature review presented in Chapter 2 of the dissertation highlight the continued economic importance of natural resources, despite the dominant role of technology in today's world. With primary products accounting for approximately 18% of global trade (CEPII, 2023) and almost all total exports in selected resource-dependent countries, the persistent issue of unsuccessful resource-led development must be addressed. Thus, based on the current state of the art, four research gaps were identified:

RG1. The existing literature is highly inconclusive regarding the growth mechanisms of resource-dependent countries. The results obtained vary considerably depending on the employed resource proxy or the composition of the analyzed country sample (Brunnschweiler and Bulte, 2008; Ji et al., 2014; Auzer, 2017; Ben-Salha et al., 2021; Tahir et al., 2023).

RG2. Only few empirical works have examined the effects of more than two natural resource types (see Ofori and Grechyna, 2021; Inuwa et al., 2022, and Nkemgha et al., 2022, for exceptions). Studying various types of natural resources simultaneously remains crucial, as the resource literature emphasizes that certain primary commodities yield different growth and diversification effects (Olsson, 2007; Tsui, 2011; Badeeb and Lean, 2017; Ertimi et al., 2023).

RG3. While several case studies (David and Wright, 1997; De Ferranti et al., 2002; Ville and Wicken, 2013) have demonstrated that resource dependence does not exclude technology-based growth, the literature provides limited evidence on the potential link between natural resources and economic restructuring towards technologically advanced production.

RG4. The role of resource dependence in export diversification trajectories has not been sufficiently addressed, particularly in the case of low-income resource-rich countries, exposed to the risk of excessive export specialization. In particular, to the best of my knowledge, the resource-based decomposition of the export diversification curve, which depicts the relationship between trade structures' heterogeneity and economic growth process (De Benedictis et. al., 2009; Cadot et al., 2011a; Parteka and Tamberi, 2013b; Gnidchenko, 2021; Parteka et al., 2025), has not yet been conducted.

On the basis of identified research gaps, this doctoral thesis, through a set of descriptive and empirical evidence, as well as country-specific examples, aims to demonstrate that a country's dependence on natural resources does not necessarily lead to economic difficulties or an inability to achieve technological advancement. Thus, the primary objective of this dissertation is **to reassess the role of natural resource dependence in the processes of economic growth and export diversification, and to determine how technological progress influences this relationship**.

The main research hypotheses, that support the primary objective of the thesis are as follows:

H1. Resource-dependent countries are not excluded from technology-based growth.

H2. Intensive natural resource exports foster productivity growth, and this effect is enhanced by technological specialization.

H3. Resource dependence slows the diversification process and is responsible for excessive export specialization at low levels of development.

H4. The diversification trajectories of resource exporters are determined by technological innovation.

H5. The effects of resource dependence on growth and diversification trajectories differ for various types of natural resources.

H1 examines specific case studies that confirm that resource rents stimulate technological innovation, which initiates the process of diversifying away from resource exports towards more technologically advanced products. This is a process in which certain resource-rich countries are already engaged. H2 studies the relationship between productivity growth and resource dependence, verifying the role of technological innovation in this relation. H3 employs the resource-based decomposition of the diversification curve to determine if and how natural resources influence the dynamics of export diversification. H4 identifies the key factors that influence the relationship between export diversification and natural resource exports. This provides a deeper understanding of diversification trajectories in resource-dependent countries. Finally, H5 addresses the diversity of growth and diversification outcomes among various types of natural resources.

This dissertation consists of six chapters and is structured as follows. Chapter 2 (following the Introduction – Chapter 1), provides a comprehensive overview of the literature on three key topics: (1) the relationship between natural resources and economic growth, including a review of the core economic growth theories, (2) structural change literature and the role of natural resources in the diversification dynamics, and (3) the growth effects of technological progress and the modern productivity paradox.

Chapter 3 describes a research methodology, focusing on: (1) the creation of the country-level database with data on trade flows and various macroeconomic indicators, (2) the creation of product-level taxonomies that cluster product codes into groups of natural resource-related and technologically advanced products, (3) the measurement of countries' comparative advantage, as well as absolute and relative specialization in natural resources and technologically advanced products, and (4) the decomposition of the relative (weighted) Theil index of export diversification and the computation of the export diversification curve based on this decomposition.

Chapters 4 and 5 present the outcomes of the empirical analysis, based on a dataset of 160 countries observed in the period 1996-2021. Chapter 4 examines the growth trajectories of resource-dependent economies and verifies the role of technological specialization in the relationship between natural resources and productivity growth. Chapter 5 verifies the role of resource dependence in the diversification trajectories. Furthermore, it addresses the question of whether natural resources drive high export specialization by presenting a resource-based decomposition of the relative Theil index. Chapter 6 concludes the thesis and discusses some policy implications of the findings. The key results are reported in the main text, while numerous additional materials and robustness checks are included in the appendices.

The research leading to this doctoral thesis was performed within the research project "Technological specialisation and productivity divergence in the age of digitalisation, automation and AI" financed by the National Science Centre (NCN, Poland) (OPUS 19, decision number DEC-2020/37/B/HS4/01302; PI: Aleksandra Parteka).

3. Methodology

The research methodology employed in this dissertation is based on the following four steps:

(1) The creation of the country-level database with data on trade flows and various macroeconomic indicators.

This dissertation adopts an approach, where key explanatory variables are created using raw, disaggregated export data and newly developed product-level taxonomies. These variables include natural resource dependence, proxied by the share of natural resources in a country's total exports, and technological specialization, proxied by the share of technologically advanced products in a country's total exports. The BACI CEPII database (CEPII, 2023) was identified as the optimal source of disaggregated trade flows, owing to its capacity to provide comparable cross-country data.

The trade database was completed by incorporating various country-level macroeconomic characteristics (data on GDP, population, employment, income classification and the annual resource price indices of selected natural resources) as well as a set of control variables (data on technological innovation, trade openness, investment levels, the Human Capital Index, natural resource rents, the quality of governance, the country's status as a landlocked nation, the distance to its closest major port (in km), the timing of its independence and country's colonial past). The completed database covers the period from 1996 to 2021.

(2) The creation of product-level taxonomies.

For the purpose of this dissertation, natural resources are defined as products belonging solely to the mineral and forestry resource categories. These correspond to categories 3 (fuels and mining products) and 4 (forestry products) of the 2010 WTO World Trade Report (Bacchetta, 2010) resource classifications. All agricultural resources are excluded from consideration. Product codes from these categories have been further categorized into the four primary and three secondary resource groups used in this dissertation: *FORESTRY, FUEL (*including *COAL, NATURAL GAS* and *PETROLEUM OILS), METAL,* and *MINERAL.* The *TOTAL NR* cluster encompasses all of the aforementioned resource groups.

Subsequently, technological classifications were established to encompass products that are broadly defined as "technologically advanced", as well as those that fall within specific technological domains. Thus, separate classifications were created for products related to the Fourth Industrial Revolution (*4IR*), Information and Communication Technology (*ICT*), and broadly defined medium-tech and high-tech products (*TECH*). The 4IR taxonomy, used in a joint work of Parteka et al. (2025), builds on the classifications of AI-related products by Domini et al. (2021) and Foster-McGregor et al. (2019). The *ICT* and *TECH* classifications were derived from UNCTAD technological categories based on the SITC-3 nomenclature, which was initially defined by OECD (2011b) and Lall (2000), respectively.

