POLITECHNIKA GDAŃSKA

Imię i nazwisko autora rozprawy: Zuzanna Helena Zarach
Dyscyplina naukowa: Ekonomia i Finanse

ROZPRAWA DOKTORSKA

Tytuł rozprawy w języku polskim: Ścieżki wzrostu gospodarczego i dywersyfikacji w krajach eksportujących surowce naturalne.

Tytuł rozprawy w języku angielskim: Growth and Diversification Trajectories of Natural Resource Exporters.

Promotor *podpis*	Drugi promotor *podpis*
dr hab. inż. Aleksandra Parteka, prof. PG	
Promotor pomocniczy *podpis*	Kopromotor *podpis*
dr Aleksandra Kordalska	

Gdańsk, wrzesień 2025

The author of the doctoral dissertation: Zuzanna Helena Zarach
Scientific discipline: Economics and Finance

DOCTORAL DISSERTATION

Title of doctoral dissertation: Growth and Diversification Trajectories of Natural Resource Exporters.

Title of doctoral dissertation (in Polish): Ścieżki wzrostu gospodarczego i dywersyfikacji w krajach eksportujących surowce naturalne.

Supervisor *signature*	Second supervisor *signature*
dr hab. inż. Aleksandra Parteka, prof. PG	
Auxiliary supervisor *signature*	Cosupervisor *signature*
dr Aleksandra Kordalska	

Gdańsk, September 2025

POLITECHNIKA GDAŃSKA

OŚWIADCZENIE

Autor rozprawy doktorskiej: Zuzanna Helena Zarach

Ja, niżej podpisana, oświadczam, iż jestem świadoma, że zgodnie z przepisem art. 27 ust. 1 i 2 ustawy z dnia 4 lutego 1994 r. o prawie autorskim i prawach pokrewnych (t.j. Dz.U. z 2021 poz. 1062), uczelnia może korzystać z mojej rozprawy doktorskiej zatytułowanej:
"Growth and Diversification Trajectories of Natural Resource Exporters"
do prowadzenia badań naukowych lub w celach dydaktycznych.[1]

Gdańsk, dnia 29.09.2025 ……………………………………………
podpis doktoranta

Świadoma odpowiedzialności karnej z tytułu naruszenia przepisów ustawy z dnia 4 lutego 1994 r. o prawie autorskim i prawach pokrewnych i konsekwencji dyscyplinarnych określonych w ustawie Prawo o szkolnictwie wyższym i nauce (Dz.U.2021.478 t.j.), a także odpowiedzialności cywilno-prawnej oświadczam, że przedkładana rozprawa doktorska została napisana przeze mnie samodzielnie.

Oświadczam, że treść rozprawy opracowana została na podstawie wyników badań prowadzonych pod kierunkiem i w ścisłej współpracy z promotorką **dr hab. inż. Aleksandrą Parteką, prof. PG** oraz promotorką pomocniczą **dr Aleksandrą Kordalską**.

Niniejsza rozprawa doktorska nie była wcześniej podstawą żadnej innej urzędowej procedury związanej z nadaniem stopnia doktora.

Wszystkie informacje umieszczone w ww. rozprawie uzyskane ze źródeł pisanych i elektronicznych, zostały udokumentowane w wykazie literatury odpowiednimi odnośnikami, zgodnie z przepisem art. 34 ustawy o prawie autorskim i prawach pokrewnych.

Potwierdzam zgodność niniejszej wersji pracy doktorskiej z załączoną wersją elektroniczną.

Gdańsk, dnia 29.09.2025 ……………………………………………
podpis doktoranta

Ja, niżej podpisana, wyrażam zgodę na umieszczenie ww. rozprawy doktorskiej w wersji elektronicznej w otwartym, cyfrowym repozytorium instytucjonalnym Politechniki Gdańskiej.

Gdańsk, dnia 29.09.2025 ……………………………………………
podpis doktoranta

---

[1] Art. 27. 1. Instytucje oświatowe oraz podmioty, o których mowa w art. 7 ust. 1 pkt 1, 2 i 4–8 ustawy z dnia 20 lipca 2018 r. – Prawo o szkolnictwie wyższym i nauce, mogą na potrzeby zilustrowania treści przekazywanych w celach dydaktycznych lub w celu prowadzenia działalności naukowej korzystać z rozpowszechnionych utworów w oryginale i w tłumaczeniu oraz zwielokrotniać w tym celu rozpowszechnione drobne utwory lub fragmenty większych utworów.
2. W przypadku publicznego udostępniania utworów w taki sposób, aby każdy mógł mieć do nich dostęp w miejscu i czasie przez siebie wybranym korzystanie, o którym mowa w ust. 1, jest dozwolone wyłącznie dla ograniczonego kręgu osób uczących się, nauczających lub prowadzących badania naukowe, zidentyfikowanych przez podmioty wymienione w ust. 1.

GDAŃSK UNIVERSITY OF TECHNOLOGY

STATEMENT

The author of the doctoral dissertation: Zuzanna Helena Zarach

I, the undersigned, declare that I am aware that in accordance with the provisions of Art. 27 (1) and (2) of the Act of 4th February 1994 on Copyright and Related Rights (Journal of Laws of 2021, item 1062), the university may use my doctoral dissertation entitled:
"Growth and Diversification Trajectories of Natural Resource Exporters"
for scientific or didactic purposes.[1]

Gdańsk, 29.09.2025 ……………………………………………….
signature of the PhD student

Aware of criminal liability for violations of the Act of 4th February 1994 on Copyright and Related Rights and disciplinary actions set out in the Law on Higher Education and Science(Journal of Laws 2021, item 478), as well as civil liability, I declare, that the submitted doctoral dissertation is my own work.

I declare, that the submitted doctoral dissertation is my own work performed under and in cooperation with the supervision of **dr hab. inż. Aleksandra Parteka, prof. PG** and auxiliary supervision of **dr Aleksandra Kordalska**.

This submitted doctoral dissertation has never before been the basis of an official procedure associated with the awarding of a PhD degree.

All the information contained in the above thesis which is derived from written and electronic sources is documented in a list of relevant literature in accordance with Art. 34 of the Copyright and Related Rights Act.

I confirm that this doctoral dissertation is identical to the attached electronic version.

Gdańsk, 29.09.2025 ……………………………………………….
signature of the PhD student

I, the undersigned, agree to include an electronic version of the above doctoral dissertation in the open, institutional, digital repository of Gdańsk University of Technology.

Gdańsk, 29.09.2025 ……………………………………………….
signature of the PhD student

[1] Art 27. 1. Educational institutions and entities referred to in art. 7 sec. 1 points 1, 2 and 4–8 of the Act of 20 July 2018 – Law on Higher Education and Science, may use the disseminated works in the original and in translation for the purposes of illustrating the content provided for didactic purposes or in order to conduct research activities, and to reproduce for this purpose disseminated minor works or fragments of larger works.

2. If the works are made available to the public in such a way that everyone can have access to them at the place and time selected by them, as referred to in para. 1, is allowed only for a limited group of people learning, teaching or conducting research, identified by the entities listed in paragraph 1.

POLITECHNIKA GDAŃSKA

OPIS ROZPRAWY DOKTORSKIEJ

Autor rozprawy doktorskiej: Zuzanna Helena Zarach

Tytuł rozprawy doktorskiej w języku polskim: Ścieżki wzrostu gospodarczego i dywersyfikacji w krajach eksportujących surowce naturalne.

Tytuł rozprawy w języku angielskim: Growth and Diversification Trajectories of Natural Resource Exporters.

Język rozprawy doktorskiej: Angielski

Promotor rozprawy doktorskiej: dr hab. inż. Aleksandra Parteka, prof. PG

Promotor pomocniczy rozprawy doktorskiej: dr Aleksandra Kordalska

Data obrony:

Słowa kluczowe rozprawy doktorskiej w języku polskim: zależność od surowców naturalnych, produktywność, specjalizacja technologiczna, dywersyfikacja eksportu, dekompozycja względnego indeksu Theila.

Słowa kluczowe rozprawy doktorskiej w języku angielskim: natural resource dependence, productivity, technological specialization, export diversification, relative Theil decomposition.

Streszczenie rozprawy w języku polskim: Niniejsza rozprawa doktorska analizuje rolę, jaką zależność od surowców naturalnych odgrywa w procesach wzrostu gospodarczego oraz dywersyfikacji eksportu, a także określa jak postęp technologiczny wpływa na ten związek. Literatura przedmiotu nie identyfikuje jednoznacznie mechanizmów rozwoju w krajach zależnych od surowców naturalnych oraz nie uwzględnia ich roli w procesie dywersyfikacji eksportu oraz wzroście opartym na technologii. Wyniki empiryczne, bazujące na próbie 160 krajów na przestrzeni 26 lat (1996-2021), wskazują, iż zależność od surowców naturalnych sprzyja wzrostowi produktywności i równocześnie utrudnia dywersyfikację eksportu. Efekty te różnią się jednak pomiędzy różnymi typami surowców naturalnych. Pomimo hamującej roli w procesie dywersyfikacji, surowce naturalne nie są odpowiedzialne za wysoką specjalizację eksportu na niskim poziomie rozwoju. Podsumowując, gospodarki zależne od surowców naturalnych nie są skazane na porażkę. Ścieżki wzrostu gospodarczego oraz dywersyfikacji eksportu w tych krajach są uwarunkowane charakterem ich zależności od surowców naturalnych oraz uwzględnieniem czynników łagodzących. Ponadto, eksporterzy surowców naturalnych mogą czerpać z rozwoju opartego na technologii, pod warunkiem, że zdecydują się na wprowadzanie innowacji w procesach produkcji surowców oraz będą zwiększać udział produktów technologicznych w swoim eksporcie.

Streszczenie rozprawy w języku angielskim: This dissertation investigates the role of natural resource dependence in the processes of economic growth and export diversification, and determines how technological progress influences this relationship. The existing literature is highly inconclusive about the growth mechanisms of resource-dependent countries and does not address the role of resource dependence in export diversification and technology-based growth. Empirical results, based on a sample of 160 countries over the time period 1996-2021, demonstrate that, overall, resource dependence fosters productivity growth but hinders export diversification. However, these effects vary considerably among specific types of natural resources. Despite their inhibiting role in the diversification trajectories, natural resources are

not responsible for excessive export specialization at low levels of development. In conclusion, natural resource exporters are not bound to fail. These countries' growth and diversification trajectories are contingent on the nature of their resource dependence and the incorporation of mitigating factors such as technological innovation and institutional quality. Moreover, they can benefit from technology-driven growth, provided that they innovate their resource production processes and increase the proportion of technologically advanced products in their export portfolio.

GDAŃSK UNIVERSITY OF TECHNOLOGY

DESCRIPTION OF DOCTORAL DISSERTATION

The Author of the doctoral dissertation: Zuzanna Helena Zarach

Title of doctoral dissertation: Growth and Diversification Trajectories of Natural Resource Exporters.

Title of doctoral dissertation in Polish: Ścieżki wzrostu gospodarczego i dywersyfikacji w krajach eksportujących surowce naturalne.

Language of doctoral dissertation: English

Supervisor: dr hab. inż. Aleksandra Parteka, prof. PG

Auxiliary supervisior: dr Aleksandra Kordalska

Date of doctoral defense:

Keywords of doctoral dissertation in Polish: zależność od surowców naturalnych, produktywność, specjalizacja technologiczna, dywersyfikacja eksportu, dekompozycja względnego indeksu Theila.

Keywords of doctoral dissertation in English: natural resource dependence, productivity, technological specialization, export diversification, relative Theil decomposition.

Summary of doctoral dissertation in Polish: Niniejsza rozprawa doktorska analizuje rolę, jaką zależność od surowców naturalnych odgrywa w procesach wzrostu gospodarczego oraz dywersyfikacji eksportu, a także określa jak postęp technologiczny wpływa na ten związek. Literatura przedmiotu nie identyfikuje jednoznacznie mechanizmów rozwoju w krajach zależnych od surowców naturalnych oraz nie uwzględnia ich roli w procesie dywersyfikacji eksportu oraz wzroście opartym na technologii. Wyniki empiryczne, bazujące na próbie 160 krajów na przestrzeni 26 lat (1996-2021), wskazują, iż zależność od surowców naturalnych sprzyja wzrostowi produktywności i równocześnie utrudnia dywersyfikację eksportu. Efekty te różnią się jednak pomiędzy różnymi typami surowców naturalnych. Pomimo hamującej roli w procesie dywersyfikacji, surowce naturalne nie są odpowiedzialne za wysoką specjalizację eksportu na niskim poziomie rozwoju. Podsumowując, gospodarki zależne od surowców naturalnych nie są skazane na porażkę. Ścieżki wzrostu gospodarczego oraz dywersyfikacji eksportu w tych krajach są uwarunkowane charakterem ich zależności od surowców naturalnych oraz uwzględnieniem czynników łagodzących. Ponadto, eksporterzy surowców naturalnych mogą czerpać z rozwoju opartego na technologii, pod warunkiem, że zdecydują się na wprowadzanie innowacji w procesach produkcji surowców oraz będą zwiększać udział produktów technologicznych w swoim eksporcie.

Summary of doctoral dissertation in English: This dissertation investigates the role of natural resource dependence in the processes of economic growth and export diversification, and determines how technological progress influences this relationship. The existing literature is highly inconclusive about the growth mechanisms of resource-dependent countries and does not address the role of resource dependence in export diversification and technology-based growth. Empirical results, based on a sample of 160 countries over the time period 1996-2021, demonstrate that, overall, resource dependence fosters productivity growth but hinders export diversification. However, these effects vary considerably among specific types of natural resources. Despite their inhibiting role in the diversification trajectories, natural resources are

not responsible for excessive export specialization at low levels of development. In conclusion, natural resource exporters are not bound to fail. These countries' growth and diversification trajectories are contingent on the nature of their resource dependence and the incorporation of mitigating factors such as technological innovation and institutional quality. Moreover, they can benefit from technology-driven growth, provided that they innovate their resource production processes and increase the proportion of technologically advanced products in their export portfolio.

CONTENTS

List of Abbreviations

4IR – products related to the 4IR technologies.

AI – Artificial Intelligence.

BELX – Belgium and Luxembourg.

COAL – natural resource taxonomy comprising coal products.

DIV – export diversification.

FORESTRY – natural resource taxonomy comprising forestry products.

FUEL – natural resource taxonomy comprising fossil fuel products.

GAS – natural resource taxonomy comprising natural gas products.

GDP – Gross Domestic Product.

GMM – Generalized Method of Moment estimation method.

GNP – Gross National Product.

ICT – products related to the ICT technologies.

METAL – natural resource taxonomy comprising metal products.

MINERAL – natural resource taxonomy comprising mineral products.

NR – Natural Resources.

OLS – Ordinary Least Squares estimation method.

OPEC – Organization of the Petroleum Exporting Countries.

PETROLEUM – natural resource taxonomy comprising petroleum oils products.

R&D – Research and Development.

RCA – Revealed Comparative Advantage.

RT – Relative Theil index.

SPEC – export specialization.

TECH – products related to the middle- and high-tech products.

TFP – Total Factor Productivity.

TOTAL NR – natural resource taxonomy comprising all types of resource products.

1. Introduction

This doctoral dissertation addresses the issue of the economic effects of natural resource dependence, evaluated within a broad international setting. Excluding the context of resources, it is situated within the streams of technological progress and structural transformation literature. Regarding the source data, this research departs from the traditional approach, adopting a methodology in which key explanatory variables are created using raw, disaggregated export data and newly elaborated product-level taxonomies. This work provides a substantial set of descriptive and empirical materials, as well as country-specific examples, attempting to assess the intricate nature of resource dependence both in growth and diversification trajectories. Despite the dissertation's pronounced emphasis on primary commodities, it does not neglect to acknowledge the pivotal role of technology-driven growth in today's world. Specifically, this research examines the inclusion of resource-dependent countries in the technological race. This is a consideration that, to the best of our knowledge, has not been addressed frequently enough in the past.

As of 2021, primary products accounted for nearly 18% of global trade and up to 90% of total exports in countries such as Angola, Iraq and Qatar (BACI, 2023). In light of the continued economic importance of natural resources, combined with climate change, inevitable resource depletion, and challenges related to the efficient use of renewable energy sources, it is essential to identify potential solutions to mitigate excessive resource dependence. Economic theory offers no satisfactory explanation as to why the possession of natural resources should be detrimental (Mellor, 1995; Auty, 2001; Lewis, 2009). Contrastingly, some influential trade theories suggest that commodities are produced more cheaply by the nations that have an abundance of the resources used in their production (Heckscher and Ohlin, 1991), while additional rents coming from natural resource exports allow higher investment and greater opportunities to import capital goods (Auty and Mikesell, 1998). Despite these advantages associated with natural resource endowments, resource-dependent economies are often perceived as being destined for failure, and, unfortunately, this perception materializes quite frequently (as in commonly studied examples of Venezuela (Satti et al., 2014), Nigeria (Ghecham, 2021), Sudan (Ali et al., 2023), or Yemen (Badeeb and Lean, 2017)).

Additionally, given the ongoing technological acceleration (i.e., the increasing importance of automation, robotization, and artificial intelligence - Aghion et al., 2019; Brynjolfsson et al., 2019; Roodman, 2020; Acemoglu et al., 2023; Growiec, 2024; Korinek and Suh, 2024; Acemoglu, 2025), it is important to comprehend the intricate relationship between natural resource dependence and countries' ability to benefit from the technological race. There are several examples of economies that have used resource rents to fund technological innovation (e.g. Scandinavian countries, Australia and Canada; David and Wright, 1997; De Ferranti et al., 2002; Ville and

Wicken, 2013) However, natural resource exporters can be excluded from the technological race (Foster-McGregor et al., 2019) due to a significant disparity in the economic profiles of countries specializing in advanced technological production and those depending almost exclusively on natural resources (Fagerberg and Verspagen, 2021). Consequently, it is crucial to understand whether technological specialization can influence resource-dependent nations.

All these issues make natural resource dependence a significant and fascinating topic to be studied. This research 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. **Specifically, 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 dissertation builds upon the rich literature on: (1) the growth mechanisms in economic theory, (2) the relationship between natural resources and economic growth, (3) structural change and diversification trajectories, and (4) the growth effects of technological progress. We address four **research gaps** identified in the current state of the art. Firstly, 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 and Abdullah Auzer, 2017; Ben-Salha et al., 2021; Tahir et al., 2023). Secondly, 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). Thirdly, 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. Finally, 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.

The main research hypotheses, which serve as critical pillars supporting the primary objective of this 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).

2. The Role of Natural Resources and Technological Progress in Economic Growth – Literature Review

Throughout the decades, the role of natural resources in development literature has undergone a gradual transformation. At the beginning of the 20^{th} century, primary products were associated with accelerated economic growth. However, as time progressed, economists began to recognize the negative aspects of resource dependence and started investigating the causes of poor growth in resource-based economies. The current state of the subject literature is highly inconclusive regarding the growth mechanisms of resource-dependent countries. 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.

This chapter recaps the current state of the discussion on economic effects of natural resources and provides a comprehensive overview of the literature on topics related to this dissertation's objectives, namely: (1) growth mechanisms in economic theory, (2) structural transformation and diversification dynamics, and (3) the growth effects of technological progress and the modern productivity paradox..

2.1. Growth Mechanisms in Economic Theory

The literature on the mechanisms of growth in economic theory can be divided into three main categories: (1) classical growth theory; (2) neoclassical theory of exogenous growth; (3) endogenous growth theory.

The ideas of Adam Smith, Thomas Malthus, and David Ricardo represent the first stream of literature and are often considered the precursors to modern growth theory. Inspired by the tremendous changes that shook 18th- and 19th-century England amidst the first industrial revolution, their works are often referred to as classical growth models. Their concepts were greatly influenced by political economy, which sought a scientific explanation for the governing forces behind economic systems, as well as by philosophical concerns about progress, a condition essential to societal development. The primary goal of the initial classical theories of economic growth was to determine the agents that promoted or hindered societal development and to suggest policies that would influence those factors (Harris, 2007).

Adam Smith, frequently referred to as the father of modern economics[4], was one of the first researchers to study progress in terms of national wealth growth. His most popular work, "The Wealth of Nations" (Smith, 1776), which, apart from economics, addresses philosophical, political,

[4] Smith's works were the basis for David Ricardo's definition of economics. This was the first time economics was defined as a separate field of study. Moreover, among Smith's contributions, one can find the creation of the concept of gross domestic product (GDP).

and social issues, primarily focuses on the role of industry and agriculture in economic growth. Taking a classical approach, Smith examines progress by applying a comprehensive economic perspective rather than focusing solely on the theory of economic growth. He recognizes the accumulation and reinvestment of a certain part of the social product as the key growth-driving force[5]. In capitalist conditions, this takes the form of reinvested profits. Smith's account of growth links faster capital accumulation with an accelerating growth of employment, output and living standards (Eltis, 1984). However, his work lacks a systematic approach to the relationship between capital accumulation and technological change. Smith also highlights another important issue: the potential for extending the division of labor. In his opinion, the division of labor increases productivity (Smith, 1776). This idea was fundamental to the creation of wealth generated by assembly-line production methods, which are now commonplace. Finally, Adam Smith is the author of several well-known concepts, including the "Invisible Hand Theory"[6] and the "Philosophy of Free Markets"[7].

Thomas Malthus's most influential work, the Malthusian Law of Population Growth (Malthus, 1798), presents a thorough and systematic theory of population growth and its social implications. Its main assumptions are exponential population growth and linear growth in the supply of resources (in particular land and food). Depending on the characteristics of the model, population growth occurs in response to rising wages (Harris, 2007), increased productivity (Weil, 2014), or technological advances (Lee, 1987). In the long run, these prerequisites for habitancy growth lead to a decline in the availability of resources per capita and the eventual implementation of "checks" that control the population. These checks take the form of either preventive or positive inhibitors[8], which ultimately constrain the population. Therefore, in compliance with Malthusian law, countries with higher productivity levels will not have higher living standards; they will only be more populous. Solely preventive checks can improve living standards and raise the population's well-being, not technological progress (Weil, 2014). Hence, the Malthusian model describes a primitive society with incomes slightly above the subsistence level (Lee, 1987). In such a society, rates of capital accumulation, which are crucial for economic growth, could hardly begin, let alone continue in the long run (Harris, 2007). Thus, the Malthusian Law of Population Growth clearly

---

[5] Apart from capital accumulation, Smith also lists returns to scale in various sectors of the economy and the ratio of productive to unproductive employment as factors that influence economic development (Eltis, 1984).

[6] According to Smith, free capitalist markets are guided toward social and economic prosperity by self-interest, supply and demand forces, and competition for scarce resources (Skousen, 2015).

[7] Smith was a staunch advocate for limited government intervention and taxation. Nevertheless, he acknowledged the government's role in the education and defense sectors (Skousen, 2015).

[8] According to Malthus, positive checks are circumstances that shorten the lifespan of humans, such as war, plague, and famine. A Malthusian catastrophe occurs when positive checks lead to high rates of premature deaths. A preventive check, on the other hand, is a situation in which human decisions alter population changes. These can include celibacy and chastity, as well as contraception, infanticide, abortion, and adultery, all of which were highly condemned by Malthus (Simkins, 2001; Malthus, 1798)

does not apply to today's growth mechanisms, yet it is often cited by advocates of population control (Dolan, 2000).

As a pure theorist, David Ricardo was one of the first economists to introduce abstract yet logical models of the economy without the use of mathematics. He later used these models to resolve practical, policy-oriented issues (Eltis, 1984). His most significant contributions to economic theory include his work on the theories of international trade (comparative advantage), value and income distribution, as well as economic growth. Ricardo's theory of income distribution[9] depicts national output as distributed among rents, wages, and profits in a society comprising of three classes: capitalists who receive profits, landlords who receive land rents, and laborers who receive wages (Kaldor, 1955). According to Ricardo's classical definition, rent is the portion of the land's produce paid to the landlord for its use. In this sense, rent is merely a payment for the use of land; it does not include the landlord's interest (Ricardo, 1817). As land becomes scarcer and more expensive over time, output distribution may reach a stationary state where wages stagnate at the subsistence level, rents reach their maximum, and profits equal zero (Stigler, 1952). However, Ricardo's theory of international trade posits that technological progress and international trade delay the onset of the Stationary State.

Within this framework, he also proposed the innovative concepts of comparative advantage and country specialization, which disengaged from the previously dominant idea of mercantilism[10]. In line with Ricardo's thought, countries can benefit from bilateral trade even if one country has an absolute advantage in producing all traded products. In this situation, what matters is the relative efficiency and a relatively lower opportunity cost in producing a particular good - in other words, a comparative advantage in production (Ricardo, 1817). Finally, the Ricardian model of economic growth, combining all the abovementioned theories, is based on the assumptions of the three factors of production[11], the labor theory of value[12], the law of diminishing returns in agriculture[13], Malthusian population growth, and perfect competition. According to this model, economic growth occurs through capital accumulation, which takes place via investment supervised by

[9] Ricardo's theory of income distribution incorporates the concepts of marginal and surplus principles. The marginal principle explains the share of rent in total output. The surplus principle, on the other hand, determines how the remaining output is divided between wages and profits (Kaldor, 1955).

[10] Mercantilism is a pre-classical economic system that regarded increasing exports and restricting imports as a means to prosperity. Mercantilism promoted agriculture, and manufacturing and considered the accumulation of gold and precious metals to be a proper sign of wealth (Krist, 2013).

[11] Although the Ricardian model includes labor, land, and capital as factors of production, land was considered a more important form of wealth than capital (in accordance with 18th- and 19th-century economic norms). The role of capital became more crucial in economic research after the Industrial Revolution (Weil, 2014).

[12] In short, the Ricardian labor theory of value posits that the value of economic goods originates from the amount of labor required to produce them. The total amount of labor in society is the most reliable source of value and the best yet imperfect measure of it (Ricardo, 1817). This theory was prevalent in the 18th and 19th centuries and was also promoted by Adam Smith and Karl Marx.

[13] As more labor is designated to the agricultural land, the average and marginal products of labor diminish.

capitalists. Investment, on the other hand, originates from profits gained from labor. As economic growth progresses, an increase in demand for food, intensive and extensive margins of land, total rents, and wages is recorded. This leads to a point where profits equal zero, a condition called a Stationary State, where investment and growth rates fall. Ricardo proposed several solutions for the Stationary State, including initiating international trade, repealing laws that benefit only landlords, and protecting the price of goods (Eltis, 1984).

During the period between the decline of classical economics and the rise of the neoclassical notion, Keynesian economics emerged in response to challenges arising from the Great Depression. Keynesianism was highly critical of the classical school of thought and its reluctance to accept economic interventionism. Its central belief is that government intervention has stabilizing effects on output, employment, and inflation, which are affected by aggregate demand that does not necessarily equal the productive capacity of the economy (Keynes, 1936). A major growth model of Keynesian economics is the Harrod–Domar model[14]. It explains growth rates in terms of capital and savings levels, suggesting that constant balance in economic growth is essentially unjustified (Harrod, 1939; Domar, 1946).

The Harrod–Domar model predated the exogenous growth models that emerged from the neoclassical research stream on economic growth in the mid-twentieth century (Hagemann, 2009). In the late 1950s, Nicholas Kaldor noted that developed countries appeared to satisfy six fundamental principles associated with long-term economic growth[15]. Since then, the main challenge of growth theory has been to account for all of these facts simultaneously (Kaldor, 1957). The first neoclassical model to satisfy all of Kaldor's conditions was the Solow–Swan model (Campante et al., 2021). Developed independently by Robert Solow and Trevor Swan, it expands the Keynesian Harrod–Domar model by eliminating the restrictive assumption that only capital contributes to growth, provided there is sufficient labor to utilize all available capital (Solow, 1956; Swan, 1956). The model attempts to explain long-run economic growth by examining capital accumulation, labor growth, and productivity increases, which are mostly driven by technological progress or knowledge accumulation (Acemoglu, 2009).

The Solow-Swan model is based on two equations: a production function and a capital accumulation equation. The production function traditionally takes the Cobb-Douglas form and

[14] The Harrod–Domar model categorizes the rate of growth into three types: warranted growth, actual growth, and natural growth. Warranted growth is the growth rate at which all savings are absorbed into investment. Actual growth is the real rate of increase in a country's GDP per year. Natural growth is the rate required to maintain full employment (Harrod, 1939).

[15] In accordance with Kaldor's stylized facts, long-term output per worker exhibits continuous growth, and the rate differs substantially across countries. The capital-output ratio and the rate of return on capital are nearly constant. Capital per worker exhibits continuous growth, and labor and capital receive constant shares of total income (Kaldor, 1957; Campante et al., 2021).

characterizes the role of inputs (capital, K, labor, L, and knowledge/technology, A) in producing output, Y (Jones, 2002). The key assumptions about the production function are that it has constant returns to scale, diminishing marginal returns to all inputs, an exogenous rate of population growth and technological progress, and that it defines all variables at every point in time[16]. From these assumptions, we can derive the following facts: (1) inputs other than capital, labor, and knowledge are essentially irrelevant for the model. (2) the economy is large enough that the benefits of specialization have been exhausted (Romer, 2010). On the other hand, the capital accumulation equation describes how capital accumulates over time. According to this equation, the change in the capital stock equals the sum of the actual investment and the break-even investment. The break-even investment addresses two issues: first, since capital depreciates, it must be replaced to prevent the capital stock from falling; second, since the quantity of effective labor is growing, the capital stock must grow to remain steady (Romer, 2010).

Additionally, the Solow-Swan model implies that all countries will converge to a balanced growth path, regardless of their initial position[17]. According to the model, growth occurs solely during the transition to a balanced growth path when capital and labor are developing. Once on this path, each model variable grows at a constant rate[18], and output growth is purely determined by the rate of technological progress. However, the model does not identify the determinants of technological progress because it treats knowledge accumulation as an exogenous factor. Thus, the Solow-Swan model lacks the prerequisites for long-term growth because it does not characterize the only potential long-term growth accelerator, technological progress (Romer, 2010; Campante et al., 2021).

In its basic form, the Solow-Swan model disregards natural resources as a contributor to economic growth. However, incorporating restrictions on exhaustible natural resources and land could provide more accurate insights into the prerequisites of growth. The first attempts to theorize this approach originated with Nordhaus (1974), who was later followed by Stiglitz (1974a, 1974b), Nordhaus et al. (1992), and Cavalcanti et al. (2011b). Including natural resources and land as inputs to the model was matched with the following assumptions: an exogenous extraction rate of natural

[16] Apart from these assumptions, the Cobb-Douglas production function satisfies the so-called Inada conditions, which define the shape of a function with well-behaved properties in economic models (Inada, 1963). These conditions are: (1) the function exhibits positive and diminishing marginal products with respect to each input, (2) the function exhibits constant returns to scale, and (3) the marginal product of capital or labor approaches infinity as capital or labor approaches zero and approaches zero as capital or labor approaches infinity. All neoclassical production functions must satisfy all Inada conditions (Campante et al., 2021).

[17] The Solow-Swan model implies conditional convergence, whereby less advanced states with lower output and capital per worker are bound to have higher growth rates than developed countries within a group of structurally similar economies. Absolute convergence, on the other hand, is the hypothesis that poorer countries grow faster than richer countries, regardless of the characteristics of the economies under consideration (Romer, 2010).

[18] Sometimes, a balanced growth path is mistakenly assumed to be a state of no growth. In reality, it is a steady state characterized by a constant growth rate of all variables included in the model. (Campante et al., 2021).

resources, a fixed amount of land that cannot increase, and a declining share of natural resources in the production process. Traditional assumptions of constant returns to scale and diminishing returns for each input also apply (Maris and Holmes, 2023). As the economy converges to a balanced growth path, higher rates of resource extraction result in lower rates of long-term steady-state growth (Zhang et al., 2022). Therefore, limitations in natural endowments can cause output per worker to fall, and the greater the dependence on natural resources in the production process, the greater the drag on growth (Gylfason and Zoega, 2006). However, if 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)[19].

Although the original Solow-Swan model defines technological progress as an exogenous factor, it can also be modified to allow for endogenous growth. One of the simplest models that includes endogenous technological progress is the AK model[20]. Its production function is a special case of the Cobb-Douglas function, in which the output elasticity of capital equals one. This implies that the function is linear in capital and therefore has a constant marginal product of capital. In other words, each new unit of capital is as productive as the previous one, and the marginal product of each unit of capital always equals the level of technology (A), thereby enabling long-term growth. Other key properties include constant returns to scale and no convergence process (Romer, 1986). In the AK model, the economic growth rate is an increasing function of the investment rate. Thus, in a closed economy, government policies that increase the investment rate lead to a permanent increase in the economy's growth rate (Jones, 2002).

The third research stream on endogenous growth theory emerged in earnest in the 1980s as an alternative to the neoclassical theory of exogenous growth. The theory was most notably advanced by the works of Robert Lucas (1988) and Paul Romer (1986, 1990). It incorporates technological progress as an endogenous factor and defines research and development as the main driving force behind it (Jones, 2002). Within this framework, improvements in human capital are considered a primary contributor to economic growth, alongside innovation and knowledge. Furthermore, the endogenous growth theory emphasizes the importance of a knowledge-based economy and the fact that investments in new technologies and human capital lead to increases in

[19] The Solow-Swan model can be also extended to the Ramsey-Cass-Koopmans model of exogenous growth. In this model, the saving rate of actual investment is endogenized, assuming that saving decisions are up to representative households that choose particular consumption patterns to maximize their utility. This approach results in a more dynamic structure during the transition to long-run balanced growth. Therefore, the model is better suited to explaining long-term growth than short-term business cycles. (Ramsey, 1928; Cass, 1965; Koopmans, 1965).

[20] In the AK model, K represents both physical and human capital, while A is often used interchangeably to refer to either productivity or technological progress. The basis for the AK model was laid by the works of Frankel (1962) and Arrow (1962). This line of research emerged in response to dissatisfaction with the use of standard neoclassical exogenous growth models to study long-run growth.

growth, such as constant return to scale and spillover effect[21] (Helpman, 2004). Innovation-based endogenous growth theory consists of two parallel branches (Aghion and Howitt, 2009): (1) the product-variety model of Romer (1990), in which innovation-driven productivity growth stems from the creation of new products, not necessarily improvements to existing ones, and (2) the quality-improvement model of Aghion and Howitt (1992), which is based on Schumpeterian growth theory and posits that innovations and so-called creative destruction lead to productivity gains.

The Romer model of endogenous technological change (1990) is based on the idea that research and development lead to a greater variety of inputs used in production. The creation of new inputs increases the productivity of the labor force, which in turn improves the productivity of the entire company. Because of these dynamics, the Romer model is sometimes referred to as a process innovation model[22] (Acemoglu, 2009). The baseline version of the Romer model is grounded on the assumption of a fixed population consisting of R&D workers (so-called "idea makers") and output-producing employees whose utility depends solely on consumption. Final goods are produced under perfect competition using labor and a range of intermediate inputs, and they are used for consumption and investment. The only other possible application for final goods is their use in producing intermediate products. Ideas are nonrival, meaning each new innovator can use them. However, each intermediate product created, based on an idea, is monopolized by its creator, who seeks to maximize profit from it. This profit maximization is the main source of motivation for innovation activities. In the long run, productivity increases caused by the specialization of labor, greater variety in intermediate inputs, and research spillovers positively affect economic growth (Acemoglu, 2009; Aghion and Howitt, 2009).

One of the most debated characteristics of Romer's model is its prediction that economic growth should increase concurrently with the productivity of research and population size, allowing larger countries to grow faster (Aghion and Howitt, 2009). This concept, dubbed a scale effect, is

---

[21] The alleged failure of endogenous growth theory to capture and explain key empirical regularities in the growth processes of individual economies led to the development of unified growth theory (Galor, 2005; Galor, 2011). Adopting a Malthusian perspective, unified growth theory posits that for most of human history, technological progress was counterbalanced by population growth, resulting in stagnant living standards (Artzrouni and Komlos, 1985; Komlos, 2000). However, the final reinforcement of the interaction between population growth and the rate of technological progress increased the level of technological advancement and forced the allocation of resources toward education, which was the only solution to keep up with accelerating technology. The increased focus on education led to a decline in fertility rates, enabling economies to allocate the benefits of technological progress toward raising income per capita instead of increasing the population. This change facilitated sustained economic growth. Furthermore, according to unified growth theory, the differential pace of growth and divergence in income per capita across countries stem from variations in biogeographical, cultural, and institutional characteristics (Ashraf and Galor, 2011; Galor and Klemp, 2019; Franck and Galor, 2022).

[22] On the other hand, the Grossman and Helpman (1991, 1993) model emphasizes product innovation. According to this model, research and development lead to an increase in the variety of final goods produced. The greater variety of products increases utility among households and raises real income.

the main source of criticism of the model of endogenous technological change (Backus et al., 1992; Jones, 1995a and 1995b). Jones (1995a, 1995b) points out that despite the increase in the number of people engaged in R&D, U.S. data lacks evidence of an upward trend in TFP or output per worker. This contradicts the scale effect assumption in Romer's model. Furthermore, the argument of population-led growth can easily be overturned since large countries do not necessarily grow faster, and the population of most countries has recently remained constant. Based on these observations, Jones (1995a) proposed a semi-endogenous R&D-based growth model. In this model, economic growth is determined solely by population growth (an exogenous factor) and technology (an endogenous factor). It does not respond to governmental interventions (Acemoglu, 2009).

Another limitation of the endogenous technological change model is the fact that it does not account for the role of creative destruction in the growth process (Aghion and Howitt, 2009). This drawback is addressed in the quality-improvement branch of endogenous models, which is based on Schumpeterian growth theory[23]. The first attempts to incorporate the Schumpeterian approach into endogenous growth theory were made by Segerstrom et al. (1990) and Corriveau (1991). Furthermore, Aghion and Howitt (1992) propose a basic model of competitive innovations that embodies Schumpeter's concept of creative destruction, as well as the significance of firms' and workers' exit and turnover. The one-sector version of this model assumes, that during each considered period, one person attempts innovation. If successful, the innovation will create a new version of the intermediate product. Always the same product is improved by innovation. Innovation requires research, a costly and uncertain activity since it may not generate anything new. However, the more research conducted, the greater the likelihood of success (Aghion and Howitt, 2009). Due to the uncertainty of the innovation process, growth is uneven, with infrequent bursts of innovation followed and preceded by periods of no growth. Another source of uneven growth in Schumpeterian theory is that current innovations will be devalued by future growth. This situation is consistent with the concept of creative destruction (Acemoglu, 2009). In the model of quality-improving innovations, growth results from an increase in productivity and innovation size. Moreover, in line with the model's assumptions, economic progress may be enhanced by a growth in population size and the accompanying increase in the supply of labour. This brings out the scale effect problem and the challenging arguments against it (Aghion and Howitt, 2009). However, this problem can easily be resolved within the Schumpeterian paradigm, as demonstrated by fully

[23] According to Schumpeter's theory of growth, economic progress stems from innovation and the process of creative destruction, which renders older innovations obsolete and replaces them with new ones. Schumpeter argued that economic growth is rather abrupt and disjointed than gradual and peaceful. However, the process of destroying old, established norms is essential to building a new, improved technological reality (Schumpeter, 1912, 1942; Knell and Vannuccini, 2022).

endogenous Schumpeterian models without scale effects (Aghion and Howitt, 1998; Peretto, 1998; Dinopoulos and Thompson, 1998; Howitt, 1999).