(3) The measurement of countries' comparative advantage, as well as absolute and relative specialization in natural resources and technologically advanced products.

In order to quantify countries' dependence on certain types of products and verify its effect on economic performance, this dissertation uses indicators of export specialization and Revealed Comparative Advantage (RCA). The methodological approach used to compute those indices is built on the work of Bowen (1983), Ballance et al. (1985), Iapadre (2001), OECD (2011a), and Laursen (2015).

The RCA index, based on the original Balassa index, is computed as the ratio between a share of a specific product in the country's overall exports and the share of this product's global exports in the world's overall exports (Halilbasic and Brkic, 2017). Following the work of Parteka (2010), Mau (2016), and Gnidchenko (2021), both absolute and relative indicators of specialization were calculated using the Theil index. In the context of exports, the Theil index can be used to detect inequality in export shares and gauge export specialization (Brückner, 2023).

Absolute measures describe the extent to which a country specializes its export activities in a small number of product groups, independent of global trends. In contrast, relative measures compare a given country's export specialization structure to a common global benchmark. This doctoral thesis favors the relative form of the Theil index since, as posited by Gnidchenko (2021) and Parteka and Tamberi (2013a), relative measures are more suitable for analyzing export diversification in a panel data setting as they compare the export structure of a given country to a common benchmark (i.e. the rest of the countries considered). All measures were computed for each year within the 1996-2021 timespan and for every group of products, as defined by alternative taxonomies of natural resources and technologically advanced products.

(4) The decomposition of the relative Theil index of export diversification and the computation of the export diversification curve.

Decomposing the relative Theil index facilitates the identification of the factors driving diversification processes at different stages of development. This dissertation adopts the approach outlined by Parteka et al. (2025), whereby changes in the overall level of export diversification are explained by the heterogeneity adjustments in particular groups of products. These adjustments can be measured by decomposing the relative Theil index into between (B) and within (W) group components:

$$RT^c = RT^c_{(B)} + RT^c_{(W)} = \sum_g \left[S^c_g * ln\left(\frac{S^c_g}{S^w_g}\right)\right] + \sum_g \left[S^c_g * RT^c_g\right] \qquad (1)$$

where:

- g – group of products (e.g. *NR, TECH*);
- S^c_g, S^w_g – share of group *g* in total exports of country *c* (world *w*);
- RT^c_g – relative Theil index calculated using product-level export data belonging only to group *g*.

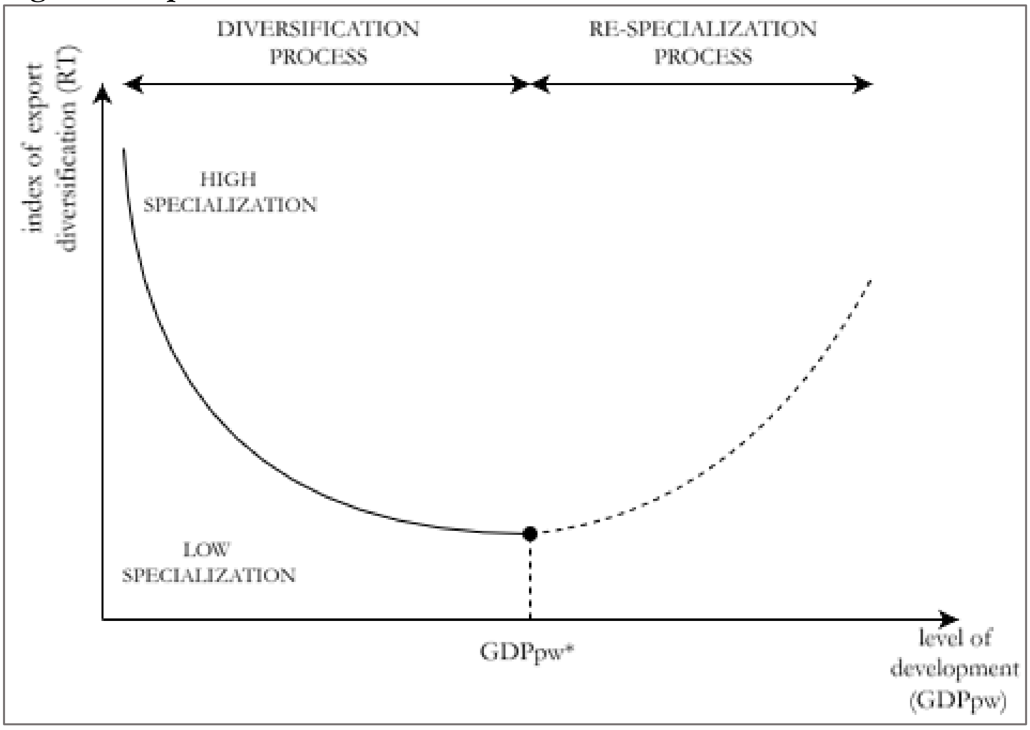
To align this decomposition with the diversification effects of resource dependence, all active export lines were divided, in accordance with existing resource taxonomies, into two groups: g_1 = resource products and g_0 = non-resource products:

$$RT^c = \underbrace{S_{g_1}^c \ln\left(\frac{S_{g_1}^c}{S_{g_1}^w}\right) + S_{g_0}^c \ln\left(\frac{S_{g_0}^c}{S_{g_0}^w}\right)}_{between^c} + \underbrace{S_{g_1}^c RT_{g_1}^c}_{within_{res}^c} + \underbrace{S_{g_0}^c RT_{g_0}^c}_{within_{non-res}^c} \qquad (2)$$

The components of the relative Theil decomposition allow for an in-depth analysis of export diversification dynamics, particularly with regard to explaining differences in diversification trajectories among countries. The between components provide information about shifts in diversity between resource and non-resource groups compared to the global trend. Within components, on the other hand, approximate the heterogeneity adjustments within resource and non-resource product groups. The magnitude of the within components reveals the degree of diversification of resource and non-resource products, weighted by their share in a country's total exports. Finally, the contribution of the decomposition components to the overall *RT* index informs which aspect (changes in the share of the group's exports or the product diversity of the group) is responsible for the existing specialization pattern.

Verifying the driving forces behind the diversification process at each stage of development was further visualized using the general diversification curve. This curve demonstrates a link between the development level (proxied by output per worker) and the degree of export diversification, plotted across country-year data points (Cleveland, 1979; Hastie and Tibshirani, 1987). The export diversification curve conceptualized in this dissertation was later decomposed into between- and within-components with respect to different product groups (Zarach and Parteka, 2023; Parteka et al., 2025).

Figure 1. Export diversification curve – basic scheme



4. Key Results

4.1. Growth Trajectories of Natural Resource Exporters

By examining the growth trajectories of resource-dependent economies, Chapter 4 of the dissertation tests three main research hypotheses (H1, H2, and H5). Additionally, it verifies the role of technological specialization in the relationship between natural resources and productivity growth. Its structure is as follows: Subchapter 4.1 illustrates descriptive statistics and country-specific examples of the dynamics between natural resources, technological specialization, and overall development. Subchapter 4.2 presents the results of an empirical analysis that explores the relationship between natural resources and productivity growth. Finally, Subchapter 4.3 extends the baseline models by interacting the technology-related variable with resource exports.