As previously noted, capital-dependent, exogenous growth models acknowledge natural resources as exhaustible inputs to the production process, focusing chiefly on land and extractable primary products. However, incorporating endogenous technological change into growth theory allows us to examine the relationship between natural resources and economic growth differently. This approach emphasizes renewable resources and introduces the concepts of environmental constraints and environmental friendly innovations[24]. It simultaneously analyzes the impact of these factors on economic development and the regulatory role of directed technological change[25] in the more efficient use of non-renewable resources (Maris and Holmes, 2023). According to the simplest endogenous approach, the AK model, innovations cannot sustain long-run growth with exhaustible resources. However, the Schumpeterian model makes it possible. In this approach, long-term growth is possible thanks to innovations that reduce the use of non-renewable resources. Furthermore, these innovation activities are a priori considered "green" (Aghion and Howitt, 2009). In other words, the Schumpeterian contribution does not categorize innovation as either "clean" or "dirty" technologies, while this type of division provides significant insight into the factors influencing endogenous technological growth, particularly when considering natural resources (Acemoglu et al., 2012; Smulders et al., 2014; Witajewski-Baltvilks and Fischer, 2023). This approach is often accompanied by a two-region framework (North and South), in which the innovation capacity of both regions and the byproducts of technology flow between them are examined (Acemoglu et al., 2014; Hémous, 2016; van den Bijgaart, 2017).

[24] Nordhaus (1974, 1977) pioneered work on the relationship between economic growth and the environment. In these works, he addresses problems of environmental conservation and the constraints that natural resources could impose on growth.

[25] Directed Technical Change (DTC) is the concept which refers to the idea that technological progress affects different factors of production unequally. This inequality may be caused by various factors, including the relative prices of inputs, the availability of different types of labor, market-created incentives, and the scarcity of natural resources. DTC suggests that the exhaustion of primary products can shift the focus of innovation toward technologies that use resources more efficiently or find alternatives to non-renewable resources (Acemoglu, 2002; Hassler et al., 2021).

2.2. Natural Resources and Growth – the Resource Curse Debate

The literature on the relationship between natural resources and economic growth can be divided into six key streams: (1) natural resources as economic growth factors; (2) the decline of the "resource golden age"; (3) resource curse literature; (4) the growth effects of resource abundance and resource dependence; (5) the determinants of the resource curse; (6) survey studies and meta-analyses summarizing the resource curse.

Within the first stream, Auty (2001) emphasizes that 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). Moreover, growth theory suggests that additional rents and foreign exchange from natural resource exports should allow for higher investment levels and greater opportunities to import capital goods (Auty and Mikesell, 1998). Additionally, resource trade channels are expected to stimulate economic growth, particularly in emerging economies (Myint, 1958). Several theories of export-led growth, including the "staples thesis"[26] and the "vent for surplus thesis"[27], also emphasize the crucial role that resource trade plays in economic development.

Growth theories that highlight the positive effects of natural resources were reinforced by the example of the Golden Age of Economic Growth (1870-1913). During this period, resource-abundant countries experienced rapid growth and often outperformed resource-poor countries (David and Wright, 1997; Findlay and Lundahl, 2001; Lewis, 2009; Álvarez and Prado, 2022). The Second Industrial Revolution promoted resource-endowed states by creating dynamic demand for primary products, especially those used in steel and fuel production (Badia-Miró et al., 2015). The United States of America was undoubtedly one of the biggest beneficiaries of that period, becoming the leader in the production of nearly all crucial industrial minerals at the beginning of the twentieth century[28]. At the same time, David and Wright (1997) argue that the success of the American resource industry was owed not only to actual deposits, but also to the crucial role played by research and technology. In this instance, American mineral expansion exhibited many features of a modern knowledge-based economy, which facilitated prolonged economic growth (David and

[26] According to the staples theory, the presence of staple commodities and the expansion of the natural resource export sector enhance economic development (Southey, 1978; Badia-Miró et al., 2015). However, this theory has been heavily criticized since the 1990s (Altman, 2003).
[27] The vent for surplus theory, a concept developed by Adam Smith, characterizes trade as a means of generating economic growth and wealth by utilizing unexploited natural resources (Innis, 1956; Bertram, 1963; Chambers & Gordon, 1966; Smith, 1976; Altman, 2003).
[28] In addition to the United States, Australia, Canada, and the Scandinavian countries exemplify how to successfully leverage abundant natural resources for sustainable development (De Ferranti et al., 2002; Álvarez and Prado, 2022).

Wright, 1997). Indeed, the inclusion of the technology in resource industries has proven to be key to productivity growth (De Ferranti et al., 2002).

The second stream (on the decline of the "resource golden age") emphasizes that the mid-twentieth century marked the end of prosperity for most resource-endowed countries. Despite a few periods of skyrocketing resource prices and substantial windfalls, the poor performance of resource-led states in the second half of the twentieth century redirected researchers' attention to the negative effects of resource abundance (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; Berge et al., 1994). Raúl Prebisch (1950) was one of the first post-war authors to study the growth trajectories of resource-abundant countries. He projected a decline in the terms of trade for natural resources. At the same time and independently, Hans Singer (1950) came up with similar research results. Their theorem, known today as the "Prebisch-Singer hypothesis", states that the price of primary products deteriorates relative to the price of manufactured goods imported by developing resource-led states. According to Prebisch and Singer, this situation is the result of prolonged and unsustainable dependence on raw materials. Other scholars searched for the causes of poor growth based on natural resources in export theories (Baldwin, 1956; Hirschman, 1958; Seers, 1964; Baldwin, 1966), especially highlighting that the backward-forward linkages between resource industries and the rest of the economy are destined to be small. This is mainly due to the nature of natural resource production, which is substantially capital-intensive and requires a less complex division of labour. A workforce consisting mainly of "cheap labour" results in an imbalanced distribution of income, which leads to disturbances in the demand and fiscal linkages. Therefore, the economy is prone to specialization and usually falls into the "staple trap"[29].

The discovery of a large natural gas field in the Netherlands in the late 1960s, along with the accompanying deterioration of economic growth, initiated a new branch of resource literature. The characteristic symptoms that emerged after the discovery of the field, including a rise in the currency value, worsening of the economy's competitiveness, and an increase in the volume of imports, are known today as "Dutch Disease". Corden and Neary (1982) thoroughly described this phenomenon for the first time and proposed a three-sector model to explain it. In simple terms, the discovery of resource deposits triggers positive income growth and expansion of the tradable resource sector. Consequently, this results in a transition to non-tradable sectors (usually services), yielding a deterioration of the tradable manufacturing and/or agricultural sectors. Thus, the discovery of resources increases the risk of deterioration in the manufacturing sector and slower

[29] To counter this hypothesis, Roemer (1970) and Lewis (1989) provided examples of countries (e.g., Peru) that avoided the staple trap and enjoyed sustained resource-based growth.

economic growth compared to a situation without new resource deposits (Corden, 1984). Furthermore, temporary resource booms can lead to a loss of competitiveness (Krugman, 1987). Similarly, Auty (1990) and Gelb (1988) examine the oil price shocks of the 1970s and the associated windfall gains. They conclude that political factors may actually be responsible for the poor performance of resource-abundant countries.

A seminal paper by Sachs and Warner (1995) initiated the third stream of literature regarding natural resources and their potential negative effects on economic growth. They showed that economies with a high ratio of primary exports to GDP (in the initial year of 1971) tended to have low growth rates between 1971 and 1989. This direct, negative effect of natural resource intensity remained significant even when controlling for important economic growth determinants and introducing alternative measures of resource abundance[30]. Additionally, resource intensity was found to operate negatively and indirectly through one of the determinants of growth, namely trade openness. However, this effect was much weaker than the direct one. The abovementioned findings, though described by the authors as "preliminary and far from definitive", popularized the "resource curse" phrase[31] and reignited the "natural resource – economic growth" debate. The methodology put forth by Jeffrey D. Sachs and Andrew M. Warner later served as a source of inspiration for other researchers. Mehlum et al. (2006) used the same data as Sachs and Warner (1995) to examine the role of grabber-friendly institutions in the resource-growth nexus. They found that a lower quality of institutions, combined with more natural resources, decreases aggregate income. On the other hand, in line with the results obtained by Yang (2010), institutional quality in developing countries does not significantly influence resource-growth relations. What actually helps with impeding the resource curse are governmental policies. Arezki and van der Ploeg (2010) expanded Sachs and Warner's dataset to the 1965-1990 period. Using the same proxy for resource abundance, they attempted to estimate the effect of the interaction between it and trade policies on economic growth. According to their findings, the negative effects of the resource curse are less severe in countries with fewer trade restrictions and higher institutional quality. However, once the endogenous nature of some regressors was considered, the empirical evidence for the resource curse was not robust.

[30] Primary exports, referred to as SXP, are the sum of non-fuel (SITC categories 0, 1, 2, 4, and 68) and fuel (SITC category 3) primary products. The set of control variables featured trade openness, the investment rate, bureaucratic efficiency, and initial levels of GDP. Alternative measures of resource abundance included the share of mineral production in GDP, the share of primary exports in total exports, and the log of land area per person (Sachs and Warner, 1995).

[31] The resource curse phenomenon occurs when resource-rich countries are unable to benefit fully from their abundance and perform notably worse than economies without an abundance of primary products (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; Doraisami, 2015; Sharma and Pal, 2021; Inuwa et al., 2022).

A major objection to the methodology of Sachs and Warner (1995) concerns the selection of the proxy for natural resource abundance[32]. As Brunnschweiler (2008) stressed, choosing between resource abundance and resource dependence can lead to entirely different estimation results. To address this issue, she proposed a more accurate measure of resource abundance[33] and considered the role of institutional quality. She then presented evidence that challenges the resource curse hypothesis. A clear distinction between the measures of resource dependence and abundance has also been included in various subsequent works. For instance, Kropf (2010) gauged resource wealth as the annual rent of resource production per capita, demonstrating its positive correlation with economic growth. The resource abundance proxies[34] preferred by Brunnschweiler and Bulte (2008) positively affected growth and institutional quality. Ding and Field (2004) used natural resource capital as a proxy for resource abundance and the ratio of natural resources to total capital as a proxy for resource dependence. They confirmed the positive impact of abundance and the negative impact of dependence on economic growth. Dependence on fossil fuel exports, particularly when associated with poor-quality institutions, significantly impedes GDP growth. Conversely, per capita fossil fuel wealth positively affects economic performance (Moshiri and Hayati, 2017). Lastly, Ertimi et al. (2022) demonstrated that oil abundance promotes economic progress and that the hindering nature of oil dependence can be conditioned only by the transmission mechanisms.

The fourth stream of literature reveals, that when compared simultaneously, natural resource abundance usually exhibits a positive effect on economic growth, contrary to natural resource dependence (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 as well as resource abundance may affect growth positively and negatively. Contrary to common belief, countries rich in natural resources can sustain economic growth (Sharma and Paramati, 2022; Brunnschweiler, 2008), particularly when they are endowed with fossil fuel subsoil assets (Cotet and Tsui, 2013; Alexeev and Conrad, 2009). Even at the provincial level, resource abundance may positively influence economic performance (Ji et al., 2014). Furthermore, a country's oil abundance, as measured by production levels, has short- and long-term positive effects on economic growth (Altaee et al., 2022; Cavalcanti et al., 2011a). Nevertheless, examining

[32] The share of primary exports in GDP at the beginning of the observation period should serve as a better indicator of resource dependence because it regards natural resource exports. The relative availability of this indicator made it popular among scholars, and many subsequent studies demonstrated the negative growth effects of resource abundance based on it.
[33] Mineral production in 1970 (per capita and as a share of GDP) and the World Bank's resource wealth measure.
[34] Brunnschweiler and Bulte (2008) used the log of total natural capital and mineral resource assets in US$ per capita as a proxy for resource abundance. However, their measure of resource dependence, the ratio of primary exports to GDP, was found to be insignificant in relation to economic growth.

individual countries reveals that production of natural resources impedes the development of various growth determinants (Buccellato and Mickiewicz, 2009; Oskenbayev et al., 2013; Papyrakis and Gerlagh, 2007; Zhang et al., 2009).

When it comes to natural resource dependence, an increase in oil exports has been shown to improve economic performance (Karamelikli et al., 2017; Sultan and Haque, 2018; Khayati, 2019; Khan and Khan, 2023), thus debunking the resource curse theory. Total resource rents[35] significantly and positively impact the economic growth of individual countries (Tahir et al., 2023; Wahyudi and Palupi, 2023) as well as groups of countries (Karimu et al., 2017; Fuinhas et al., 2017; Aljarallah, 2020; Ben-Salha et al., 2021; Shittu et al., 2022; Destek et al., 2023; Mesagan and Vo, 2024). Regarding oil rents specifically, the literature provides evidence of their positive impact on entrepreneurial start-ups (Ajide and Soyemi, 2022), educational quality (Farzanegan and Thum, 2020), GDP per capita (Jalili et al., 2019; Okoye et al., 2022), and GDP growth rate (Haque, 2020). Researchers also emphasize the essential role of oil revenues (Alkhathlan, 2013; Chekouri et al., 2017; Hilmawan and Clark, 2019; Raifu, 2021). Lastly, Danesh Jafari et al. (2020) stress that government size and spending depend significantly on oil revenues.

Despite the many contributions to the resource-blessing argument, researchers frequently point out the inhibiting characteristics of natural resource dependence. Excessive dependence on resources can lead to rent-seeking behaviours (Gylfason, 2000), lower economic performance (Auzer and Abdullah Auzer, 2017; Ndjokou and Tsopmo, 2017; Saeed, 2021; Inuwa et al., 2022), armed conflicts (Carbonnier and Wagner, 2015; Elbadawi and Soto, 2015) the crowding-out effect (Horváth and Zeynalov, 2014), high levels of corruption (Brückner, 2010; Salari and Noghanibehambari, 2021), high levels of non-resource export concentration (Bahar and Santos, 2018), lower levels of human development (Bulte et al., 2005), weaker institutions (Park and Lee, 2006; Boschini et al., 2013), lower total factor productivity growth (Cuevas Ahumada and Calderón Villarreal, 2022; Awoa Awoa and Ondoa, 2023), increased wealth inequality (Tadadjeu et al., 2023), a lower rate of genuine savings (Atkinson and Hamilton, 2003), and a decline in the growth of domestic value-added exports per capita (Bontadini, 2021). These negative results are typically obtained in cross-country analyses with a large sample size and a broad timespan.

A universal explanation as to why some countries are blessed with natural resources while others are not has yet to be determined. Nevertheless, some answers proposed by researchers seem to bring us closer to the truth, and these answers constitute a fifth literature stream presented in this review. The quality of institutions and governing bodies appears to be one of the most widely used and important factors in the debate on the paradox of plenty (see, among many: Atkinson

[35] Total resource rents are measured as a percentage of GDP and consist of an aggregate of oil, gas, coal, mineral, and forest rents.

and Hamilton, 2003; Isham et al., 2005; Mehlum et al., 2006; Boschini et al., 2007; Brunnschweiler, 2008; Torvik, 2009; Cavalcanti et al., 2011a; Boschini et al., 2013; Horvath and Zeynalov, 2014; Farhadi et al., 2015; Ben-Salha et al., 2018; Epo and Nochi Faha, 2020; Shittu et al., 2022). The impact of resource abundance and dependence on economic growth depends directly on the quality of institutions (Torres et al., 2012; Moshiri and Hayati, 2017; Ndjokou and Tsopmo, 2017). Mehlum et al. (2006) point out that the resource curse only affects countries with grabber-friendly institutions, whereas producer-friendly institutions protect against this phenomenon[36]. Cross-country regressions, conducted by Atkinson and Hamilton (2003) and Torvik (2009), revealed a significant and negative relationship between resource endowments and economic growth, which is caused by governing bodies' inability to sustainably manage large resource revenues. Furthermore, countries with weak institutions tend to be more susceptible to the resource curse (Butkiewicz and Yanikkaya, 2010; Elbadawi and Soto, 2012; Horvath and Zeynalov, 2014). At the same time, the quality of institutions can transform the resource curse into a blessing (Farhadi et al., 2015). Once institutional quality surpasses a certain threshold, resource abundance has a significant positive effect on economic growth (Boschini et al., 2013; Sarmidi et al., 2014; Belarbi et al., 2016).

The quality and type of governance play a crucial role in the potential success of natural resource exporters. Reverse causality, whereby resource deposits are the cause of a lower level of democracy, may also occur (Barro, 1999; Ross, 2001; Jensen and Wantchekon, 2004; Collier and Hoeffler, 2005; Oskarsson and Ottosen, 2010; Arezki and Brückner, 2011; Tsui, 2011; Bjorvatn et al., 2012; Awoa Awoa and Ondoa, 2023). According to Barro (1999), overall, for a given standard of living, democracy tends to decrease with a greater dependence on primary commodities. Jensen and Wantchekon (2004) present empirical evidence of a statistically significant negative correlation between natural resource endowments and the level of democracy in Africa[37]. Furthermore, Park and Lee (2006) emphasize that African countries must maintain a certain quality of governance to avoid the negative effects of resource exports on economic growth. This effect is exacerbated by their non-democratic and unstable political environments. Finally, Tsui (2011) stresses that oil wealth is particularly causally related to long-term democratic development and significantly contributes to lower levels of democracy in resource-abundant countries compared to other economies. Additionally, Ross (2001) shows that oil exports are strongly connected with

[36] The mitigating effects of producer-friendly institutions were also highlighted by Epo and Nochi Faha (2020) and Shittu et al. (2022).

[37] According to Jensen and Wantchekon (2004), post-Cold War democratic reforms were only successful in countries without significant natural resources deposits (e.g. Mali, Benin and Madagascar).

authoritarian rule, an effect that is relevant in all resource-dependent countries, not just Middle Eastern oil exporters[38].

Among the variables that mitigate the relationship between natural resources and economic growth, one can also find trade openness and financial development (see, for example: Lederman and Maloney, 2007; Van der Ploeg and Poelhekke, 2009; Arezki and Van der Ploeg, 2010; Satti et al., 2014; Farhadi et al., 2015; Majumder et al., 2020; Destek et al., 2023; Mesagan and Vo, 2024). In the case of resource-dependent countries, financial inclusion yields significant and positive effects on GDP growth (Adabor and Mishra, 2023). At the same time, a well-developed financial sector can mitigate the effects of the resource curse (Van der Ploeg and Poelhekke, 2009). Furthermore, Satti et al. (2014), demonstrate that financial development, coupled with trade openness, can boost economic growth in resource-abundant countries. Trade openness alone plays an important role in reducing the negative effects of the resource curse (Majumder et al., 2020). Countries with less restrictive trade policies alleviate symptoms of the paradox of plenty (Arezki and Van der Ploeg, 2010), while greater economic freedom transforms the negative growth effects of resource abundance into positive ones (Farhadi et al., 2015). Lastly, economic complexity is an important channel for promoting long-term resource prosperity (Mesagan and Vo, 2024), and it plays a significant role in mitigating the negative effects of natural resource dependence (Canh et al., 2020).