To explore the relationship between natural resources $NR_{c,t-1}$ and productivity growth $g(y)_{ct}$ we estimate a baseline model (eq. 3):

$$g(y)_{ct} = \alpha + \beta_1 y_{c,t-1} + \beta_2 NR_{c,t-1} + P_t^{NR} + \varepsilon_{ct} \tag{3}$$

The dependent variable is expressed as the annual growth rate (in %) of labor productivity which is measured as output per worker. The main explanatory variable is expressed as the share of a country's natural resource exports in its total exports. To account for the volatility of natural resource prices, the resource price index variable P_t^{NR} substitutes time-fixed effects. In line with the assumptions of the conditional convergence theory (Solow, 1956; Swan, 1956; Barro and Sala-i-Martin, 1992), the model also includes the level of labor productivity as a lagged explanatory variable.

The relationship between productivity growth and natural resource exports is susceptible to reverse causality and endogeneity issues (Farhadi et al., 2015). Bearing this in mind, the estimation methods in Chapter 4 are based on a two-step efficient GMM estimator with a one-year lag of the potentially endogenous variable as an instrument. Additionally, exports of natural resources tend to be highly persistent, due to relatively stable extraction and production levels. Therefore, to avoid losing all cross-country variability, country fixed effects are not included in the regressions.

We further expand the baseline model with a set of control variables $X_{c,t-1}$ (eq. 4) which potentially influence productivity growth (i.e. trade openness, the Human Capital Index, and the level of investment). Since the productivity effects of the activities in fields represented by the control variables are not immediate, all controlling agents are lagged by one year:

$$g(y)_{ct} = \alpha + \beta_1 y_{c,t-1} + \beta_2 NR_{c,t-1} + \beta_3 X_{c,t-1} + P_t^{NR} + \varepsilon_{ct} \tag{4}$$

Table 1 only presents statistically significant estimation results for model (4). The negative correlation between productivity growth and lagged productivity level implies that countries with lower initial output per worker tend to have higher productivity growth (which is in line with the convergence theory). Overall, dependence on natural resources enhances productivity growth, though the type of resource exported matters. Fossil fuels, particularly petroleum oils, stand out as the most significant determinant of productivity growth among all the types of natural resources. Conversely, mineral resources impede the process of catching-up. A proxy for time fixed effects (resource price index) is positively correlated with the output growth per worker, suggesting that higher natural resource prices enhance productivity growth. The correlation between productivity growth and all control variables is positive, which aligns with productivity theory. Nevertheless, the effects are weak.

Table 1. Estimation results (eq. 4) – relationship between productivity growth, Dependence[1] on natural resources and control variables

Dependent variable: $g(y)_{ct}$	Type of NR: *TOTAL NR*	*FUEL*	*MINERAL*	*PETROLEUM*
	(1)	(2)	(3)	(4)
$y_{c,t-1}$	-0.037***	-0.039***	-0.036***	-0.039***
	(0.006)	(0.007)	(0.006)	(0.007)
$NR_{c,t-1}$	1.384*	2.178**	-2.296*	2.721**
	(0.798)	(1.054)	(1.395)	(1.254)
$INV_{c,t-1}$	0.096***	0.100***	0.102***	0.101***
	(0.033)	(0.033)	(0.033)	(0.033)
$OPEN_{c,t-1}$	0.011***	0.012***	0.011***	0.011***
	(0.002)	(0.002)	(0.002)	(0.002)
$HC_{c,t-1}$	0.582**	0.710**	0.445	0.761***
	(0.273)	(0.279)	(0.283)	(0.285)
P_t^{NR}	0.039***	0.020***	0.045***	0.022***
	(0.006)	(0.004)	(0.005)	(0.005)
No.of obs.	2,737	2,737	2,737	2,737
No. of countries	128	128	128	128
K-P rk Wald F	56552	31490	3004	23267
K-P rk LM	886.3	531.7	156.3	406.5
K-P rk LM (p-val)	0.000	0.000	0.000	0.000

Notes: *,**,*** denote significance at the 1%, 5%, and 10% levels respectively; robust standard errors in parentheses; all specifications contain time fixed effects in a form of NR price indices (P_t^{NR}); K-P refers to Kleibergen-Paap test statistics. Instrumented variable: $NR_{c,t-1}$. Constant included – not reported.
1) The resource dependence is measured by the export share of various groups of resource products in total country exports, expressed as a decimal between 0 and 1.
Source: author's elaboration.

To empirically examine the effect of technological specialization on the relationship between natural resources and productivity growth, we further extend the baseline model by interacting technology-related variable $TECH_{c,t-1}$ with natural resources $NR_{c,t-1}$ (eq.5):

$$g(y)_{ct} = \alpha + \beta_1 y_{c,t-1} + \beta_2 NR_{c,t-1} + \beta_3 TECH_{c,t-1} + \beta_4 (NRxTECH)_{c,t-1} + P_t^{NR} + \varepsilon_{ct} \quad (5)$$

Once again, to avoid potential issues of reverse causality and endogeneity, the share of technological exports is considered as a one-year lagged instrument within the two-step system GMM estimator. $(NRxTECH)_{c,t-1}$ is the interaction term between the shares of resource and technological exports. It is also lagged by one year to account for delayed productivity effects.

Table 2 only presents statistically significant estimation results of model (5) for the comprehensive technological taxonomy of middle- and high-tech products (*TECH*). Technological specialization enhances productivity growth; however, this relationship is statistically significant only in the results obtained from the *TOTAL NR, FUEL* and *PETROLEUM* resource group estimates. Productivity amplification is weaker for technological exports than for resource exports. Furthermore, the negative interaction terms imply that incorporating technologically advanced products into the resource-based export portfolio could exacerbate output per worker growth. Nevertheless, these findings are statistically insignificant. The positive influence of expanding the resource export portfolio with products of technological specialization is only evident in the empirical results for *MINERAL* resources.

Table 2. Estimation results (eq. 5) – relationship between productivity growth, dependence on natural resources[1] and TECH exports

Dependent variable: $g(y)_{ct}$	Type of NR: *TOTAL NR*	*FUEL*	*MINERAL*	*PETROLEUM*
	(1)	(2)	(3)	(4)
$y_{c,t-1}$	-0.030***	-0.031***	-0.025***	-0.029***
	(0.006)	(0.006)	(0.005)	(0.006)
$NR_{c,t-1}$	2.858***	3.303***	-4.697***	3.542**
	(1.025)	(1.199)	(1.608)	(1.405)
$TECH_{c,t-1}$	2.686***	2.410***	-0.859	2.015**
	(0.996)	(0.901)	(0.845)	(0.867)
$(NRxTECH)_{c,t-1}$	-5.827	-9.700	27.000*	-11.561
	(5.317)	(6.429)	(16.055)	(7.532)
P_t^{NR}	0.040***	0.022***	0.045***	0.024***
	(0.007)	(0.004)	(0.006)	(0.005)
No.of obs.	3,520	3,520	3,520	3,520
No. of countries	160	160	160	160
K-P rk Wald F	6764	8734	1812	9428
K-P rk LM	1045	1109	267.0	1109
K-P rk LM (p-val)	0.000	0.000	0.000	0.000