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; Boschini et al., 2007; Olsson, 2007; Butkiewicz and Yanikkaya, 2010; Van der Ploeg, 2011; Belarbi et al., 2016) and fossil fuels (see, for example: Isham et al., 2005; Torvik, 2009; Tsui, 2011; Badeeb and Lean, 2017; Cuevas Ahumada and Calderón Villarreal, 2022; Ali et al., 2023; Ertimi et al., 2023). Nevertheless, 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), especially when the proxy for oil dependence serves as an explanatory variable (Alkhathlan, 2013; Sultan and Haque, 2018; Jalili et al., 2019; Danesh et al., 2020; Haque, 2020; Majumder et al., 2020; Ajide and Soyemi, 2022). It is also worth mentioning that, somewhat surprisingly, forestry rents exhibit a positive effect on economic growth when juxtaposed with oil and mineral rents (Naidoo, 2004; Ofori and Grechyna, 2021; Nkemgha et al., 2022; Zarach and

[38] At the other end of the spectrum, Oskarsson and Ottosen (2010) challenge Ross's (2001) findings and reveal that the alleged negative influence of fossil fuels and minerals on democracy is not supported by evidence and leaves this theory inconclusive. A strong democratic government guarantees that resource wealth can positively affect economic growth, even in environments with poorly developed institutions (Bjorvatn et al., 2012). Furthermore, maintaining democratic institutions may allow resource-rich countries to avoid the resource curse (Awoa Awoa and Ondoa, 2023).

Parteka, 2023a). 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).

The sixth stream comprises several survey studies from the last decade and a half that attempted to summarize nearly 30 years of vast and often contradictory literature on natural resources (e.g., Frankel, 2010; Van der Ploeg, 2011; Ross, 2015; Havranek et al., 2016; Badeeb et al., 2017; Dauvin and Guerreiro, 2017; Papyrakis, 2017; Van der Ploeg and Poelhekke, 2017; Zhang and Brouwer, 2020; Alssadek and Benhin, 2023). Numerous review papers confirm that the literature does not offer a simple answer to the question of whether natural resources are a "curse" or a "blessing". Despite the abundance of research papers presenting multiple arguments for and against, the debate on the resource curse remains open.

According to Van der Ploeg (2011) and Van der Ploeg and Poelhekke (2017) empirical evidence suggests that both the resource blessing and the resource curse are possible. Resource-rich countries with accountable institutions, high rates of investments and trade openness can benefit from natural resource wealth. However, most resource-dependent countries, especially those dealing with corruption and poor-quality institutions, have low or negative growth records and high inequality. Unfortunately, resource bonanzas may strengthen rent-seeking behavior and make economies more prone to civil wars and vulnerable to commodity price volatility[39]. Ross (2015) in his analysis of the "political resource curse", finds that high levels of petroleum income display its negative influence more vividly than other resources. This strengthens the likelihood of more durable authoritarian regimes, governmental corruption, and prolonged conflict, especially in low- and middle-income countries inhabited by marginalized ethnic groups. Ross (2015) also identifies three questions concerning the resource curse: the scope of the resource effect, its mechanisms and conditions, and appropriate policy recommendations. A survey on the natural resource curse by Badeeb et al. (2017) highlights the lack of consensus in the literature regarding the existence of the paradox of plenty. Resource abundance does not always lead to slow growth, as some developing resource exporters (e.g., Botswana, Chile, Peru, and Yemen) have experienced positive economic growth. Importantly, Badeeb et al. (2017), building on Karl (2005), argue that the problem of the resource curse may lie in low natural resource diversification rather than in possessing natural resource deposits. Papyrakis (2017) summarizes research papers that provide evidence for the complexity and conditionality of the resource curse, which can manifest at the country or regional level, with many of its effects being not directly measurable. This survey depicts

[39] Alssadek and Benhin (2023) reach similar conclusions. They emphasize that the lack of consensus on the existence of the resource curse is primarily due to the variety of data used, time periods, proxies for natural resource variables, and estimation methods. Furthermore, by comparing the economic performance of subgroups of developed and developing countries, Alssadek and Benhin (2023) conclude that oil-endowed Middle Eastern and North African (MENA) and Sub-Saharan African (SSA) countries are underperforming considerably.

the paradox of plenty as strongly context-specific, depending on many sociopolitical and economic conditions.

Finally, a meta-analysis of 33 studies examining the characteristics of the resource curse, conducted by Havranek et al. (2016), revealed noticeable heterogeneity among the results of individual estimations. Of the statistically significant outcomes presented in this survey, one-third revealed a positive relationship, while two-thirds exposed a negative relationship[40]. According to Havranek et al. (2016), estimations that account for the interaction term between institutional quality and resource endowments are less likely to find evidence consistent with the paradox of plenty. At the same time, controlling for investment level usually supports the resource curse hypothesis. Furthermore, resource abundance, as measured by oil endowment, is less likely to support the negative effect of primary products on economic growth than precious metals. Similarly, Dauvin and Guerreiro (2017) focused on two types of meta-regression: first, the direct effects of natural resources on growth, and second, the indirect effects of natural resources through institutional quality. They concluded that a "soft" resource curse can be detected in the literature, though it depends heavily on the characteristics of the studies. The control variables included in the primary models, the measures of natural resource abundance/dependence, the econometric methods, and the sample under study were highlighted as the most prominent sources of heterogeneity. The authors also stress that, while institutional quality plays no significant role in the natural resource–economic growth nexus, its interaction with natural resources is crucial for economic prosperity.

[40] Havranek et al. (2016) addressed two main issues: verifying the overall mean effect of natural resources on economic growth and determining why various scholars obtain different results when analyzing the same concept.

2.3. Growth Effects of Technological Progress and the Modern Productivity Paradox

Technology is a key component of the production function[41] (Solow, 1956; Zellner et al., 1966) and serves as a crucial factor in many growth models (among others: Romer, 1986, 1990; Lucas, 1988; Aghion and Howitt, 1992; Jones, 1995a; Acemoglu, 2003; Ha and Howitt, 2007; Bloom et al., 2020; Kruse-Andersen, 2023). Within the production, technology can be incorporated as either Hicks-neutral (factor augmenting), Harrod-neutral (labor augmenting) or Solow-neutral (capital augmenting) factor. Initially, technology was seen as a means of improving labor productivity and product quality, as well as generating new, growth-enhancing ideas (Romer, 1990; Jones, 2005; Klump et al., 2007). Nowadays, with the Fourth Industrial Revolution in full swing, technological innovations may not only advance the production process, but also replace human labor in certain sectors or activities (Brynjolfsson and McAfee, 2014; Acemoglu and Restrepo, 2018; Bresnahan, 2019; Agrawal et al., 2024), or even lead to the singularity (Kurzweil, 2005; Aghion et al., 2019; Roodman, 2020; Davidson, 2023).

The role of technology as a determinant of economic growth was strongly emphasized in early neoclassical growth models in the late 1950s. The classic Solow-Swan model views technological progress as the key long-term driver of growth (Solow, 1956; Swan, 1956). However, the model does not explain what determines changes in technological progress. Therefore, technological progress is defined as an exogenous factor of the model[42]. This exogenous role of technology was maintained until the late 1980s, when Paul Romer defined technology as an endogenous factor, determined by economic agents within the model. Romer's model of endogenous technological change[43] is based on the idea that research and development (R&D), undertaken by profit-maximizing economic factors, fuels growth. This, in turn, affects the incentives for allocating resources to R&D. The growth implications of the Romer model are examined for a fixed population consisting of R&D workers (so-called "idea makers") and output-producing employees. In the long run, increases in productivity and population size in the R&D sector have a positive effect on economic growth (Romer, 1990).

One of the greatest challenges to Romer's model of endogenous technological change is the discrepancy between long-term trends in R&D and productivity, primarily within OECD countries. Even though the number of people engaged in R&D in the US has increased fivefold between the 1950s and the 1990s, there has been no visible upward trend in Total Factor

[41] The Constant Elasticity of Substitution (CES) production function is one of the most prevalent neoclassical functions. It satisfies all Inada conditions and exhibits constant elasticity of substitution among all inputs (Arrow et al., 1961; Klump et al., 2012). The most popular CES production function is the Cobb-Douglas production function (Cobb and Douglas, 1928).

[42] For this reason, the Solow-Swan model is also referred to as the "exogenous growth model".

[43] Romer's model defines technological change (A) as a set of available ideas or stock of knowledge.

Productivity (TFP) nor in output per worker. (Jones, 1995a, 1995b). Based on this observation, Jones (1995a) proposed a semi-endogenous, R&D-based growth model which incorporates diminishing returns to the stock of knowledge in R&D. This model is exogenous in that long-term productivity growth depends on the growth rate of the labor force[44]. However, the model is endogenous because it stems from the pursuit of new technologies by rational, profit-maximizing agents. Research using US productivity data from 1953 to 2018 provides evidence in favor of Jones's model (Kruse-Andersen, 2023)[45]. Conversely, Ha and Howitt (2007) argue that long-term trends in productivity and R&D are more supportive of the fully endogenous Schumpeterian growth theory[46] than the semi-endogenous theory. To support their claim, the authors cite stationary TFP growth accompanied by a threefold decrease in the growth rate of R&D inputs since the early 1950s.

Even before technology was recognized as a key factor in macroeconomic growth models, it fueled productivity through technological revolutions, which sparked industrial revolutions. In their work, Freeman and Perez (1988) present five technological revolutions that culminated in successive techno-economic long waves. The first occurred when Arkwright introduced the water frame in the 1770s, automating the textile industry using water power. Later, the introduction of railways and steam engines enabled steam-powered industrialization. These two revolutions are usually referred to collectively as the First Industrial Revolution. The Second Industrial Revolution began in the 1870s with electrification and included the spread of the fossil-fuel-driven industry that originated in the late 1910s. Popular breakthroughs associated with this revolution feature Edison's electric lighting and Ford's moving assembly line. Finally, the fifth industrial revolution began in the 1970s with the introduction of the microprocessor by Intel and was based on digitalization and computerization.

As mentioned above, significant technological advancements have consistently been associated with increased productivity (Schurr et al., 1960; Crafts, 2004). Therefore, since the 1980s, the impact of information and communication technologies (ICT), an indicator of the third Industrial Revolution, has been intensively analyzed in relation to economic growth and productivity (among others: Inklaar et al., 2005; Timmer and van Ark, 2005; Oliner et al., 2007;

[44] Unlike the R&D models of Romer (1990), Aghion and Howitt (1992), and Grossman and Helpman (1993) the growth rate in this model is determined by the parameters that are impervious to policy manipulation. An increase in the labor force yields more new ideas through R&D. This, in turn, fosters productivity growth and, eventually, growth in the entire economy (Jones, 1995a).

[45] Kruse-Andresen also emphasizes that productivity-enhancing ideas become progressively harder to find as technologies become more advanced (Kruse-Andresen, 2023).

[46] Schumpeterian growth theory is based on the Schumpeterian concept of technological acceleration in creative destruction (Knell and Vannuccini, 2022). Schumpeter (1912) viewed technological innovation as arising from within the economic system and occurring at random intervals. According to Schumpeter, innovation creates new economic conditions by destroying old equilibria. In Schumpeter's theory, discontinuous innovation is explained by technological revolutions based on Kondratiev's long cycles (Knell and Vannuccini, 2022).

Jorgenson et al., 2008; Acemoglu et al., 2014; Aum et al., 2018; Jones and Tonetti, 2020; Farboodi and Veldkamp, 2021). Interestingly, while information technologies played a crucial role in the United States' productivity recovery in the late 1990s and early 2000s (Jorgenson et al., 2008), OECD countries in Europe experienced a significant slowdown in productivity growth (Timmer and Van Ark, 2005; Van Ark et al., 2008). This has led to the deepening of the Atlantic technological divide (Van Ark et al., 2019). Ceccobelli et al. (2012) analyzed the disappointing case of OECD countries (excluding the US) and concluded that, to become a general-purpose technology, ICT must be supported by complementary investments. The impact of ICT on productivity and economic growth is much more evident when combined with research and development (R&D) activities (Pilat et al., 2003). Furthermore, R&D can accelerate technical change and generate spillovers within sectors (Pieri et al., 2018). Finally, the rise of information technology and big data analytics has drawn attention to the productivity effects of data accumulation. The nonrivalrous nature of data may lead to increasing returns and social gains (Jones and Tonetti, 2020). However, as with capital accumulation, data-driven growth cannot be sustained without improvements in other areas of productivity (Farboodi and Veldkamp, 2021).

Recently, economic literature analyzing the effects of technological progress has paid increased attention to new digital technologies, including artificial intelligence (AI), automation, and robotization. While a great body of existing literature highlights the positive effects of robots' adoption on productivity growth (among others: Graetz and Michaels, 2018; Acemoglu et al, 2020; Ballestar et al, 2020; Kromann et al., 2020; Van Roy et al., 2020; Dixon et al., 2021; Koch et al., 2021; Acemoglu et al., 2023), the AI-related perspectives on the future of global economic growth remain inconclusive. Researchers have diverse standpoints on the effects of rapid technological advancement on productivity. Some predict secular stagnation[47], characterized by negligible or no long-term economic growth caused mainly by an aging society and an unsatisfactory boost in growth by technological advancement (Gordon, 2000; Jones, 2002; Krugman, 2014; Summers, 2014 & 2016; Gordon, 2017; Acemoglu and Restrepo, 2017; Gomułka, 2023). Others anticipate anything from balanced growth with limited automation (Acemoglu and Restrepo, 2018; Bloom et al., 2020; Davidson, 2021; Acemoglu, 2025) to accelerated growth with disruptive automation (Brynjolfsson and McAfee, 2014; Brynjolfsson et al., 2019; Trammell and Korinek, 2023; Chui et al., 2023; Korinek and Suh, 2024). The most optimistic researchers point to the possible occurrence of technological singularity (Kurzweil, 2005; Bostrom, 2014; Aghion et al., 2019; Roodman, 2020; Davidson, 2023). The technological singularity is a concept of an uncontrollable growth resulting

[47] In broader terms, the concept of secular stagnation is based on four facts: (1) a slowdown in investment despite low interest rates, (2) low productivity growth, (3) high profits, and (4) a growing variance in productivity and profits among producers (Haskel and Westlake, 2017).

in unforeseeable changes for humanity[48]. Kurzweil (2005) predicts that the technological singularity (or the moment when AI surpasses humans) will occur around 2045. According to Growiec (2024) and Growiec and Prettner (2025), transformative artificial intelligence (TAI)[49] is an accelerator of an intelligence explosion that could lead to a technological singularity. On the other hand, Aghion et al. (2019) suggest that a singularity can be produced by humanity without relying on complete automation or an intelligence explosion[50]. In contrast, Nordhaus (2021) argues that the hypothesis of accelerating technology-driven growth does not hold up to scrutiny and that the singularity is not imminent.

The literature on the impact of AI technologies on macroeconomic productivity addresses a variety of issues related to the challenges of measuring AI solutions and their overlap with ICT technologies. Researchers attempt to gauge technological innovation in artificial intelligence via bibliometric data on scientific publications related to AI (Klinger et al., 2018; Bianchini et al., 2020; Baruffaldi et al., 2020; Parteka and Kordalska, 2023; Chun and Hwang, 2024), patent records and applications (WIPO, 2019; Bassetti et al., 2020; Damioli et al., 2021; Benassi et al., 2022; Hötte et al., 2024) as well as trade data (Foster-McGregor et al., 2019; Goldfarb and Trefler, 2019; Domini et al., 2021; Castellani et al., 2022; Parteka et al., 2025). The standard procedure for collecting patent records includes verifying and classifying classification codes related to AI patents (Tseng and Ting, 2013; Buarque et al., 2020; Xiao and Boschma, 2023) using the Cooperative Patent Classification (CPC) system, as well as keyword-based screening of the titles, abstracts, and descriptions of AI-related patents (EPO, 2020; Cicerone et al., 2023; Hötte et al., 2024). Interestingly, the development of AI technologies enables the faster and more precise identification of AI-related patent activities across technological domains (USPTO, 2020).

Apart from measurement difficulties, the core issue that literature on technology growth is currently focusing on concerns the so-called "modern productivity paradox". This puzzling mismatch between high expectations and poor productivity outcomes (Polák, 2017; Crafts, 2018; Brynjolfsson et al., 2019 & 2021) is a recurrence of the ICT productivity paradox[51] of the late 1980s

---

[48] Aghion et al. (2019) distinguish between two types of technological singularity that diverge from steady-state growth: (a) growth explosion, in which growth rates increase without bounds, yet remain finite at any given moment, and (b) growth explosion, in which infinite output is achieved within a finite amount of time.

[49] Transformative artificial intelligence (TAI) can be defined as "a suite of algorithms that allow machines to perform every economically valuable task better than humans, thereby fully automating human labor if implemented" (Growiec and Prettner, 2025).

[50] In principle, AI is not necessary for automation to occur since automation began long before AI was introduced (Growiec et al., 2024). Nevertheless, AI has the power to reinforce the automation process by replacing human cognitive work in non-routine tasks (Brynjolfsson et al., 2019; Eloundou et al., 2024).

[51] Brynjolfsson (1993) based his observations on a famous quote by Robert Solow ("You can see the computer age everywhere but in the productivity statistics"), who in 1987 highlighted the disappointing productivity statistics of the computer age (Solow, 1987). Consequently, the ICT productivity paradox is sometimes referred to as the Solow paradox.

(Brynjolfsson, 1993). Several possible explanations have been proposed by researchers as to why developed countries have recorded a noticeable decrease in productivity growth rates despite a rise of investments in digital technologies (Byrne et al., 2016; Haskel and Westlake, 2017; Syverson, 2017; Ahmad et al., 2017; Elstner et al., 2018; Brynjolfsson et al., 2019&2021; Miyagawa, 2021; Venturini, 2022). Brynjolfsson et al. (2019) specifically point to false hopes, overegged optimism, mismeasurement of output and productivity, and the fact that the benefits of new technologies are enjoyed only by a few[52]. Furthermore, Bloom et al. (2020) document that, in many fields of technological progress, research productivity has fallen. The modern productivity paradox has mostly been documented in developed countries (Byrne et al., 2016; van Ark, 2016; Elstner et al., 2018). Venturini (2022) records it for a wider sample of industrialized countries.

Another topic to consider in relation to artificial intelligence is its potential impact on employment. Studies prove that less productive and lower-performing workers will benefit the most from AI (Brynjolfsson et al., 2023; Noy & Zhang, 2023; Peng et al., 2023). Bresnahan (2019) and Agrawal et al. (2024) also emphasize that AI can create new, productivity-enhancing tasks that will reorganize production processes. Albanesi et al. (2023) examined a sample of 16 European countries and found that occupations with high exposure to AI experienced increases in average employment shares. Aghion et al. (2020) argue that the effects of AI and automation on employment depend to a large extent on institutional settings and the implemented policies. Therefore, when combined with improper competition policy and institutions, AI may actually end up inhibiting growth. Conversely, Acemoglu et al. (2022) found that companies whose workers perform tasks in accordance with AI's current capabilities experienced rapid growth in AI-related job openings. However, at a more aggregated level, these effects are too small to be detected. Similarly, Korinek and Juelfs (2022) emphasize that, as AI becomes more advanced and prevalent in the economy, its positive impact on employment could be reversed. Finally, Acemoglu (2025), building on the work of Bursztyn et al. (2023), highlights that, apart from its effect on employment, AI might negatively impact social life by creating algorithms for online manipulation.

[52] Researchers also point to the J-curve hypothesis as a possible explanation for the modern productivity paradox. According to this hypothesis, modern technologies generally require more time and additional investments to fully materialize (Bresnahan and Trajtenberg, 1995; Brynjolfsson et al., 2021).