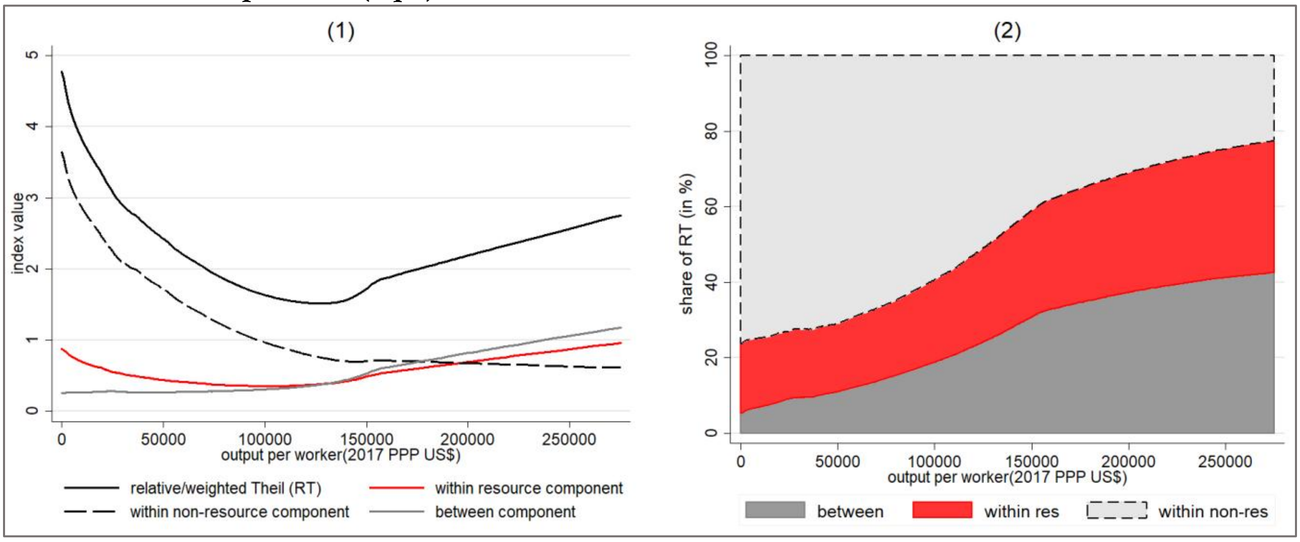
Notes: *,**,*** denote significance at the 1%, 5%, and 10% levels respectively; robust standard errors in parentheses; all specifications contain time fixed effects in a form of NR price indices (P_t^{NR}); K-P refers to Kleibergen-Paap test statistics; TECH includes products from the middle- and high-tech classification based on Lall (2000). Instrumented variables: $NR_{c,t-1}$ and $TECH_{c,t-1}$. Constant included – not reported.
1) The resource dependence is measured by the export share of various groups of resource products in total country exports, expressed as a decimal between 0 and 1.
Source: author's elaboration.

4.2. Diversification Trajectories of Natural Resource Exporters

By verifying the role of resource dependence in the diversification trajectories, Chapter 5 of the doctoral thesis tests three main research hypotheses (H3, H4, and H5). Moreover, it addresses the question of whether natural resources drive high export specialization by presenting a resource-based decomposition of the relative Theil index. Its structure is as follows: Subchapter 5.1 illustrates the descriptive statistics and the outcomes of the resource-based decomposition of the export diversification curve. Subchapter 5.2 presents the results of an empirical analysis exploring the relationship between natural resources and the diversification of exports. Finally, Subchapter 5.3 extends the baseline models by incorporating the institutional quality and technological innovation proxies into them.

The relative Theil (*RT*) index decomposition presented in this dissertation was conducted for the *TOTAL NR* and *FUEL* groups of resource products, since results for other resource taxonomies did not provide any valuable information. Figure 2 presents the core results of the resource-based decomposition, using equation (2) and the *TOTAL NR* resource taxonomy.

Figure 2. Resource-based decomposition[1] of the export diversification curve: relative Theil (RT) index and its components (eq.2)



Notes: (1) *RT* index value (2) – contribution of *RT* components to total index value.
Here, the decomposition of the relative Theil index into between and within components by output per worker intervals, with respect to the *TOTAL NR* product group.
Source: author's elaboration.

Overall, the value of the *RT* index decreases along the development path (black solid line in Figure 2.1), which aligns with the theory of stages of diversification. Countries' export baskets are the most diversified (the *RT* index is the lowest) when output per worker equals around $120k. Above that level, there exists a possibility of re-specialization. However, this phenomenon is mostly attributable to the presence of wealthy fossil fuel exporters in the sample.

The contribution of particular components of *RT* varies at different stages of development. At low levels of productivity, export diversification is dominated by the weighted heterogeneity adjustments within the non-resource group of products (within non-resource component, a dashed line in Figure 2.1). This component constitutes around 70% of the overall diversification level in countries with an output per worker of less than \$60k (light gray area in Figure 2.2). Above the turning point of the lowest *RT* index value, which equals 1.52, rising export specialization is mostly driven by shifts in diversity between the resource and non-resource groups (the dark gray area in Figure 2.2) and the rising importance of weighted diversity in resource exports (the red area in Figure 2.2). The within non-resource component definitely loses its dominant role at an output per worker of around \$125k. At very high levels of productivity (\$150k and above), the between- and within-resource components each account for around 35% of the total *RT* index.

Table 3. Results of the relative Theil decomposition (eq. 5) with respect to total natural resources

	Output per worker (2017 PPP US\$)													
	Full sample (4160 obs.)		< 50k (2864 obs.)		50k - 100k (991 obs.)		100k - 150k (240 obs.)		150k - 200k (48 obs.)		200k - 250k (14 obs.)		> 250k (3 obs.)	
	value	*structure*	*value*	*structure*	*value*	*structure*	*value*	*structure*	*value*	*structure*	*value*	*structure*	*value*	*structure*
RT	2.87	100%	3.41	100%	1.68	100%	1.57	100%	2.15	100%	2.56	100%	2.32	100%
within non-resource	2.07	71.7%	2.52	73.0%	1.13	72.7%	0.83	62.3%	0.77	35.6%	1.00	41.1%	0.75	37.5%
$S^c_{non-res}$	0.71		0.71		0.74		0.64		0.36		0.43		0.37	
$RT^c_{non-res}$	3.10		3.65		1.87		1.78		2.46		3.08		3.24	
within resource	0.53	17.6%	0.61	17.6%	0.32	16.3%	0.39	20.7%	0.59	26.2%	0.85	31.9%	0.76	30.1%
S^c_{res}	0.29		0.29		0.26		0.36		0.64		0.57		0.63	
RT^c_{res}	2.25		2.63		1.42		1.28		1.56		2.27		1.42	
between	0.27	10.7%	0.27	9.5%	0.22	11.0%	0.35	17.0%	0.80	38.2%	0.71	27.0%	0.81	32.4%

Notes: the decomposition of the relative Theil index into between and within components by output per worker intervals, with respect to the *TOTAL NR* product group.
Source: author's elaboration.

Examining the structure of the *RT* index (see Table 3) reveals the importance of the within non-resource component at lower levels of productivity. This can be attributed to the observation that in low-productivity countries, the group of products other than natural resources occupies a significant share of total exports ($S^c_{non-res}$) and is at the same time poorly diversified (high value of $RT^c_{non-res}$). As countries diversify, their non-resource exports become more heterogeneous, hence the decrease in the $RT^c_{non-res}$ and the overall *RT* index. The moderately high share of non-resource products challenges the common belief that natural resources are associated with lower productivity levels. Above the turning point where output per worker equals \$120k, the between component drives the initial stages of re-specialization, accounting for around 40% of the *RT* index. At very high levels of productivity, rising export specialization is caused by the increasing share of natural resources in total exports (S^c_{res}) and the low heterogeneity of products outside the resource domain ($RT^{c}_{non-res}$). The weighted variety of products within the resource group is more pronounced at very high levels of productivity (i.e., RT^{c}_{res} is lower), meaning that dependence on natural resources in rich, fuel-exporting countries is characterized by the relative diversity of those exports.

To further explore the relationship between natural resource dependence NR_{ct} and export diversification $lnRT_{ct}$ we estimate the following model (eq.6):

$$lnRT_{ct} = \alpha + \beta_1 NR_{ct} + \beta_2 lnSIZE_{ct} + \beta_3 lnDEV_{c,t-1} + \beta_4 X_{ct} + P^{NR}_{t} + \varepsilon_{ct} \quad (6)$$

The dependent variable is computed for three groups of products: the diversification of overall ($lnRT_{ct}$) , non-resource ($lnRT_{c,nonNR_t}$) and technological ($lnRT_{c,TECH_t}$) exports. The main explanatory variable is calculated as the share of natural resources in a country's total exports. Apart from the resource dependence, the baseline model (eq.6) controls for two major determinants of export diversification. These are the development level, measured by output per worker ($lnDEV_{c,t-1}$) and the country size, proxied by expenditure-side real GDP ($lnSIZE_{ct}$). Time-fixed effects in the form of resource price indices P^{NR}_{t}, account for the volatility of resource prices. Additionally, we employ a set of control variables (X_{ct}) that describe countries' geopolitical characteristics, which potentially affect export diversification. This set includes the following: country's status as a landlocked nation ($LANDLOCK_{ct}$), its distance to the closest major port (in km) ($AIRDIST_{ct}$), the timing of its independence ($NEWST_{ct}$), and its colonial past ($COLONIAL_{ct}$).

All of the models in Chapter 5 are log-log models, accounting for the elasticity of export diversification with respect to the explanatory variables. They also exclude country fixed effects to avoid losing cross-country variability. Due to the potential for reverse causality and endogeneity between the development level and export diversification, and since the effects of *DEV* on *RT* index are not immediate, development level is lagged by one year and used as an instrument within the two-step efficient GMM estimator framework.

Table 4 presents the estimation results of model (6) for the *TOTAL NR* and *FORESTRY* resource taxonomies. The positive correlation between the dependent variable and the *TOTAL NR* explanatory variable suggests that excessive dependence on natural resources results in a stronger specialization of exports (including the non-resource and technological exports). This trend holds for all types of natural resources, except for forestry products. In this case, an increase in the share of *FORESTRY* products in a country's total exports results in a decrease in the *RT* index value. This indicates that forestry products can significantly enhance the diversification of overall, non-forestry and technologically advanced exports.

Table 4. Estimation results (eq. 6) – relationship between natural resource dependence[1] and three types of export diversification

Dependent variable:	$lnRT_{ct}$		$lnRT_{c,nonNR_t}$		$lnRT_{c,TECH_t}$	
	TOTAL NR	*FORESTRY*	*TOTAL NR*	*FORESTRY*	*TOTAL NR*	*FORESTRY*
	(1)	(2)	(3)	(4)	(5)	(6)
NR_{ct}	0.145***	-0.421***	0.610***	-0.717***	0.620***	-1.258***
	(0.020)	(0.073)	(0.021)	(0.085)	(0.027)	(0.146)
$lnSIZE_{ct}$	-0.175***	-0.179***	-0.171***	-0.180***	-0.179***	-0.194***
	(0.004)	(0.004)	(0.004)	(0.004)	(0.005)	(0.006)
$lnDEV_{c,t-1}$	-0.113***	-0.103***	-0.133***	-0.103***	-0.146***	-0.105***
	(0.006)	(0.006)	(0.007)	(0.006)	(0.009)	(0.010)
$COLONIAL_{ct}$	0.117***	0.121***	0.146***	0.121***	0.117***	0.134***
	(0.014)	(0.014)	(0.016)	(0.014)	(0.020)	(0.023)
$LANDLOCK_{ct}$	0.074***	0.071***	0.017	0.072***	0.038**	0.026
	(0.013)	(0.013)	(0.014)	(0.013)	(0.019)	(0.020)
$AIRDIST_{ct}$	0.000***	0.000***	0.000***	0.000***	0.000***	0.000***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
$NEWST_{ct}$	0.010**	0.017***	0.026***	0.015***	0.042***	0.071***
	(0.005)	(0.005)	(0.005)	(0.005)	(0.007)	(0.007)
P_t^{NR}	0.001***	0.001*	0.001***	0.001*	0.001***	0.002***
	(0.000)	(0.001)	(0.000)	(0.001)	(0.000)	(0.001)
No.of obs.	3,239	3,239	3,239	3,239	3,239	3,239
No. of countries	135	135	135	135	135	135
K-P rk Wald F	215589	254482	215589	254482	215589	254482
K-P rk LM	927.1	959.2	927.1	959.2	927.1	959.2
K-P rk LM (p-val)	0.000	0.000	0.000	0.000	0.000	0.000

Notes: *,**,*** denote significance at the 1%, 5%, and 10% levels, respectively; robust standard errors in parentheses; all specifications contain time fixed effects in the form of NR price indices (P_t^{NR}); K-P refers to the Kleibergen-Paap test statistics. Instrumented variable: $lnDEV_{c,t-1}$. Constant included – not reported.

1) The resource dependence is measured by the export share of various groups of resource products in total country exports, expressed as a decimal between 0 and 1.

Source: author's elaboration.

To better understand why some resource exporters, achieve diversification while others do not, we extend the baseline model (6) and incorporate the influence of institutions $INST_{ct}$ (eq.7) and technological innovations $INNOV_{ct}$ (eq.8):

$$lnRT_{ct} = \alpha + \beta_1 NR_{ct} + \beta_2 INST_{ct} + \beta_3 (NRxINST)_{ct} + \beta_4 lnSIZE_{ct} + \beta_5 lnDEV_{c,t-1} + \\ + \beta_6 X_{ct} + P_t^{NR} + \varepsilon_{ct} \quad (7)$$

$$lnRT_{ct} = \alpha + \beta_1 NR_{ct} + \beta_2 INNOV_{ct} + \beta_3 (NRxINNOV)_{ct} + \beta_4 lnSIZE_{ct} + \beta_5 lnDEV_{c,t-1} + \\ + \beta_6 X_{ct} + P_t^{NR} + \varepsilon_{ct} \quad (8)$$

The quality of institutions is expressed as a percentile rank, with 0 corresponding to the worst and 100 corresponding to the best possible institutional quality. $(NRxINST)_{ct}$ is the interaction term between the share of natural resources in a country's total exports and its institutional quality. The technological innovation variable includes three proxies for a country's level of technological innovation, namely the share of technologically advanced products in a country's total exports, the R&D expenditure (expressed as a percentage of GDP), and patent applications (expressed in thousands). The interaction term $(NRxINNOV)_{ct}$ was included to verify the role of technological innovation in the relationship between resource dependence and export diversification.