2.4. Resource Dependence, Structural Change and Export Diversification

Over time, the patterns of export specialization undergo various structural changes, shifting from one set of export products to another. This process of evolution between specialization and de-specialization (diversification[53]) is a continuous and dynamic phenomenon (Dalum et al., 1998; Alcorta et al., 2021). The trajectories of these processes are determined not only by existing technological and industrial capabilities (Dosi, 1982; Patel and Pavitt, 1997; Hidalgo et al., 2018), but also by an abundance of specific types of products such as natural resources (Cadot et al., 2011a). The determination of export patterns by natural endowments stays in line with Heckscher-Ohlin's theory of international trade (Heckscher and Ohlin, 1991). According to it, a commodity will be produced more cheaply by the nation that has an abundance of the resources used in its production. If a commodity uses a relatively large amount of capital (i.e., primary commodities), then countries with abundant natural resources will have a comparative advantage in producing that commodity (Leamer, 1995). However, the relationship between endowments, trade, and growth is far more complex than the Heckscher-Ohlin theorem suggests. 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 (1962)[54]. The arguments of the Prebisch-Singer theorem have also been confirmed by modern studies (Harvey et al., 2010; Arezki et al., 2014).

Nevertheless, 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). Together with the recent slowdown in trade growth due to "slowbalization", these findings underscore the importance of export diversification for commodity-dependent countries (OECD 2019). Therefore, explaining the diversification process in the context of natural resource endowments can provide insight into the challenges that resource exporters face with strong export specialization.

[53] Export diversification is the exact opposite of export specialization (DIV = 1/SPEC). These terms are used interchangeably in this dissertation.

[54] In short, according to the Prebisch-Singer hypothesis, countries with abundant natural resources are particularly vulnerable to deteriorating terms of trade. This is because, in the long term, the price of natural resources declines relative to the price of manufactured goods.

By definition, export diversification can be achieved by adjusting the proportion of commodities in the existing export portfolio or by adding new commodities to the export mix (Wilhelms, 1967; Ali et al., 1991). Furthermore, export diversification can be analyzed using either crude sector-level data (Imbs and Wacziarg, 2003; Duarte and Restuccia, 2010; Parteka and Tamberi, 2013a; Herrendorf et al., 2014) or product-level data (Hummels and Klenow, 2005; Hidalgo and Hausmann, 2009; Cadot et al., 2011a; Parteka and Tamberi, 2013b). Thus, the degree of export diversification can be measured by the weight of different products or sectors in a country's total exports (Handoyo and Ibrahim, 2021). Although export diversification can be analyzed at various levels, which are usually country-specific (Ali et al., 1991), it is especially important for underdeveloped countries because it fosters economic growth (Klinger and Lederman, 2004; Lederman and Maloney, 2009; Handoyo and Ibrahim, 2021).

Apart from its crucial role in emerging economies, export diversification benefits all countries, regardless of their level of development. It promotes export growth (Hummels and Klenow, 2005; Kehoe and Ruhl, 2013), increases exporters' productivity (Feenstra and Kee, 2008), improves long-run terms of trade (Mania and Rieber 2019), stabilizes long-term export earnings (Al-Marhubi, 2000), reduces the risks associated with price fluctuations (Ouedraogo et al., 2018), and strengthens trade linkages and trade liberalization for poorly integrated countries (Dennis and Shepherd 2011; Aditya and Acharyya 2015). Export diversification also supports the acquisition of knowledge and experience through the variety of tasks performed in reducing excessive dependence on a limited number of products (Gozgor and Can, 2016; Can et al., 2024). Furthermore, export diversification is a critical factor in structural transformation (Pageorgiou et al. 2014) and significantly promotes macroeconomic stability and sustainable development (Mania and Rieber, 2019).

Natural resources are among the most frequently cited negative factors influencing export diversification (Jetter and Ramírez Hassan, 2015; Giri et al., 2019; Vogel, 2022). However, scholars identify several country-level characteristics that positively affect export heterogeneity. Among them are: the level of development (De Benedictis et al., 2009; Parteka, 2010; Cadot et al., 2011a; Parteka and Tamberi, 2013a and 2013b; Mau, 2016; Cieślik and Parteka, 2021), the size of the economy (Hummels and Klenow, 2005; Parteka and Tamberi, 2013b; Basile et al., 2018; Cieślik and Parteka, 2021; Lee and Zhang, 2022), the quality of institutions (Cadot et al., 2011b; Sheng and Yang, 2016), trade costs and trade liberalization policies (Regolo, 2013; Dutt et al., 2013; Feenstra and Ma, 2014; Mau, 2016), human capital (Agosin et al., 2012; Jetter and Ramírez Hassan, 2015), economic complexity (Ranjbar and Rassekh 2022; Oumbé et al., 2023), and real exchange rate stability (Hausmann et al., 2007; Agosin et al., 2012).

Despite its concentration characteristics, technological specialization based on technological advancements and innovation evinces a potential to enhance export diversification (Habiyaremye and Ziesemer 2006; Gunday et al., 2011; Cirera et al., 2015; Nham and Bao, 2023). The introduction of new export products or the expansion of existing ones constitutes a form of technological innovation that promotes export diversification (Krugman, 1979; Dollar, 1986; Grossman and Helpman, 1989). Furthermore, innovation in the form of patent applications has been demonstrated to successfully stimulate extensive and intensive export margins (Chen, 2013). Digital transformation has been shown to positively impact export diversification (Nham and Bao, 2023), while the introduction of robots into the production process has been found to lead to greater diversification of exported products (Gu et al., 2024; Hong et al., 2025). Finally, higher technological capacity, particularly in developing countries, has been shown to have a significant and positive effect on the intensive and extensive margins of exports, resulting in a more diverse and voluminous export structure (Vergara, 2019).

A narrower branch of the diversification literature focuses on the evolution of export diversification along the development path (Imbs and Wacziarg, 2003; De Benedictis et. al., 2009; Cadot et al., 2011a; Parteka and Tamberi, 2013b; Cadot et al., 2013; Mau, 2016; Basile et al., 2018; Caselli et al., 2020; Gnidchenko, 2021). This field often uses the concept of cones of diversification[55] to theoretically explain the diversification process. Here, researchers' main interest rests upon the so-called "diversification curve", which approximates the nonlinear relationship between the degree of export diversification and development level[56]. According to the literature on "stages of diversification", countries tend to be highly specialized in the initial stages of development, with primary products usually comprising most of their exports. Then, as income per capita increases, they undergo a diversification process. They progress through manufactured goods of various levels of advancement, and their export structures finally become more heterogeneous, consisting mostly of advanced products. (Cadot et al., 2011a). This concept falls under the category of literature on structural transformation. According to this literature, as countries develop, economic activity gradually shifts from agriculture to manufacturing to services (Herrendorf et al., 2014). Some scholars have also postulated a nonlinear relationship and re-

[55] The theory of cones of diversification assumes that countries within the same cone are characterized by an identical range of factor endowments. This range yields similar factor proportions and prices, as well as the production of the same set of goods. Despite initial focus on one-cone version of the theory (Leamer and Levinsohn, 1995), subsequent research has shifted its attention to the multiple-cone version (Debaere and Demiroglu, 2003, Schott, 2003, Xiang, 2007).

[56] The curve is obtained by plotting a line through country-year observation points, linking synthetic indicators of export specialization (concentration) and income per capita. The methodology related to the export diversification curve comes from Cleveland (1979) and Hastie and Tibshirani (1987). Flexible estimation settings, such as nonparametric lowess/loess as used by Gnidchenko (2021) or semiparametric GAM General Additive Model as employed in De Benedictis et. al. (2009) and Parteka and Tamberi (2013b), are crucial to plotting the diversification curve.

specialization at high development levels (Imbs and Wacziarg, 2003; Cadot et al., 2011a). However, this concept is disputed[57] (De Benedictis et. al., 2009; Parteka and Tamberi, 2013b; Mau, 2016; Gnidchenko, 2021).

Most of the literature on diversification focuses solely on the quantitative properties of the processes, while the qualitative aspect—the extent to which various product groups influence the mechanisms of export diversification—has received little attention. One way to address this is by deconstructing the overall diversification curve according to the type of exported products. Cadot et al. (2011a) proposed the decomposition of the absolute Theil index into between and within components (also referred to as extensive and intensive export margins[58], as in Hummels and Klenow (2005)), by dividing export lines into active and inactive ones. Cadot et al. (2011a) conclude that the diversification process is mostly driven by changes at the extensive margin. However, Gnidchenko (2021) argues that these results may be biased because they do not account for the structure of the world demand (an argument also raised by De Benedictis et. al., 2009; Parteka and Tamberi, 2013; Mau, 2016). Instead, Gnidchenko proposes decomposition of the relative (weighted) Theil index with an additional split of the intensive margin into quantitative and qualitative components. His research indicates that the intensive margin is a major driver of export diversification, with the quantitative part of the within component dominating (which relates to the difference in export volume between a country and the world).

Despite its important role in trade theory, the concept of resource dependence has not received much attention in debates about the decomposition of the diversification curve. Among the few exceptions are Bahar and Santos (2018), who stress that larger shares of natural resource exports yield a higher concentration of the non-resource export basket. Furthermore, they argue that changes in the volume of existing export lines (i.e., the intensive margin of exports) rather than the number of active export lines (i.e., the extensive margin of exports) are responsible for higher non-resource concentration. Zarach and Parteka (2023a) find that the over-intensive exports of natural resources negatively affect the composition of non-resource exports and the technological diversity of countries. However, these effects depend on the type of resources exported (e.g., fossil fuels hinder diversification, while forestry products promote it) and the institutional setting (e.g., a high-quality institutional environment is an important determinant of diversification trajectories). Similarly, based on the case of Nigeria, Charles et al. (2018) claim that attempts by resource-

[57] Highly concentrated countries with abundant fossil fuels and very high levels of output per worker are the only ones where re-specialization is plausible (Parteka and Tamberi, 2013b; Gnidchenko, 2021; Zarach and Parteka, 2023a). Furthermore, when the structure of world demand is considered, the re-specialization trend tends to disappear (Parteka and Tamberi, 2013a, 2013b; Mau, 2016; Gnidchenko, 2021).

[58] The intensive margin refers to changes in the structure of exports related to an increase in the volume of existing export lines. The extensive margin, on the other hand, refers to changes induced by the addition of new export lines. (Dennis and Shepherd 2011).

dependent countries to diversify exports may be unsuccessful due to the poor quality of their governing institutions. Nevertheless, resource exporters can become more diversified. According to Ross (2019), Oman, Malaysia, Colombia and New Zealand diversified their export baskets after the 1970s oil shocks, despite unaltered or rising oil revenues. Saudi Arabia has also grown more diversified over the years, though this process was mostly prompted by declining per capita oil revenues (Albassam, 2015). Finally, as Murshed and Serino (2011) point out, resource exporters will not achieve satisfactory growth rates unless they diversify their economic and export structures.

Some studies on patterns of specialization and resource dependence also addressed 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 (2023a) 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.

A general picture that emerges from the presented literature review is threefold. Firstly, the literature on the effects of natural resources on economic growth is highly inconclusive, with results varying between resource dependence and abundance proxies and the types of natural resources under examination (see, among many others: Olsson, 2007; Brunnschweiler, 2008; Tsui, 2011; Badeeb and Lean, 2017; Sultan and Haque, 2018; Awoa Awoa and Ondoa, 2023; Ertimi et al., 2023). Secondly, despite several examples of successful resource development with the use of technological innovations (David and Wright, 1997; De Ferranti et al., 2002; Ville and Wicken, 2013), the relationship between technology and natural resources has not been addressed frequently enough (see: Zarach and Parteka, 2023a & 2023b, for exceptions). Moreover, resource-dependent countries are considered to be excluded from the technological race (Foster-McGregor et al., 2019; Fagerberg and Verspagen; 2021). Thirdly, though natural resources are regarded in trade theory as an important determinant of structural change and comparative advantage (Heckscher and Ohlin, 1991; Dalum et al., 1998; Alcorta et al., 2021), they are usually connoted with excessive export specialization and are not regarded in the context of diversification dynamics (see: Bahar and Santos, 2018; Ross, 2019; Zarach and Parteka, 2023a for few exceptions).

In the following chapters, presenting econometric results, we will make an attempt to unambiguously determine the relationship between natural resource dependence and productivity growth (Chapter 4) as well as export diversification (Chapter 5). Moreover, in light of the identified research gap and the findings of the extant literature review, these trajectories will be examined for various types of natural resources. Finally, we strive to establish whether factors such as technological specialization and institutional quality can mitigate this relationship.

3. Research Methodology

The empirical research of this doctoral dissertation has been divided into four main steps: (1) the creation of the country-level database including data on trade flows and various macroeconomic indicators; (2) the creation of product-level taxonomies clustering product codes into groups comprising natural resource-related products and technologically advanced products; (3) the measurement of countries' comparative advantage, absolute and relative specialization in natural resources and technologically advanced products, using trade data and product-level taxonomies; (4) the decomposition of relative (weighted) Theil index of export diversification and the computation of the export diversification curve based on this decomposition.

3.1. Database Construction – key steps, data sources, sample composition

As far as the source data is concerned, this work departs from the traditional approach. Most of the studies surveyed in the literature review investigate natural resource phenomena using aggregate data on natural resource rents, natural resource capital, natural resource production, or the share of primary exports in GDP (GNP) as the main explanatory variable[59] (among many others: Sachs and Warner, 1995; Olsson, 2007; Brunnschweiler and Bulte, 2008; Cavalcanti et al., 2011a; Gerelmaa and Kotani, 2016; Canh et al., 2020; Ben-Salha et al., 2021; Sharma and Paramati, 2022). Similarly, the growing literature on advanced technologies (including automation, robotization, and AI) does not typically examine technological specialization using trade data (see: Foster-McGregor et al., 2019; Goldfarb and Trefler, 2019; Domini et al., 2021; Castellani et al., 2022; Parteka et al., 2025 for exceptions). This dissertation adopts a different approach, where key explanatory variables are created using raw disaggregated export data and newly elaborated 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.

Following a thorough examination of the available trade data collections, the BACI CEPII database (CEPII, 2023; Gaulier and Zignago, 2010) was identified as the optimal source for

[59] Assuming that resource abundance (or, interchangeably, resource endowment) can be associated with a country's specific resource deposits, indicators such as resource wealth, capital, stock, assets, production, and extraction levels can be treated as proxies for the aforementioned. Meanwhile, resource dependence, which describes how deeply a country subordinates its functioning to natural resources, can be measured as a ratio of resource exports, rents, and revenues to GDP (or, in the case of resource exports, to total exports). A literature review in Chapter 2 reveals that researchers more frequently choose proxies for resource dependence, since they are relatively easy 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. As such, they are used to prejudge the occurrence or the nonoccurrence of the resource curse phenomenon (Crutzen and Holton, 2011; Satti et al., 2014; Gerelmaa and Kotani, 2016; Perez-Sebastian and Raveh, 2016; Kim and Lin, 2017; Shahbaz et al., 2018; Redmond and Nasir, 2020; Ghecham, 2021; Ridzuan et al., 2021).

disaggregated trade flows, owing to its capacity to provide comparable cross country data. The BACI CEPII database supplies product-level data on bilateral trade flows identified at the 6-digit level, which is consistent with the six subsequent Harmonized System (HS) nomenclatures, each of which covers a different time span. Furthermore, the BACI database offers only strictly positive trade flow records and excludes the trade flows below 1000 USD and UN Special Codes. The HS96 nomenclature was chosen due to the availability of data and the potential for cross-checking with other data sources. At the time of downloading in December 2023, the 202301 version encompassed the time period from 1996 to 2021. The raw BACI CEPII data necessitated numerous modifications to be exploitable and adjusted to the empirical requirements of this dissertation. Firstly, country codes corresponding to Custom and Trade Unions, as well as countries that ceased to exist prior to or within the 1996-2021 timespan[60] were removed. Secondly, the issue of an unequal number of product codes throughout the analyzed timespan was addressed. In order to obtain a balanced dataset, vanishing product codes[61] were deleted. The final database comprises 4747 product codes. Thirdly, joint data, under the abbreviation BELX, was prepared for Belgium (BEL) and Luxembourg (LUX) to match earlier revisions of trade data[62]. Finally, the database's bilateral dimension (i.e., importer-exporter) was modified to unilateral by aggregating the importer dimension.

Following the completion of the preparatory data cleansing, the subsequent steps entailed the calculation of country-level variables based on trade data[63] , and the incorporation of various country-level macroeconomic characteristics (all of which were downloaded in January 2024). Data on Gross Domestic Product, population and employment[64] were obtained from the Penn World Table, version 10.01[65] (Feenstra et al., 2015). Income classifications from the World Bank's Country and Lending Groups were added to categorize countries by their level of development[66], in accordance with the 2021 ratings (World Bank, 2024c). To account for the volatility of natural

[60] For instance Former Ethiopia, NRD, RFN, Southern African Customs Union or Former USSR Soviet Union.

[61] The vanishing product codes are the codes no longer used in updated versions of HS96 nomenclature or not transformed into new product codes in conversion tables.

[62] In 1996, 1997 and 1998 the BACI CEPII trade data for Belgium and Luxembourg were aggregated.

[63] Indicators of export specialization, the share of natural resources and technologically advanced products in a country's total exports, as well as the decomposition components.

[64] These variables were used to calculate labor productivity, one of the two main dependent variables of this dissertation.

[65] This version of the Penn World Table provides macroeconomic data for 183 countries from 1950 to 2019. Consequently, there exists a two-year gap between the availability of PWT variables and those of the other variables included in this dissertation's database. Extrapolation of the PWT data proved unsuccessful due to data disturbances caused by the COVID-19 pandemic. Thus, in the estimations where labor productivity appears, especially in Chapter 4, the timeframe encompasses only the years from 1996 to 2019.

[66] The group of developing countries consists of low, lower-middle, and upper-middle income economies. The developed countries' group encompasses high-income economies. For a comprehensive list of countries and their respective income classifications, see Table A.1. in Appendix A.

resource prices, the annual resource price indices[67] of selected natural resources were employed from the World Bank Commodity Price Data Annual Indices (World Bank, 2024a).

A set of control variables includes data on technological innovation, trade openness, investment levels, the Human Capital Index, and natural resource rents[68], obtained from the World Development Indicators (World Bank, 2024b). The data concerning the quality of governance[69] were derived from the World Governance Indicators (World Bank, 2024d). Dummy variables employed to describe a country's characteristics, including its status as a landlocked nation, the distance to its closest major port (in km), and the timing of its independence, were retrieved from Harvard's Center for International Development Dataverse (Gallup et al., 1999). Information regarding the colonial past[70], which is of particular significance in the context of resource-dependent countries, was derived from Harvard's COLDAT Colonial Dates Database (Becker, 2019). Summary statistics for all variables are shown in Table A.7 in Appendix A.

Finally, to align with the previously established country codes in the trade data, the data for Belgium and Luxembourg was summed or averaged (depending on the variable's properties) under the BELX abbreviation. The final stage of the data cleaning involved the exclusion of microstates (countries with a population of 100k or fewer inhabitants) and those lacking complete data throughout the considered time period. As a result, the country-level database used in this dissertation contains data from 160 countries over the period of 26 years (1996-2021). The list of countries is provided in Table A.1 in Appendix A.

3.2. Product-level Taxonomies

In this dissertation, we define natural resources as products belonging to the mineral and forestry resource categories. Consequently, all agricultural resources, including plant and animal products, are excluded from consideration. Measuring indices of export specialization requires the

[67] The "Pink Sheet" Data version of the World Bank's annual commodity prices (World Bank, 2024a) provides the data on resource price indices. In the empirics of Chapter 4 and Chapter 5, resource price indices were utilized as proxies for time-fixed effects.