Table 5. Estimation results (eq. 7) – relationship between natural resource dependence[1] and export diversification: the role of institutional quality[2]

	Type of NR: TOTAL NR		
Type of dependent variable:	$lnRT_{ct}$	$lnRT_{c,nonNR_t}$	$lnRT_{c,TECH_t}$
	(1)	(2)	(3)
NR_{ct}	-0.460***	0.094***	-0.122***
	(0.032)	(0.033)	(0.039)
$INST_{ct}$	-0.010***	-0.011***	-0.018***
	(0.000)	(0.000)	(0.000)
$(NRxINST)_{ct}$	0.012***	0.008***	0.010***
	(0.001)	(0.001)	(0.001)
$lnSIZE_{ct}$	-0.181***	-0.185***	-0.202***
	(0.003)	(0.004)	(0.004)
$lnDEV_{c,t-1}$	0.005	0.032***	0.114***
	(0.007)	(0.008)	(0.010)
$COLONIAL_{ct}$	0.092***	0.109***	0.058***
	(0.012)	(0.014)	(0.016)
$LANDLOCK_{ct}$	0.086***	0.025*	0.047***
	(0.012)	(0.013)	(0.016)
$AIRDIST_{ct}$	0.000***	0.000***	0.000***
	(0.000)	(0.000)	(0.000)
$NEWST_{ct}$	-0.009**	-0.004	-0.006
	(0.004)	(0.004)	(0.005)
P_t^{NR}	0.000	-0.000	-0.000
	(0.000)	(0.000)	(0.000)
No.of obs.	3,239	3,239	3,239
No. of countries	135	135	135
K-P rk Wald F	122913	122913	122913
K-P rk LM	1058	1058	1058
K-P rk LM (p-val)	0.000	0.000	0.000

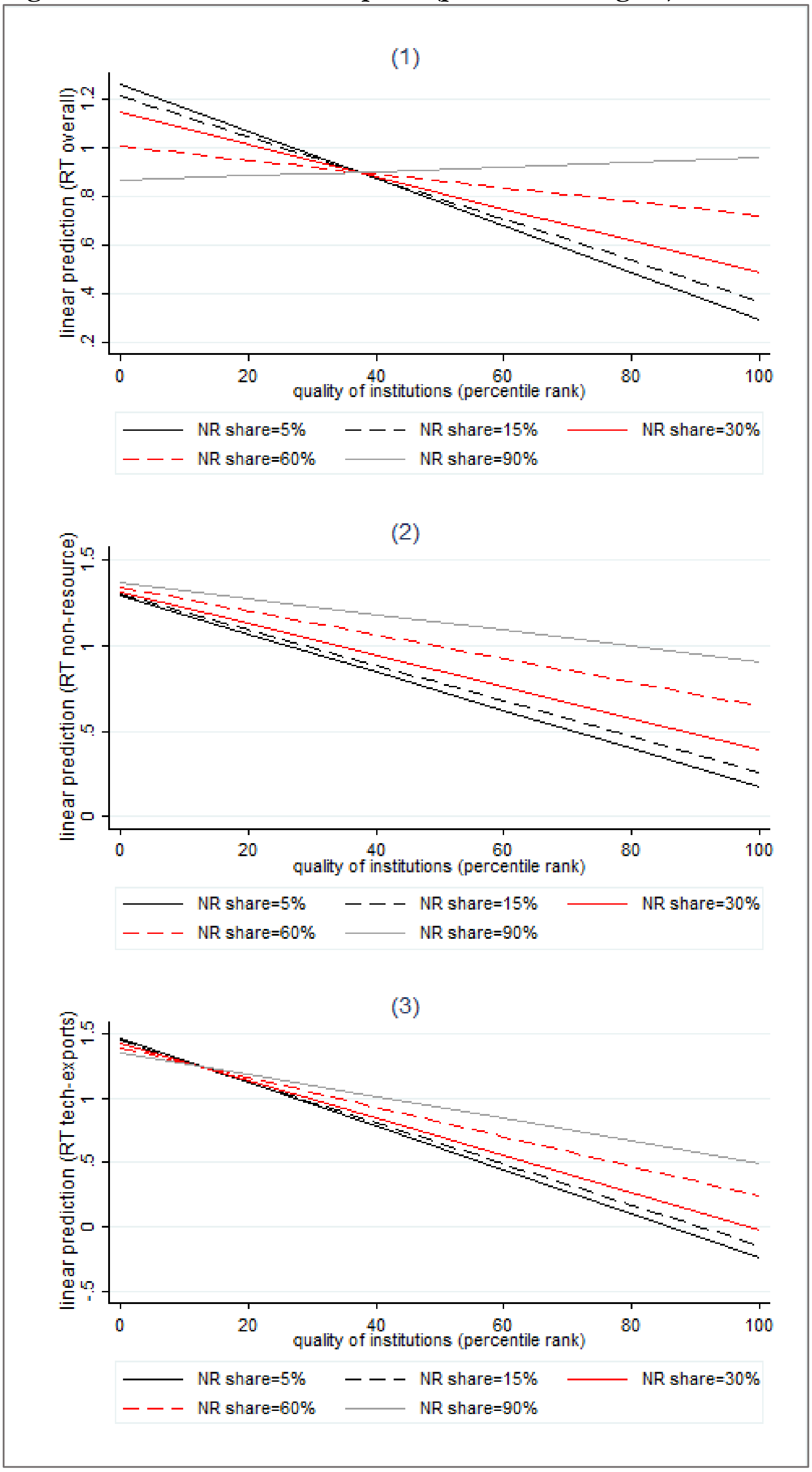
Notes: *,**,*** denote significance at the 1%, 5%, and 10% levels, respectively; robust standard errors in parentheses; all specifications contain time fixed effects in the form of NR price indices (P_t^{NR}); K-P refers to the Kleibergen-Paap test statistics. Instrumented variable: $lnDEV_{c,t-1}$. Constant included – not reported.
1) The resource dependence is measured by the export share of *TOTAL NR* resource products in total country exports, expressed as a decimal between 0 and 1.
2) *INST* is expressed as a percentile rank indicating the country's rank among all countries, with 0 corresponding to the lowest rank (the weakest institutions) and 100 to the highest rank (the strongest institutions).
Source: author's elaboration.

Table 5 reports the estimation results for model (7), calculated using the *TOTAL NR* resource classification. Overall, institutional quality positively promotes all types of export diversification, meaning that countries with better institutions have a lower Theil index value, which yields higher export diversification. However, this effect is marginal. To better understand the role of governmental quality in the relationship between resource dependence and export diversification, we plot the predictive margins. The empirical evidence presented in Figure 3 suggests that increasing the quality of institutions, particularly in resource-dependent countries with a resource export share no higher than 60%, leads to a decrease in the RT index value for all three product groups. For economies with very high shares of resource exports (90% or more), the correlation between institutional quality and the diversification of overall exports is moderately positive. This indicates that, for this group of countries, a higher quality of institutions leads to a stronger export specialization (Figure 3.1).