[68] Technological innovation is measured by the number of patent applications submitted by residents, the percentage of R&D expenditures in the country's GDP, and by the export share of various groups of technologically advanced products (see Table A.5. in Appendix A) in total country exports, expressed as a decimal between 0 and 1. Trade openness is measured as the ratio of exports and imports of goods and services to GDP, the level of investment is gauged as gross fixed capital formation (% of GDP), and the Human Capital Index, which ranges from 0 to 1, calculates the contributions of health and education to the future workforce's productivity (World Bank, 2024b). Finally, natural resource rents are calculated as the difference between the value and the total cost of resource production at regional prices and expressed as a percentage of GDP. They are categorized into five types: coal, forest, oil, gas, and minerals, as well as a total group which encompasses all above.

[69] The quality of institutions is calculated as a mean of six indicators, capturing various perceptions of governmental quality, including Control of Corruption, Government Effectiveness, Political Stability and Absence of Violence/Terrorism, Regulatory Quality, Rule of Law, Voice and Accountability (World Bank, 2024d). It is expressed as a percentile rank, with 0 corresponding to the worst and 100 corresponding to the best possible institutional quality.

[70] Dummy "Colonialism" indicates whether the country was a British, French, German, Spanish, Italian, Belgian, Dutch, or Portuguese colony and/or protectorate.

establishment of appropriate product taxonomies that identify groups of natural resources according to the definition provided in this dissertation. Resource classifications come from the 2010 WTO World Trade Report (Bacchetta, 2010). According to its Statistical Appendix, natural resources can be classified into five primary categories[71]: (1) fish, (2) raw materials, (3) fuels and mining products, (4) forestry products, and (5) other semi-manufactures. Moreover, the Report subdivides these categories into two clusters: "Natural resources broadly defined" (groups from 1 to 5) and "Natural resources narrowly defined" (groups 1, 3, and 4). Since the latter is more relevant to the context of this dissertation, we use it as the basis for our analysis while excluding the fish category. Product codes from groups 3 (fuels and mining products) and 4 (forestry products) were categorized into four primary resource groups: *FORESTRY, FUEL, METAL,* and *MINERAL*. The *TOTAL NR* cluster encompasses all the aforementioned resource groups. The *FUEL* group was further divided into three subgroups, namely *COAL, NATURAL GAS* and *PETROLEUM OILS*. This subdivision was created to thoroughly explore the role of fuel dependence in growth and diversification trajectories. Table A.4 in Appendix A provides the detailed information on the resource taxonomies.

The subsequent phase included the establishment of technological classifications, encompassing not only products broadly defined as "technologically advanced" but also those that fall within specific technological domains. Thus, separate classifications, embodying products related to the 4th Industrial Revolution (*4IR*), Information and Communication Technology (*ICT*), and broadly defined medium-tech and high-tech products (*TECH*) were created. 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 SITC-3 nomenclature, which was initially defined by OECD (2011b) and Lall (2000), respectively[72]. Table A.5 in Appendix A provides a summary of the technological classifications. All product codes assigned to both resource and technological taxonomies can be found in the file entitled *"classifications_PhD.xlsx"*, which is provided in the Replication Package.

3.3. Comparative Advantage and Export Specialization Indices

The methodological approach used to compute the indices of specialization and comparative advantage is based on the works of Bowen (1983), Balance et al. (1985), Iapadre

71 The product codes included in these resource groups are in compliance with the third revision of the Standard International Trade Classification (SITC). Conversion tables were used to match SITC-3 codes with HS96 nomenclature from the BACI CEPII database.
72 In this case, too, the conversion tables were used to match the SITC-3 codes with the HS96 nomenclature from the BACI CEPII database.

(2001), OECD (2011a), and Laursen (2015). To quantify countries' dependence on certain types of products[73] and to verify how this dependence affects countries' economic performance, the indicators of export specialization and Revealed Comparative Advantage (RCA) were calculated. According to Aiginger and Davies (2004), specialization is defined as "the extent to which a given country specializes its activities in a small number of industries or sectors". This definition can be easily adapted for trade, comprising export and import specialization, which may occur inside or between sectors (Glejser et al., 1982). Simplifying, specialization of exports, of particular interest to this dissertation, occurs when a few export products account for a large share of a country's export portfolio (Aiginger et al., 1999). The simplest way to measure export specialization is to calculate the percentage share of a selected group of commodities in the total export value[74].

A more complex approach defines a country's specialization through the concept of comparative advantage[75], which, by definition, guarantees that resources are employed efficiently and that the country benefits from trade with other countries (Halilbasic and Brkic, 2017). The Revealed Comparative Advantage (RCA) index employs a relative approach, assessing a country's export structure in relation to the prevailing global trade structure (OECD, 2011a). The RCA is based on the Balassa index[76] (Balassa, 1965; Balassa, 1989), which was originally developed to assess trade performance, particularly exports, and to reveal the relative advantage or disadvantage through a comparison of different goods and services across various sectors and/or countries (Adigwe, 2022). An RCA index with a value greater than one indicates that a nation possesses a comparative advantage in a specific product or group of products. Conversely, a value lower than one reveals the presence of a comparative disadvantage. The RCA index employed in this dissertation, which is 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):

[73] In the case of this dissertation on natural resources and technologically advanced products.

[74] Export concentration, on the other hand, is predicated on the concept of geographic concentration, which Aiginger and Davies (2004) define as "the extent to which activity in a given industry is concentrated in a few countries". The geographic concentration of economic activity has the potential to engender specialization, as demonstrated in Krugman's models of the New Economic Geography (Krugman, 1991; Krugman and Venables, 1990; Fujita et al., 2001).

[75] David Ricardo (1921) introduced and instituted the concept of comparative advantage. According to his theory, countries can benefit from bilateral trade even if one country has an absolute advantage in producing all traded products. In this situation, relative efficiency and lower opportunity costs in producing a particular good are what matter.

[76] According to Leromain and Orefice (2014), the Balassa index exhibits empirical distribution weakness, primarily characterized by time instability and inadequate empirical distribution characteristics. Furthermore, Yeats (1985) and Hinloopen and Van Marrewijk (2001) conclude that the Balassa index, which is computed using observable trade flows, unintentionally overlooks all the factors influencing them. Despite this misapprehension, the RCA index, which is based on the Balassa index, remains the most commonly used measure of country-product-sector relative performance (Adigwe, 2022).

$$RCA_c = \frac{S_{i,c}}{S_{i,w}} = \frac{\frac{E_{i,c}}{E_c}}{\frac{E_{i,w}}{E_w}} \tag{1}$$

where:

- $S_{i,c}$, $S_{i,w}$ – share of product *i* in total exports of country *c* (world *w*),
- $E_{i,c}$, $E_{i,w}$ – value of total exports of product *i* in a country *c* (world *w*),
- E_c , E_w – value of total exports of country *c* (world *w*).

and time subscripts are omitted for simplicity.

The distinction between absolute and relative measures of export specialization follows the works of Parteka (2010), Mau (2016), and Gnidchenko (2021). Absolute measures describe the degree to which a country specializes its export activities in a small number of product groups without making a comparison to global trends. In contrast, relative measures compare a given country's export specialization structure to a common world benchmark. This dissertation employs the Theil index in both absolute and relative forms. Theil index, initially developed as a metric for assessing economic inequality (Theil, 1967; Theil, 1972), has been employed in the context of exports to detect inequality in export shares and to gauge export specialization (Brückner, 2023). The absolute (unweighted) version of the Theil index implemented in this dissertation is based on Theil's entropy[77] index (as in Cadot et al., 2011a) and was calculated using the Stata software module *EGEN_INEQUAL*, which provides extensions to generate inequality and poverty measures (Lokshin & Sajaia, 2006):

$$Theil_c = \frac{1}{n}\sum_{i=1}^{n}\left[\frac{E_{i,c}}{\mu} * ln\left(\frac{E_{i,c}}{\mu}\right)\right] \tag{2}$$

where:

- $\mu = \frac{1}{n}\sum_{i=1}^{n} E_{i,c}$
- n – total number of products exported in the analyzed group of countries.

The absolute Theil index ranges from zero, indicating perfect export diversification[78], i.e., equal distribution of exports across product lines, to $\ln(n)$, denoting high export specialization and inequality in export distribution. The maximum value of the absolute Theil index suggests that the exports of country *c* are composed exclusively of one product.

[77] An entropy measure quantifies the degree of a system's disorder, uncertainty, or randomness. Thiel has argued that the entropy concept is a useful tool for measuring inequality (Cowell 2011: 48).

[78] Export diversification is the exact opposite of export specialization (DIV = 1/SPEC). These terms are used interchangeably in this dissertation.

As posited by Gnidchenko (2021) and Parteka and Tamberi (2013a), relative measures are more suitable for analyzing export diversification in a panel data setting because they compare the export structure of a given country to the common benchmark (which is the rest of the countries considered). The relative Theil index for country *c* and product *i* is computed following Gnidchenko (2021):

$$RT_c = \sum_{i=1}^{n} \left[S_{i,c} * ln\left(\frac{s_{i,c}}{s_{i,w}}\right)\right] \tag{3}$$

Relative Theil (*RT*) is an inverse entropy measure of export diversification. Therefore, as its value increases, so does the export specialization of country *c* (relative to the world). The lowest possible value for this index is zero. In this scenario, the country's export structure is fully diversified and perfectly matches global demand. In essence, the concept of full diversification signifies the absence of a revealed comparative advantage in any product. The decreasing trend of the relative Theil index over time and during the course of development corresponds to a progressive export diversification process[79] (De Benedictis et al., 2009; Cadot et al., 2013; Parteka and Tamberi, 2013a, 2013b; Mau, 2016; Caselli et al., 2020).

Time subscripts in formulas (1), (2), and (3) have been omitted for simplicity, but measures of countries' absolute and relative specialization and comparative advantage were computed for each year within the 1996-2021 timespan. Furthermore, the calculation of both specialization indices and the RCA index was conducted for specific groups of products "*g*" using alternative taxonomies of natural resources and technologically advanced products (as defined in subchapter 3.2). This was done so that:

- in the natural resource variant of measurement, *g* = {*FORESTRY, FUEL, METAL, MINERAL, COAL, NATURAL GAS, PETROLEUM OILS*, and *TOTAL NR*, which collectively represent all natural resources};
- in the technological variant of measurement, *g* = {*ICT, 4IR, TECH*}.

For example, the relative Theil index for a group of resource products *g* = *TOTAL NR*, would be calculated using the following formula:

$$RT_{NR,c} = \sum_{NR} \left[S_{NR,c} * ln\left(\frac{s_{NR,c}}{s_{NR,w}}\right)\right] \tag{3a}$$

where:

- $S_{NR,c}$, $S_{NR,w}$ – share of *TOTAL NR* group in a country's *c* (world's *w*) total exports.

[79] Cadot et al. (2011a) suggest that re-specialization is possible at high levels of development using the absolute measure of export specialization (unweighted Theil). However, Parteka and Tamberi (2013b) and Gnidchenko (2021) provide evidence against this claim. They take into consideration world demand, employing the weighted Theil index, and highlight that this trend is only observable when rich fuel exporters are present in the sample.

3.4. Decomposition of Export Specialization Indices and the Export Diversification Curve

The literature on export diversification draws upon studies of income inequality (see, among others: Theil, 1967 & 1972; Allison 1978; Akita; 2003; Cowell, 2006; Charles-Coll, 2011; Cowell, 2011), adopting the methodology of Theil index decomposition (both weighted and unweighted). It enables deeper analysis of export diversification dynamics, particularly in explaining differences in diversification trajectories among countries. The first application of this method in trade studies goes back to Cadot et al. (2011a), who decomposed the absolute Theil index into intensive (i.e., an increase in the volume of exports of existing product codes) and extensive (i.e. the creation of new product lines) margins. Recently, Gnidchenko (2021) proposed an alternative approach to analyzing export diversification, highlighting the advantageous properties of the relative Theil index. In his work, he separates the relative (weighted) Theil index into extensive and intensive margins while simultaneously dividing the intensive margin into quantitative and qualitative margins. This further division facilitates the interpretation of differences in the export structures between a country and the global context from the perspective of product quality (as measured by export unit values) and product quantity (as represented by volume in physical terms).

This dissertation adopts yet another, slightly different approach as outlined in Parteka et al. (2025)[80] where changes in the overall level of export diversification can be explained by the heterogeneity adjustments in particular groups of products. These adjustments can be measured through the decomposition of the relative Theil index into between (B) and within (W) group components (time subscripts omitted):

$$RT^c = RT^c_{(B)} + RT^c_{(W)} = \sum_g \left[S^c_g * ln\left(\frac{S^c_g}{S^w_g}\right)\right] + \sum_g \left[S^c_g * RT^c_g\right] \tag{4}$$

where:

- g – group of products (e.g. *TECH, NR*);
- 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*.

In order to align this decomposition with the diversification effects of resource dependence, a key explanatory factor of this research, all active export lines were divided into two groups: g_1 = resource products and g_0 = non-resource products. Allocation of all product lines to these groups was possible due to natural resource taxonomies (see Subchapter 3.2 and Table A.4

[80] Parteka et al. (2025) extend the methodology of Gnidchenko (2021) by decomposing the relative Theil index into between and within components.

in Appendix A), using the methodology previously employed in Zarach and Parteka (2023a). The subsequent decomposition of the overall RT^c index into between, within resource, and within non-resource components is as follows:

$$RT^c = \underbrace{S_{g_1}^c \ln\left(\frac{S_{g_1}^c}{S_{g_1}^w}\right) + S_{g_0}^c \ln\left(\frac{S_{g_0}^c}{S_{g_0}^w}\right)}_{between^c} + \underbrace{S_{g_1}^c RT_{g_1}^c}_{within_{res}^c} + \underbrace{S_{g_0}^c RT_{g_0}^c}_{within_{non-res}^c} \tag{5}$$

The weighted Theil index decomposition (5) facilitates the identification of the factors driving diversification processes at different stages of development. 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. The contribution of the decomposition components to the overall *RT* index is also informative. For instance, the share of the within-resource component in the total *RT* index can help verify whether natural resources are responsible for a country's high export specialization, which is especially characteristic of low levels of development. If so, a deeper analysis of the within-resource component can reveal whether this impact depends on changes in the share of resource exports (S_{g1}^c) or on the product diversity of the resource group (RT_{g1}^c).

Likewise, a similar decomposition can be performed for technological and non-technological product groups (based on the methodology presented by Parteka et al. (2025), and taxonomies of technologically advanced products - see Table A.5 in Appendix A):

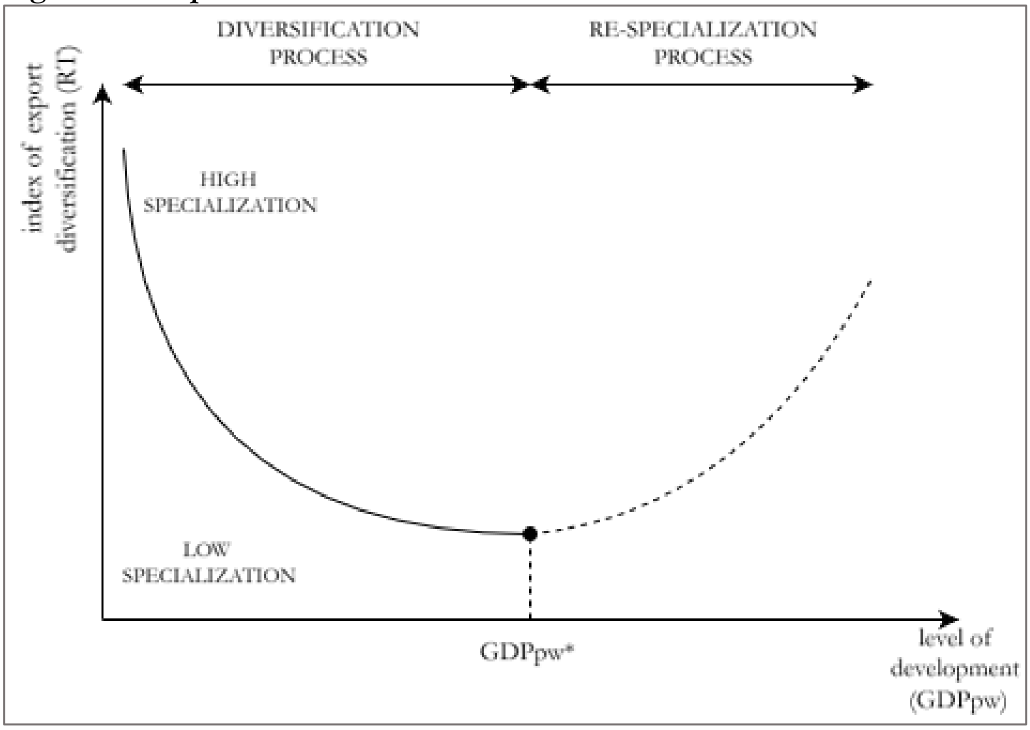
$$RT^c = \underbrace{S_{g_1}^c \ln\left(\frac{S_{g_1}^c}{S_{g_1}^w}\right) + S_{g_0}^c \ln\left(\frac{S_{g_0}^c}{S_{g_0}^w}\right)}_{between^c} + \underbrace{S_{g_1}^c RT_{g_1}^c}_{within_{tech}^c} + \underbrace{S_{g_0}^c RT_{g_0}^c}_{within_{non-tech}^c} \tag{6}$$

Creating a graphical representation of the decomposition facilitates the verification of the driving forces behind the diversification process at each stage of development. This relationship can be conceptualized using the general diversification curve. The export diversification 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 (see a graphical representation in Figure 3.1). The methodology related to the representation of the diversification curve was developed by Cleveland (1979) and Hastie and Tibshirani (1987). It is based on the flexible nonparametric "lowess" estimation settings[81]. This methodology is employed to plot a line through country-year observation points and obtain the diversification curve. Furthermore, the export

[81] This methodology has been used by Gnidchenko (2021), Zarach and Parteka (2023a), and Parteka et al. (2025), for example. An alternative technique is the semiparametric General Additive Model (GAM), which was employed, for instance, in De Benedictis et al. (2009) or Parteka and Tamberi (2013b).

diversification curve can be decomposed into between- and within-components regarding different product groups (Zarach and Parteka, 2023a; Parteka et al., 2025). The graphical results of export decomposition in this dissertation are provided in Subchapter 5.1.

Figure 3.1. Export diversification curve – scheme



Notes: GDPpw – proxy for output per worker; GDPpw* - the turning point where Relative Theil (RT) index reaches its lowest level (the export diversification is at its maximum).
Source: author's elaboration.

4. Growth Trajectories of Natural Resource Exporters

This chapter is related to the paper that we co-authored[82]. It examines the growth trajectories of resource-dependent economies and 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. The chapter verifies three main research hypotheses (H1, H2, and H5) and shows that natural resource exporters are not excluded from technology-based growth. Additionally, it demonstrates that the relationship between resource dependence and productivity growth varies depending on the type of natural resource.

4.1. The Role of Resource Dependence in Countries' Development Dynamics – descriptive statistics and country-specific examples

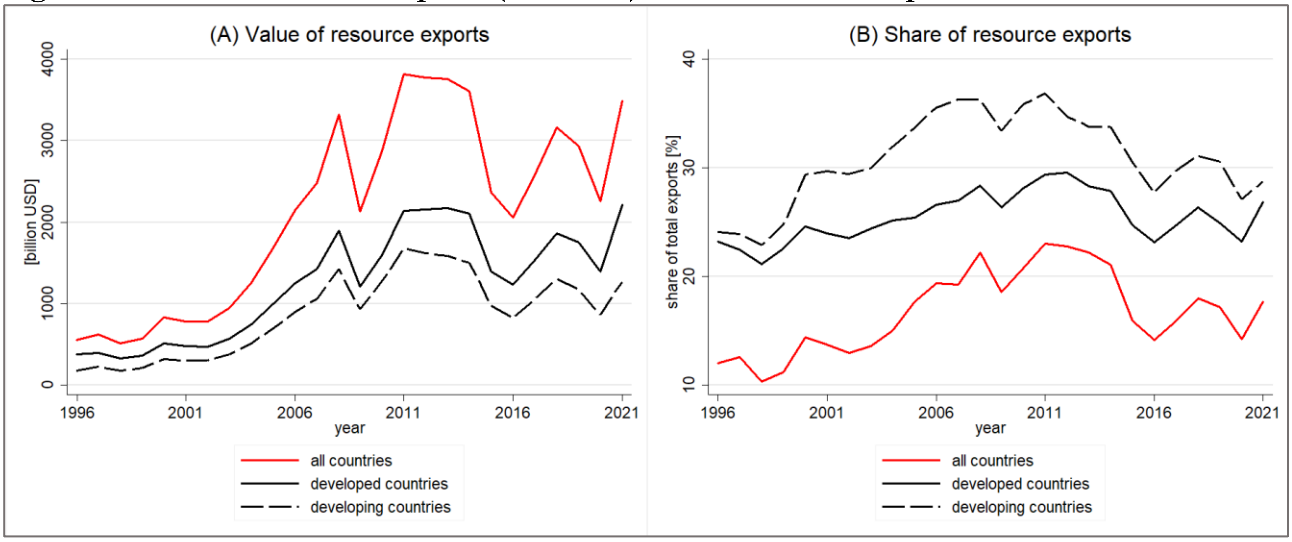
Natural resources have always played an important role in development dynamics. For years, the accumulation of natural capital was the most common measure driving economic progress[83]. Resource-based economies experienced their fastest growth during the first two industrial revolutions, when the demand for natural resources was at its highest. Nowadays, despite the growing importance of renewable resources, exports of primary products remain valuable. Figure 4.1 illustrates this trend by presenting changes in the value and share of resource exports from 1996 to 2021. The value of natural resource exports peaked in 2011 at $3.81 trillion. Afterwards, there was a gradual decrease, partly due to lower resource prices, however the trend reversed and the value reached 3.49 trillion dollars in 2021. Although developing countries tend to be more resource dependent than developed economies, the latter account for around 60-70% of the total value of resource exports. However, the dominant role of developed countries disappears when we consider the share of resource exports in a country's total exports. On average, natural resources account for 17% of exports overall. This figure is 31% in developing countries, reaching a high of 36.8% in 2011, and 25% in high-income countries. As of 2021, natural resources

[82] Zarach, Z. H., & Parteka, A. (2023b). Productivity effects of trade in natural resources—comparison with mechanisms of technological specialisation. *The World Economy*, 46(9), 2684-2706. For the purpose of this thesis, the Zarach and Parteka (2023b) dataset has been updated, and the number of resource types examined has increased. Additionally, the empirical models were extended with an interaction term between natural resources and technologically advanced products to verify the effect of technological specialization on the relationship between resource dependence and productivity growth.

[83] The crucial role of natural resources in economic growth was examined in many 19th- and 20th-century theories, such as the Smithian concepts of the "staples thesis" and the "vent for surplus thesis," and the Malthusian law of population growth.

contributed 28.7%, 26.8% and 17.6% respectively, to the exports of developing, developed, and all countries.

Figure 4.1. Natural resource exports (1996-2021) - value and total exports' share



Notes: the figures' plot values calculated using the sample of 160 countries over the 1996-2021 timespan (for the list of countries see Table A.1. in Appendix A); countries grouped using the World Bank's 2021 income classification (World Bank, 2024c).
The share and the value of resource exports are calculated for the TOTAL NR product group (see Table A.4. in Appendix A for details on the applied taxonomy).
Source: author's elaboration based on trade data from BACI CEPII (CEPII, 2023; Gaulier and Zignago, 2010).

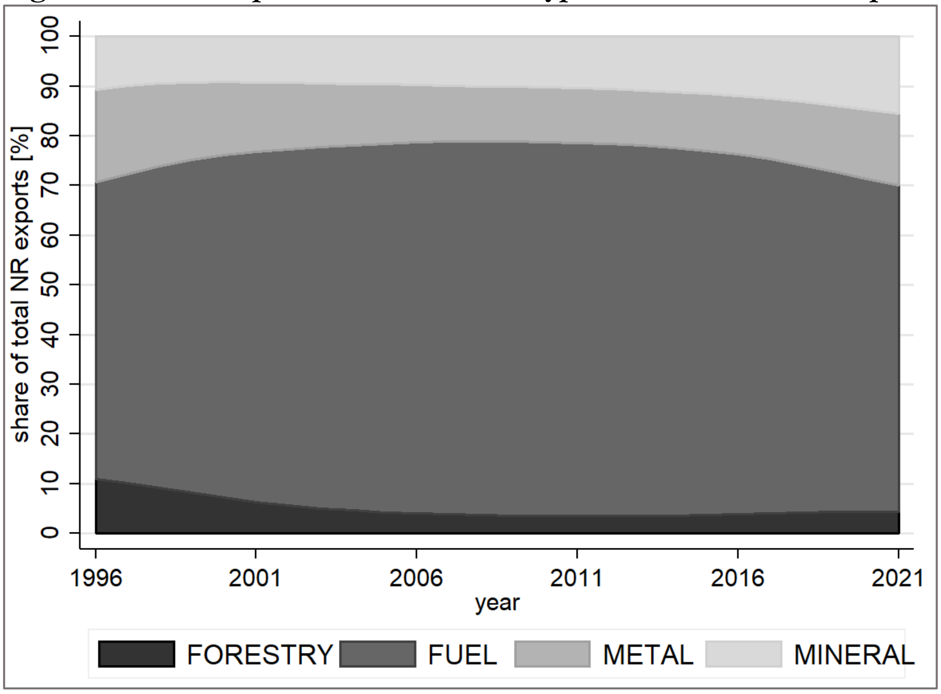
When it comes to the share of natural resource types in overall country exports (see Figure A.2. in Appendix A), fossil fuel products dominate and on average account for 12% of total exports (or \$1.5 trillion in value, peaking at \$2.9 trillion in 2012). For comparison, metal, mineral, and forestry products constitute an average of 2.1%, 1.7% and 0.8%, respectively. As in Figure 4.1, developing countries continue to export a higher percentage of resources, yet the value of these exports is lower than that of developed countries.

Figure 4.2 illustrates changes in the importance of various types of natural resources in total resource exports over the years. Fossil fuel products stand out in the natural resource category, accounting for an average of 70% of resource exports. This dominance was the strongest in 2011, when fuel exports accounted for 75% of all NR exports[84]. Metal and mineral resources fluctuate around a 10% share, suggesting the rather stable demand for these products in modern production processes[85]. Finally, the share of forestry products equaled nearly 11% in 1996. Since then, forestry products have accounted for a smaller percentage of total natural resources, reaching 4,5% in 2021. The division of the sample into developed and developing countries shows that fuel products dominate more in low- and middle-income countries (see Figure A.1. in Appendix A). High-income countries have a greater proportion of metal and mineral products in their total resource exports.

[84] This was partly due to the disruptive situation of the Arab Spring and the subsequent high oil prices.
[85] The manufacture of lithium-ion batteries used in electric vehicles, for example, requires many minerals and metals, including aluminum, cobalt, copper, graphite, iron, lithium, and nickel.

This can be explained by the fact that developed countries specialize in advanced, high-tech production processes that use these types of resources.

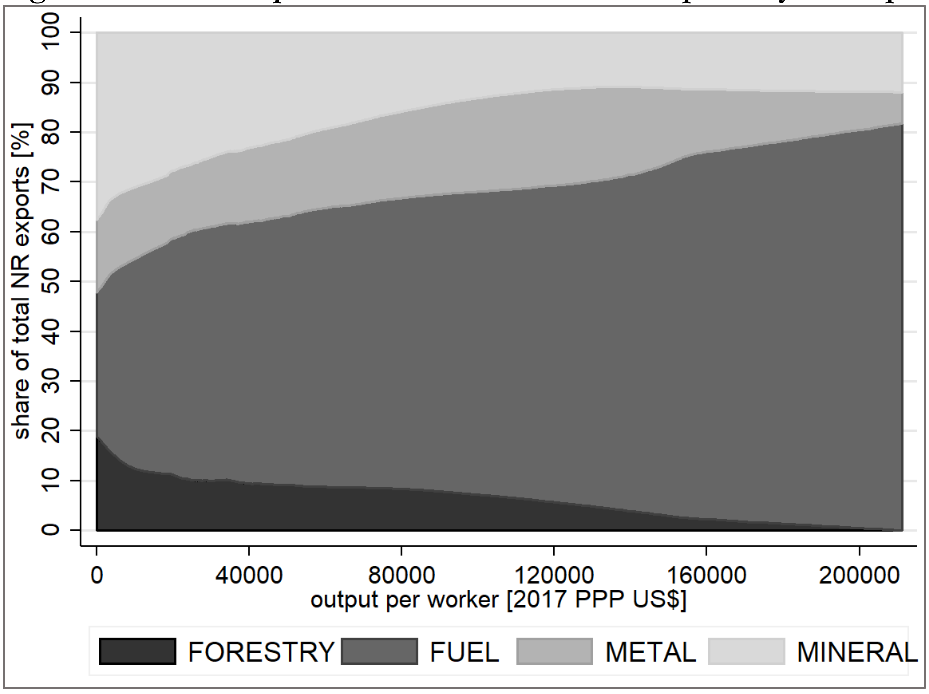
Figure 4.2. The importance of resource types in total resource exports (1996-2021)



Notes: the figure's plot values calculated using the sample of 160 countries over the 1996-2021 timespan (for the list of countries see Table A.1. in Appendix A); types of natural resources based on the taxonomies from Table A.4. in Appendix A.
Source: author's elaboration based on trade data from BACI CEPII (CEPII, 2023; Gaulier and Zignago, 2010).

As displayed in Figure 4.3, the importance of different types of resources in total exports of primary products is reliant on the level of development. At the lowest level of output per worker ($5k or less), countries' total resource exports are more heterogeneous than those at a higher level. Low-productivity exporters divide their resource export basket between all four groups of resources, favoring mineral and fossil fuel products, each of which accounts for a 35% share. However, this versatility does not extend to the variety of products within particular resource groups. Table 4.1 presents a revealed comparative advantage (RCA) in natural resource products and shows that the average number of product codes with an RCA greater than one is relatively small in low-productivity countries. It indicates that, apart from exporting products from all resource groups, those economies are quite uncompetitive within them. The situation is different for countries with a very high level of output per worker ($200k or more). High-income economies tend to specialize in fossil fuels, which constitute 85% of all their resource exports. At the same time, rich fossil fuel exporters (including countries such as Saudi Arabia and the United Arab Emirates) reveal a comparative advantage in, on average, 20% of their exported products. This suggests the relative advancement and greater quality of resource production processes in resource-dependent countries characterized by high output per worker.

Figure 4.3. The composition of natural resource exports by development level



Notes: the figure's plot values calculated using a sample of 160 countries over the 1996-2021 timespan (for the list of countries see Table A.1. in Appendix A); types of natural resources based on the taxonomies from Table A.4. in Appendix A.
Source: author's elaboration based on trade data from BACI CEPII (CEPII, 2023; Gaulier and Zignago, 2010) and output per worker data from PWT 10.01 (Feenstra et al., 2015).

Acquiring specific knowledge about the production of natural resources paves the way for further advancements in non-resource sectors of the economy. The Scandinavian forestry sector is a perfect example of this process[86]. At the end of the 19th century, Finland and Sweden were just undistinguished, resource-dependent countries. However, their unique work culture, ongoing human capital investments, and focus on innovative research and development led to the creation of highly developed resource sectors. These sectors were able to compete with growing competition from cheaper sources of wood successfully and became crucial drivers of economic growth[87] (De Ferranti et al., 2002). In this instance, the key to successful development was to leverage, not compete against, the resource strengths. The knowledgeable inclusion of high technology in resource sectors was crucial for productivity growth and enabled a successful coexistence of resource and high-tech sectors.

[86] Many of the world's most developed countries have based their successful development on the resource sectors (David and Wright, 1997; De Ferranti et al., 2002; Ville and Wicken, 2013). Examples include Australia (mining and metallurgical products), Canada (forestry products), and the United States (mineral products). As of 2021, natural resource products accounted for 73%, 38% and 20% of those countries' total exports, respectively.
[87] As of 2021, the resource sector constituted 24% and 18%, respectively, of Finland's and Sweden's total exports.

Table 4.1. Comparative advantage in natural resource products by development stage (as of 2021)

NR product group#	Countries:					
	Developed (52)		Developing (108)			
			Middle income (85)		Low income (23)	
	No.*	%**	No.*	%**	No.*	%**
ALL NR	55	17%	29	9%	13	4%
FORESTRY	10	21%	4	9%	2	4%
FUEL	7	18%	4	10%	1	3%
METAL	19	16%	9	8%	3	3%
MINERAL	19	17%	13	11%	8	7%
COAL	3	16%	1	5%	0	0%
NATURAL GAS	1	14%	1	14%	0	0%
PETROLEUM OILS	2	17%	1	8%	1	8%

Notes: * average number of product codes with RCA>1 within the group, ** share of product codes with RCA>1 in the total number of NR products within each resource group;
NR product groups are based on established resource taxonomies (see Table A.4. in the Appendix A).
Source: own calculations based on trade data from BACI CEPII (CEPII, 2023; Gaulier and Zignago, 2010) and the World Bank's 2021 income classification (World Bank, 2024c).

Despite the abundance of examples of successful resource-led growth, the most prevalent question in resource literature remains: Why do some resource-abundant countries suffer from the resource curse while others do not, despite being similar in terms of macroeconomic characteristics? The incorporation of innovative techniques in the resource sector, as described above, appears to be unable to fully answer this question. Literature aiming to explain resource curse dynamics provides a variety of case studies, the most popular example of a successful resource-rich country being Norway[88].

Norway entered its resource era in the early 1970s as a developed country. It was able to transform its newly discovered undersea oil deposits into a permanent blessing. Since then, it has served as an excellent example of sustainable growth based on natural endowments. There are four main reasons for this successful outcome. First, Norway was a stable democracy when the oil was discovered. Its well-functioning state bureaucracy, legal systems, and active media have prevented behaviors such as rent-seeking, corruption, and the misuse of resource revenues (Holden, 2013). Second, from the beginning, the Norwegian government has had extensive control over the management of natural resources. This control comes from collecting information about the size and availability of deposits to organizing and controlling the exploration and production of resources (Cappelen and Mjøset, 2009). At the same time, Norwegian companies, often state-held, are guaranteed participation in all petroleum activities (Holden, 2013).

88 Researchers often highlight Botswana as an example of reasonable resource management in a developing country. Sometimes referred to as an "African economic miracle," Botswana is in a somewhat advantageous position due to the type of natural resources it possesses. Its main export is diamonds, which are luxury goods that are usually not subject to fluctuating prices (Zubikova, 2018). Thanks to this fact and prudent macroeconomic policies, the government has been able to transform diamond ownership into a blessing (Zubikova, 2019).

Thirdly, following the fiscal rule implemented in 2001, the Norwegian government ensured that most oil revenues were saved in the form of the Pension Fund, founded in 1990. Thus, in the event of diminishing petroleum production or fluctuating petroleum prices, current and future generations will enjoy the unchanging benefits of abundant oil resources, which are compensated by the returns from the Pension Fund (Holden, 2013)[89]. Finally, the society's natural inclination toward education and hard work made it easy to establish an intensely technological extraction industry (Larsen, 2005). This resulted in the expansion of domestic tech innovations and capabilities (Ville et al., 2019), allowing Norway to be regarded as an example of a "resource-based knowledge economy" (Ville and Wicken, 2013).

The complex relationship between natural resources and technology, which may result in two disparate growth trajectories, is a key part of the research problem undertaken. While natural resource dependence can disqualify a country from technological specialization (Foster-McGregor et al., 2019; Fagerberg and Verspagen, 2021), profits from resource exports can also fund technological innovation, like in the case of Scandinavian countries (De Ferranti et al., 2002; Cappelen and Mjøset, 2009; Holden, 2013; Ville et al., 2019). Over the past decade, exports of technologically advanced products[90] have accounted for approximately half of total trade, peaking at $9.8 trillion in 2021. Developed countries account for around 80% of global technological exports (see Figure A.3 in Appendix A). What's more, high-income economies also dominate in terms of competitiveness within the group of technological exports. As of 2021, an average of 18% of tech exports within this group had a comparative advantage (see Table A.6 in Appendix A). Conversely, the share of total exports from more specific technological categories, such as Information and Communication Technologies (ICT) and the Fourth Industrial Revolution (4IR), is not that prominent. From 1996 to 2021, ICT and 4IR products averaged 11.5% and 0.8%, respectively, in worldwide exports (see Figure A.3 in Appendix A). This is due to stricter market entry barriers and the more sophisticated production requirements.

---

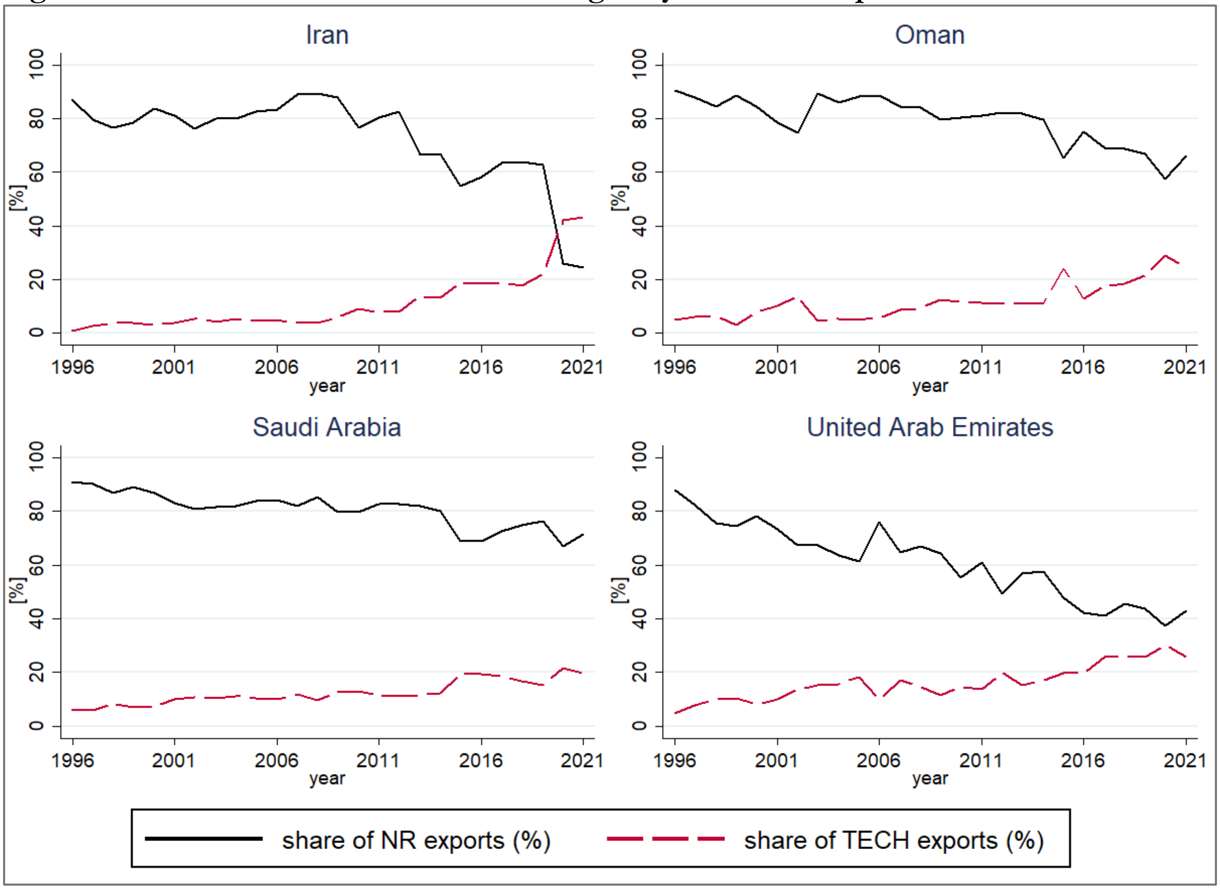
[89] An example of the opposite is Venezuela. As one of the fastest-growing economies in the 1950s, Venezuela reached 90% of the United States' GDP per capita (Bello et al., 2011). It was also a popular destination for Latin American immigrants seeking refuge from their struggling home countries (Sassen-Koob, 1979). However, this oil-fueled bonanza came to an abrupt end when oil prices plummeted in the mid-1970s. A combination of mismanagement and ineffectiveness in the extraction industry, as well as rent-seeking behaviors among the population and a lack of savings schemes concerning oil revenues, led to severe economic problems (Agnani and Iza, 2011). The steep decline in GDP per capita in the second half of the 20th century lowered Venezuelans' living standards and consequently created strong social resentment (Rodríguez and Sachs, 1999). In addition to persistent economic problems, the country has been battling hyperinflation, a civilian exodus, and an authoritarian system of governance since the 2000s (Ellis, 2017). Recently, primarily due to sanctions imposed by the United States, the situation of ordinary Venezuelans has deteriorated rapidly. The sanctions have reduced the public's caloric intake, increased disease and mortality, and worsened economic depression and hyperinflation (Weisbrot and Sachs, 2019). As of 2025, the authoritarian regime remains strong, providing a stark example of the pitfalls of resource abundance.