Table 6 presents the estimation results for model (8), calculated using the *TOTAL NR* resource classification and technological innovation, as indicated by the share of technologically advanced products in total exports. $INNOV_{ct}$ exhibits a negative relationship with the value of the overall and non-resource *RT* index, the strongest of which is observed in the case of 4IR products.

The margin plot (Figure 4.A), computed for the 4IR-related innovation, confirms the estimation results of the $(NRxINNOV)_{ct}$ variable and demonstrates that its supportive role in the resource dependence - export diversification nexus is most distinct for countries with very high shares of *TOTAL NR* exports (see light gray line in Figure 4.A). The increase in the share of ICT-related products in the total exports does not result in a decrease in the level of export specialization in countries with moderately low levels of resource dependence (see black solid line in Figure 4.B). However, the correlation between the strength of dependence and the enhancing effect of ICT-based innovations is evident for both overall and non-resource diversification (see particularly the light gray line in Figures 4.B.1 and 4.B.2). While the impact of TECH-based products on export diversification is more distinct than that of ICT exports (see eq. (3) and (6) in Table 6), its mitigating role is the least significant among the three technologically advanced groups of products (Figure 4.C).

Figure 3. Diversification of exports (predictive margins) – the role of institutional quality



Notes: (1) all products ($lnRT_{ct}$); (2) non-resource products ($lnRT_{c,nonNR_t}$); (3) technologically advanced products ($lnRT_{c,TECH_t}$). Margin plots computed for the estimation of eq.(7), which considers the share of TOTAL NR resource products in total country exports and the quality of institutions (0– the weakest institutions, 100 – the strongest institutions). The threshold values for the resource shares are based on the percentiles of the variables (10th, 25th, 50th, 75th, and 90th).
Source: author's elaboration.

Table 6. Estimation results (eq. 8) – relationship between natural resource dependence[1] and export diversification – the role of technological innovation

	A. Dependent variable: $lnRT_{ct}$			B. Dependent variable: $lnRT_{c,nonNR_t}$		
Type of INNOV[2]	4IR	ICT	TECH	4IR	ICT	TECH
	(1)	(2)	(3)	(4)	(5)	(6)
NR_{ct}	0.093***	0.075***	-0.165***	0.548***	0.533***	0.270***
	(0.021)	(0.020)	(0.023)	(0.021)	(0.020)	(0.023)
$INNOV_{ct}$	-16.021***	-0.252***	-1.026***	-19.221***	-0.223**	-1.126***
	(2.689)	(0.088)	(0.046)	(2.967)	(0.090)	(0.050)
$(NRxINNOV)_{ct}$	-50.080***	-10.174***	-0.586***	-72.832***	-12.034***	-0.633***
	(15.528)	(0.720)	(0.190)	(19.567)	(0.854)	(0.209)
$lnSIZE_{ct}$	-0.165***	-0.161***	-0.148***	-0.160***	-0.156***	-0.142***
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
$lnDEV_{c,t-1}$	-0.092***	-0.090***	-0.057***	-0.105***	-0.105***	-0.070***
	(0.006)	(0.006)	(0.006)	(0.007)	(0.006)	(0.007)
$COLONIAL_{ct}$	0.097***	0.149***	0.067***	0.120***	0.182***	0.091***
	(0.013)	(0.013)	(0.013)	(0.014)	(0.015)	(0.015)
$LANDLOCK_{ct}$	0.089***	0.066***	0.077***	0.036**	0.008	0.021
	(0.013)	(0.012)	(0.012)	(0.014)	(0.013)	(0.013)
$AIRDIST_{ct}$	0.000***	0.000***	0.000***	0.000***	0.000***	0.000***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
$NEWST_{ct}$	0.009*	0.029***	0.017***	0.025***	0.048***	0.034***
	(0.005)	(0.005)	(0.004)	(0.005)	(0.005)	(0.005)
P_t^{NR}	0.001**	0.001**	0.001***	0.001**	0.001**	0.001***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
No.of obs.	3,239	3,239	3,239	3,239	3,239	3,239
No. of countries	135	135	135	135	135	135
K-P rk Wald F	197221	197795	156549	197221	197795	156549
K-P rk LM	996.2	932.0	878.1	996.2	932.0	878.1
K-P rk LM (p-val)	0.000	0.000	0.000	0.000	0.000	0.000

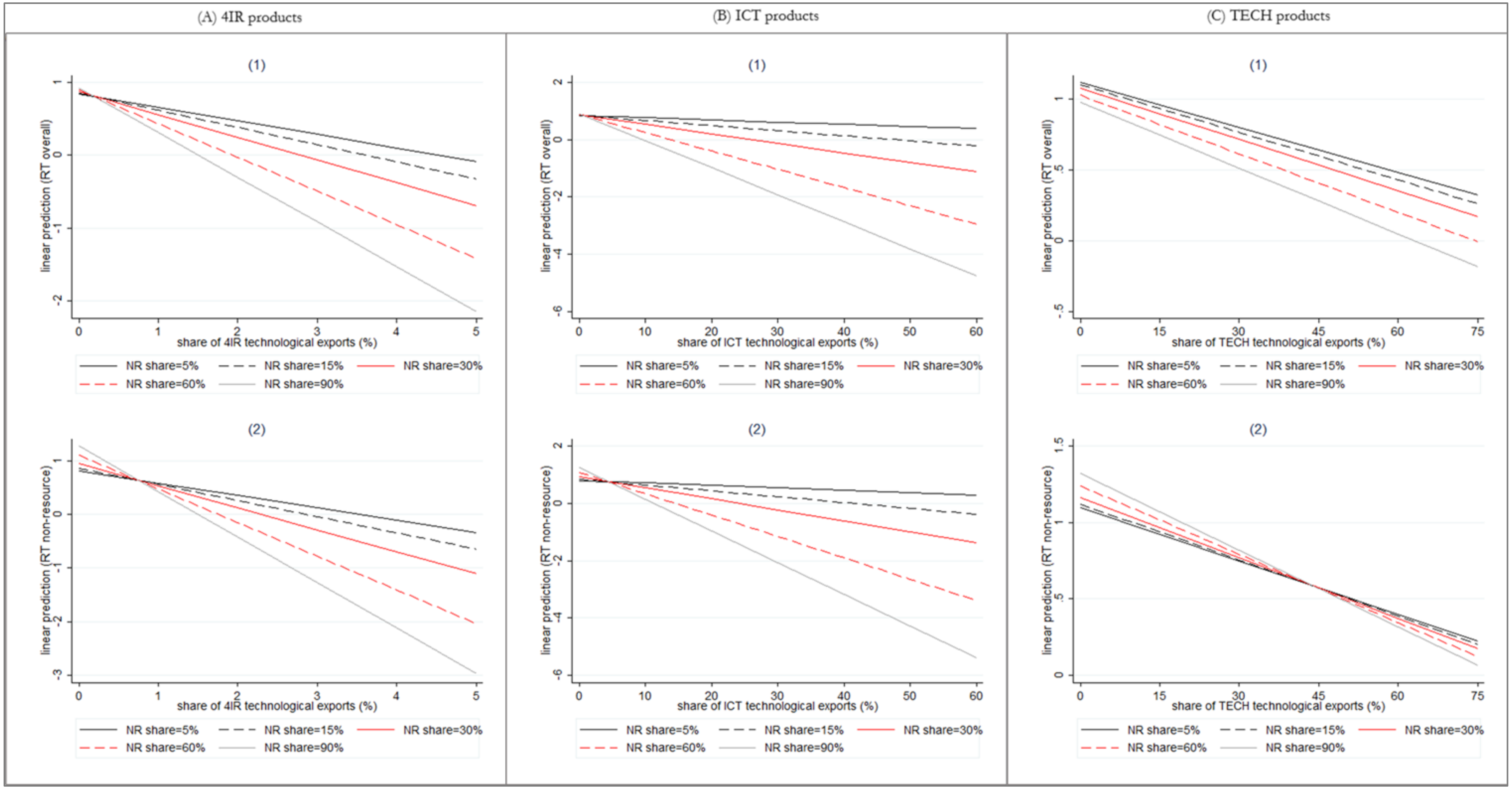
Notes: *,**,*** denote significance at the 1%, 5%, and 10% levels, respectively; robust standard errors in parentheses; all specifications contain time fixed effects in the form of NR price indices (P_t^{NR}); K-P refers to the Kleibergen-Paap test statistics. Instrumented variable: $lnDEV_{c,t-1}$. Constant included – not reported.

1) The resource dependence is measured by the export share of TOTAL NR resource products in total country exports, expressed as a decimal between 0 and 1.

2) INNOV is measured by the export share of various groups of technologically advanced products in total country exports, expressed as a decimal between 0 and 1.

Source: author's elaboration.

Figure 4. Diversification of exports (predictive margins) – the role of technological innovation



Notes: (1) all products ($lnRT_{ct}$); (2) non-resource products ($lnRT_{c,nonNR_t}$).

Margin plots computed for the estimation of eq.(8), which considers the share of TOTAL NR resource products in total country exports, as well as technological innovation, measured by the share of (A) 4IR products (B) ICT products (C) TECH products in total country exports. The threshold values for the resource shares are based on the percentiles of the variables (10th, 25th, 50th, 75th, and 90th).

Source: author's elaboration.

5. Conclusions

Through a panel-data analysis based on a sample of 160 countries over the time period 1996-2021, this doctoral thesis contributes to the existing body of knowledge in the field of resource economics by offering insights into the growth and diversification trajectories of resource-dependent countries. Firstly, it employs newly elaborated product-level taxonomies and raw, disaggregated export data to create variables representing resource dependence based on seven types of natural resources. Secondly, it simultaneously considers the development dynamics of various natural resources, thereby facilitating a more comprehensive understanding of the intricate nature of primary products. Thirdly, it conducts the resource-based decomposition of the relative Theil index to thoroughly verify the driving forces behind export diversification dynamics. Finally, it adopts interaction terms in econometric models to assess the role of technological specialization in the relationship between natural resources and development trajectories.

The answers to the research hypotheses formulated in Chapter 1 of the dissertation, stemming from empirical analysis provided in Chapters 4 and 5, are as follows:

H1. Resource-dependent countries are not excluded from technology-based growth.

Based on specific case studies, presented in Subchapter 4.1 of the dissertation, we confirm that certain resource-rich countries (i.e., Iran, Oman, Saudi Arabia, and the United Arab Emirates) are engaged in the process of diversification towards more technologically advanced sectors. This progress results in a smaller percentage of natural resources in total exports and an increasing share of technologically advanced products in export portfolios. Thus, the H1 hypothesis has been supported. Additionally, the literature review presented in Chapter 2 of the doctoral thesis provides several historical examples of resource rents stimulating technological innovation and initiating the process of technology-led growth.

H2. Intensive natural resource exports foster productivity growth, and this effect is enhanced by technological specialization.

Econometric analysis presented in Chapter 4 of the dissertation confirms that, overall, intensive natural resource exports foster productivity growth. However, those results are conditioned upon the type of natural resource under consideration. Specifically, countries that are dependent on mineral resources experience a decrease in the productivity growth rate, whereas fossil fuel exporters enjoy an enhancing effect of their dependence. When it comes to the role of technological specialization, it positively mitigates the relationship between natural resources and growth trajectories; however, this effect is significant only for the empirical results involving mineral resources. Technological specialization itself promotes productivity growth, yet again, the significance of this relationship is visible only in estimations involving mineral dependence. Consequently, available evidence is insufficient to reject the null hypothesis, thereby the H2 hypothesis cannot be supported.

H3. Resource dependence slows the diversification process and is responsible for excessive export specialization at low levels of development.

The resource-based decomposition of the relative Theil index (presented in Subchapter 5.1 of the doctoral thesis) reveals that at low productivity levels, high export specialization is dominated by the weighted heterogeneity adjustments within the non-resource group of products. Above the turning point (approx. $120k), where countries no longer diversify their exports, the increasing re-specialization is primarily driven by shifts in diversity between the resource and non-resource groups, as well as the increasing significance of weighted diversity in resource exports. Subchapter 5.2 of the dissertation presents the empirical analysis of the relationship between natural resource dependence and diversification trajectories. The outcomes suggest that excessive dependence on natural resources results in stronger specialization of overall, non-resource, and technological exports, thus impeding the diversification process. This relationship is sustained for all types of natural resources except for forestry products, which have the potential to enhance the diversification in resource-dependent economies. Considering all the results presented in Chapter 5, the evidence is insufficient to reject the null hypothesis, thereby the H3 hypothesis cannot be supported.

H4. The diversification trajectories of resource exporters are determined by technological innovation.

Chapter 5 of the dissertation also introduces the role of technological innovation to verify whether it mitigates the relationship between natural resources and export diversification. The econometric results and margin plots presented in Subchapter 5.3 suggest that technological innovation can reverse the negative dynamics between resource dependence and export diversification. Additionally, its supportive role is the most pronounced in economies with a resource export share higher than 60%. This effect is also stronger for more sophisticated technological exports (i.e., 4IR-related products). Thus, the H4 hypothesis has been supported.

H5. The effects of resource dependence on growth and diversification trajectories differ across various types of natural resources.

Empirical analysis presented in Chapters 4 and 5 of the doctoral thesis confirms that the effects of resource dependence on growth and diversification trajectories differ for various types of natural resources. Therefore, the H5 hypothesis has been supported. As discussed in Chapter 4, productivity growth is reinforced by fuel resources, particularly petroleum oils. However, dependence on fossil fuels impedes diversification processes, as highlighted in Chapter 5. Excessive reliance on mineral resources hinders catch-up in productivity. Finally, of the considered resource types, only forestry products can significantly enhance export diversification.

In conclusion, this dissertation demonstrates that resource-dependent economies are not bound to fail. The growth and diversification trajectories of these countries are contingent on the nature of their resource dependence and the incorporation of mitigating factors. Furthermore, natural resource exporters are not excluded from technology-driven growth, provided that they decide to implement technological innovations in resource production processes and they progressively augment the proportion of technologically advanced products in their export portfolio. The findings of this study contribute to the decision-making processes, with particular policy implications regarding the incorporation of mitigating factors, such as technological innovations and institutional quality, as well as the promotion of diversification within export portfolios.

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