[90] The group of technologically advanced products is based on UNCTAD's broad taxonomy of middle- and high-tech exports (Lall, 2000). See Table A.5 in Appendix A for more details on technological product taxonomies.

On the other hand, introducing high-tech manufacturing methods to the resource production processes makes resource sectors more profitable and efficient. In the long run, this enables the diversification towards more technologically advanced sectors, which in turn, results in a smaller percentage of natural resources in total exports. Figure 4.4 shows four Middle Eastern resource-rich countries that, over 26 years, transitioned from being almost entirely dependent on natural resources to having a rising share of technologically advanced products in their exports. Notably, it is not only high-income countries that owe their catch-up with developed countries to their wealth built on "petrodollars" that present diversification patterns; middle-income countries like Iran do as well. In fact, Iran experienced the most significant decrease in resource exports and increase in high-tech exports among the countries presented in Figure 4.4.

The readiness to diversify exports is not the only factor pushing resource-dependent countries towards more technologically advanced products. The most significant cause is the global shift towards renewable energy sources, which forces them to find an alternative source of income as fossil fuels are abandoned and eventually depleted. According to the BP Statistical Review of World Energy (2021), if petroleum oil production continues at the current rate, reserves will last only a little over 50 years. Saudi Arabia, for example, has primarily based its motives for diversification on declining per capita oil revenues. Since 1970, the Saudi government has issued ten five-year development plans, each focusing mainly on the diversification process. Despite various financial incentives and regulations, fossil fuels remain the main driving force of the Saudi economy (Albassam, 2015).

Figure 4.4. Diversification towards technologically advanced exports – selected countries

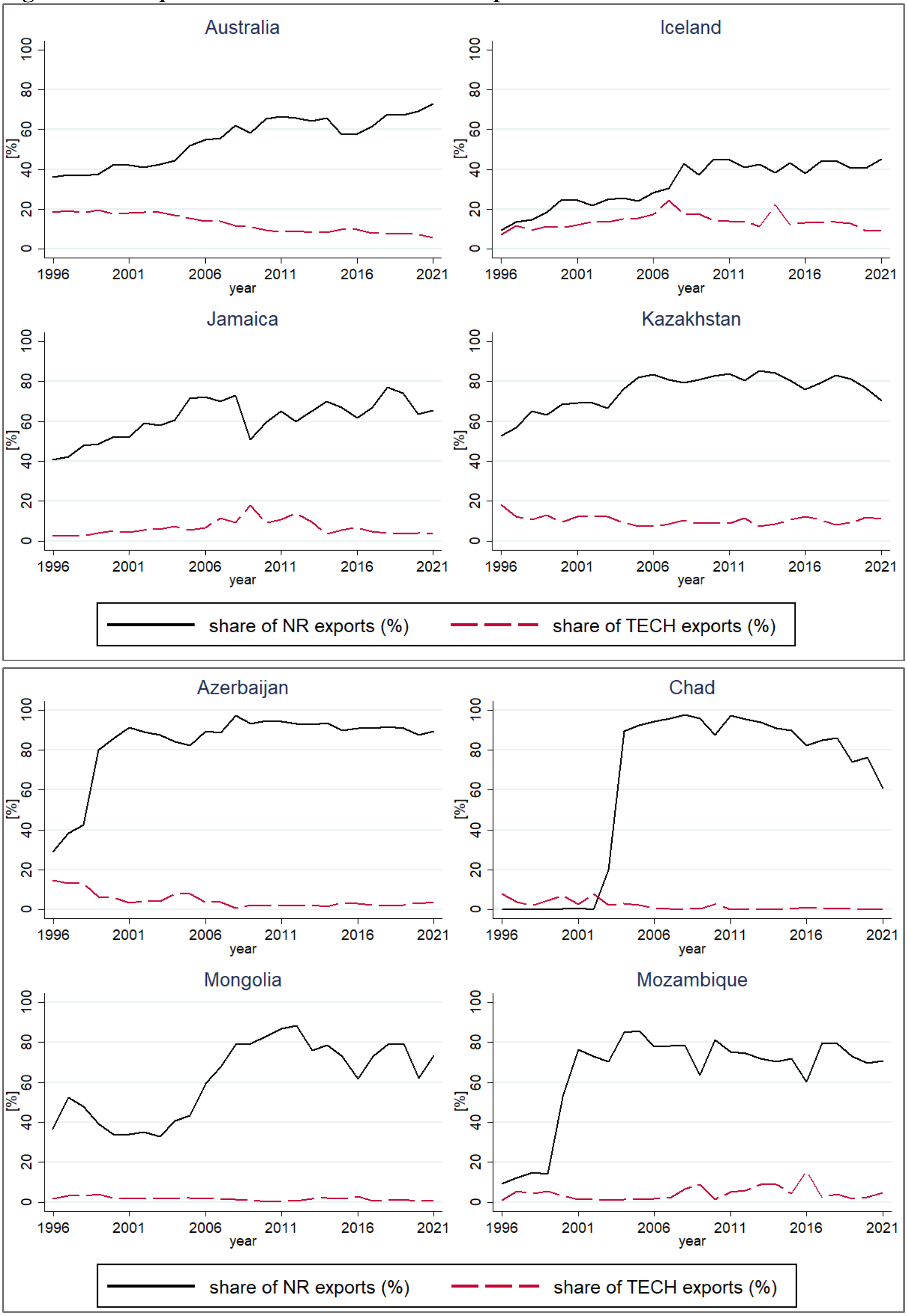


Notes: countries selected from the group of NR exporters (see Table A.2. in Appendix A); the share of NR and TECH exports was calculated using TOTAL NR and TECH classifications, respectively (see Table A.4. and Table A.5. in Appendix A for details on the applied taxonomies).
Source: author's elaboration based on trade data from BACI CEPII (CEPII, 2023; Gaulier and Zignago, 2010).

Despite the trend of diversification, an increasing number of countries, including those with higher incomes, are turning toward natural resources. This demonstrates that, during turbulent times, countries endowed with natural resources ultimately decide to play to their strengths and pursue resource-based growth. Figure 4.5 exemplifies eight countries that have increased their resource exports over the last 26 years[91]. Among them is Australia, which abandoned its developed manufacturing sector in favor of exporting fossil fuels and precious metals. Next, some low-income countries, such as Chad and Mozambique, shifted from exporting agricultural products to exporting resources after new deposits were discovered (petroleum and gold in Chad, and fossil fuels and metals in Mozambique). The final group consists of middle-income economies, such as Azerbaijan, Mongolia, and Kazakhstan, that exchanged a diversified export portfolio, including low-tech manufactured goods and agricultural products, for resource products, mainly various types of fossil fuels.

[91] Table A.12 in Appendix A shows the exact shares of resource and technological exports at the beginning and the end of the examined time period (1996-2021) for both countries that reduced (Figure 4.4) and increased (Figure 4.5) their resource exports.

Figure 4.5. Re-specialization towards resource exports – selected countries



Notes: countries selected above recorded an increase in the share of resource exports throughout the 1996-2021 period; at the same time, the share of technological exports remained unchanged or decreased.
The share of NR and TECH exports was calculated using TOTAL NR and TECH classifications, respectively (see Table A.4. and Table A.5. in Appendix A for details on the applied taxonomies).
Source: author's elaboration based on trade data from BACI CEPII (CEPII, 2023; Gaulier and Zignago, 2010).

4.2. Productivity Catching-up and Natural Resources – econometric results (1)

To explore the relationship between natural resources and productivity growth in a more systematic way, firstly, we estimate a baseline model (eq.7):

$$g(y)_{ct} = \alpha + \beta_1 y_{c,t-1} + \beta_2 NR_{c,t-1} + P_t^{NR} + \varepsilon_{ct} \quad (7)$$

where *c* denotes country (c=1, .., 160) and *t* denotes time (t=1996, .., 2019). The difference in time periods between the country-specific examples and the econometric results is due to the availability of data in the Penn World Table 10.01 database[92]. The dependent variable, $g(y)_{ct}$ is represented by the annual growth rate (in %) of labor productivity. Labor productivity is measured as output per worker[93] and expressed in thousands of US dollars (in 2017 PPP USD). In line with the assumptions of the conditional convergence theory (Solow, 1956; Swan, 1956; Barro and Sala-i-Martin, 1992)[94], we include the level of labor productivity as a lagged explanatory variable. $NR_{c,t-1}$ represents the share of a country's natural resource exports in its total exports. We calculate resource exports using product-level trade data from BACII CEPI (Gaulier and Zignago, 2010) and product taxonomies that identify seven distinct resource groups and a *TOTAL NR* group that encompasses all natural resource types[95]. Moreover, to account for the volatility of natural resource prices, we include the resource price index P_t^{NR} as a substitute for time-fixed effects[96]. Finally, exports of natural resources tend to be highly persistent, as shown in Table A.14 in Appendix A, due to relatively stable extraction and production levels[97]. Therefore, to avoid losing all cross-country variability, country fixed effects are not included in the regressions[98] (Barro, 2015; Bahar and Santos, 2018).

Next, we expand the basic model (7) by incorporating a set of country-specific control variables that potentially influence productivity growth:

$$g(y)_{ct} = \alpha + \beta_1 y_{c,t-1} + \beta_2 NR_{c,t-1} + \beta_3 X_{c,t-1} + P_t^{NR} + \varepsilon_{ct} \quad (8)$$

---

92 In the PWT 10.01 database, the time period for which labor productivity data is available covers only the years from 1996 to 2019. The extrapolation of data was unsuccessful thanks to disturbances caused by the COVID-19 pandemic. See Subchapter 3.1 for more information.

93 Output per worker is calculated by dividing expenditure-side real GDP in constant 2017 USD by the number of persons engaged. For robustness checks, we use an alternative measure of labor productivity calculated with output-side real GDP. All variables are from the Penn World Table 10.01 database (Feenstra et al., 2015). For more details on the productivity measures used, see Table A.9 in Appendix A.

94 Firstly introduced in the Solow-Swan model, conditional convergence implies that less advanced states with lower output and capital per worker are bound to have higher growth rates than developed countries within a group of structurally similar economies (Solow, 1956; Swan, 1956; Barro and Sala-i-Martin, 1992).

95 See Table A.4. in Appendix A for more details on the used taxonomies.

96 The implemented price indices come from the World Bank Commodity Price Data Annual Indices (World Bank, 2024a). Separate price indices were prepared for each type of resource group referenced in this dissertation.

97 The persistence of resource production can be altered by new resource discoveries, resource depletion, or countries' efforts at export diversification.

98 This approach aligns with Barro's (2015) thought on country fixed effects in panel regressions.

where $X_{c,t-1}$ is the set of control variables, including trade openness[99], the Human Capital Index[100], and the level of investment[101]. These variables are all from the World Development Indicators database (World Bank, 2024b). 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. Finally, the relationship between productivity growth and natural resource exports is susceptible to reverse causality and endogeneity issues (Farhadi et al., 2015). Therefore, we use a two-step efficient GMM estimator with a one-year lag of the potentially endogenous variable as an instrument[102].

Table 4.2 reports the basic estimation results of model (7). In compliance with the convergence theory, the correlation between productivity growth and lagged productivity level is negative and significant. This implies that countries with lower initial output per worker tend to have higher productivity growth. Overall, dependence on natural resources enhances productivity growth, though the type of resource exported matters. Other things being equal, a 1-percentage-point (p.p.) increase in the share of *TOTALNR* exports is associated with a 1.685-p.p. increase in the productivity growth rate. Since the resource exports are relatively persistent, this implies a moderately strong, constant, and positive relationship with productivity growth. Fossil fuels, particularly petroleum oils, stand out as the most significant determinant of productivity growth among all the types of natural resources. Ceteris paribus a 1-p.p. increase in the share of fuel exports is associated with a 2-p.p. increase in the output-per-worker growth rate. Petroleum oils have a similar, albeit slightly stronger, relationship with productivity growth (a 2.37-p.p. increase). Conversely, mineral resources impede the process of catching-up (a 3.14-p.p. decrease).

Furthermore, including resource price indices as proxies for time fixed effects does not alter the relationship between resource dependence and productivity growth. At the same time, P_t^{NR} is positively correlated with the output growth per worker, suggesting that higher natural resource prices enhance productivity growth. Incorporating control variables (see Table 4.3) does not change the overall trend either. However, the effects of natural resource exports are subtly weaker for total and mineral resources and stronger for fuel and petroleum resources. The

[99] Trade openness is measured as the ratio of exports and imports of goods and services to GDP (World Bank, 2024b). Countries that engage in more open trade activities are more likely to experience faster productivity growth (Edwards, 1998).
[100] The Human Capital Index, which ranges from 0 to 1, calculates the contributions of health and education to the future workforce's productivity (World Bank, 2024b). A healthier and more educated population is essential for generating new technologies and, consequently, for productivity growth (Kim and Loayza, 2019).
[101] Here, the level of investment is gauged as gross fixed capital formation (% of GDP). This includes land improvements, purchases of machinery and equipment, and construction of various public utility facilities (World Bank, 2024b). Investing in public infrastructure is a well-known way to enhance productivity (Straub, 2008).
[102] Without the problem of simultaneity, the one-year lag in natural resource exports would be due to their non-immediate productivity effects.

correlation between productivity growth and all control variables is positive, which aligns with productivity theory. Nevertheless, the effects are weak.

The first of several robustness checks examines the relationship between an alternative measure of labor productivity[103] and resource dependence. The magnitude or significance of the relationship between productivity growth and the explanatory variables was not altered by the inclusion of the new productivity measure (see Tables B.3 and B.4 in Appendix B). Tables B.6 and B.7 in Appendix B present estimation results using another proxy for resource dependence: *NR* rents[104]. The negative correlation between productivity growth and the previous year's productivity level has been sustained. Moreover, consistent with the main results, oil and gas rents show a positive and significant relationship with productivity growth. However, this effect is weaker than that presented in Table 4.2. For example, a 1-p.p. increase in the share of gas rents results in a 0.15-p.p. increase in the output-per-worker growth rate, ceteris paribus. In this instance, it is not the mineral resources, but the forestry resources, that negatively affect productivity growth.

To account for possible heterogeneity in levels of development, we conduct separate estimations for developed (Tables B.9 and B.10 in Appendix B) and developing countries[105] (Tables B.12 and B.13 in Appendix B). In the subsample of developed economies, the results of the baseline model (eq.7) are characterized by the same significance but a stronger magnitude, especially in the case of mineral resources. Other things being equal, a 1-p.p. increase in the share of mineral exports yields an 8.48-p.p. decrease in the output-per-worker growth rate. Incorporating control variables into the model for developed countries yields insignificant outcomes. The estimation results for the subsample of developing economies are similar to the baseline findings from Tables 4.2 and 4.3 for both models (7) and (8), with sustained significance and slightly stronger magnitude. Finally, considering that some countries have high and persistent shares of resource exports, we introduce the group of *NR* exporters[106] to verify the relationship between natural resources and productivity growth within this subsample (see Table B.15 in Appendix B). Fuel and petroleum resources are the only positive enhancers of productivity growth, increasing the output-per-worker growth rate by 3.1 and 3 percentage points, respectively, for every 1-p.p. increase in the share of resource

[103] The alternative measure of labor productivity was calculated using output-side real GDP and the number of persons employed. All variables are from the Penn World Table 10.01 database (Feenstra et al., 2015). See Table A.9 in Appendix A for more details on productivity measures.
[104] Natural resource rents are calculated as the difference between the value and the total cost of resource production at regional prices and expressed as a percentage of GDP. The NR rents used in this dissertation come from the WDI database (World Bank, 2024b). They are categorized into five types: coal, forest, oil, gas, and minerals, as well as a total group that encompasses all above.
[105] Please see Table A.1 in Appendix A for details on the list of countries and their income classification.
[106] Natural Resource (NR) exporters are countries with a share of resource exports of at least 50% (an average from 1996 to 2021). See Table A.2 in Appendix A for a list of NR exporters and their income classification.

exports. Among NR exporters, ceteris paribus, a 1-p.p. increase in the share of mineral exports results in an 8.3-p.p. decrease in the productivity growth rate.

Table 4.2. Estimation results (eq. 7) – relationship between productivity growth and dependence on natural resources[1]

	Type of NR[2]							
Dependent variable: $g(y)_{ct}$	*TOTAL NR*	*FORESTRY*	*FUEL*	*METAL*	*MINERAL*	*COAL*	*NATURAL GAS*	*PETROLEUM*
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$y_{c,t-1}$	-0.025***	-0.023***	-0.027***	-0.025***	-0.026***	-0.023***	-0.023***	-0.026***
	(0.004)	(0.004)	(0.005)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
$NR_{c,t-1}$	1.685**	5.541	2.093**	0.896	-3.141**	-2.950	1.816	2.373**
	(0.735)	(4.180)	(0.895)	(1.410)	(1.244)	(5.136)	(1.936)	(1.073)
P_t^{NR}	0.040***	0.069***	0.022***	0.044***	0.046***	0.020***	0.040***	0.023***
	(0.007)	(0.014)	(0.004)	(0.006)	(0.006)	(0.005)	(0.004)	(0.005)
No.of obs.	3,520	3,520	3,520	3,520	3,520	3,520	3,520	3,520
No. of countries	160	160	160	160	160	160	160	160
K-P rk Wald F	77578	713.4	53988	5899	3689	270.3	3257	40562
K-P rk LM	1300	86.35	781.1	105.9	190.2	42.93	110.0	590.5
K-P rk LM (p-val)	0.000	0.000	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 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.

2) The presented types of natural resources (NR) comply with the established resource taxonomies (see Table A.4. in Appendix A).

Source: own calculations based on data from BACI CEPII (CEPII, 2023; Gaulier and Zignago, 2010), PWT 10.0 (Feenstra et al., 2015), and World Bank Commodity Price Data Annual Indices (World Bank, 2024a).

Table 4.3. Estimation results (eq. 8) – relationship between productivity growth, dependence on natural resources[1] and control variables

Dependent variable: $g(y)_{ct}$	Type of NR[2]							
	TOTAL NR	*FORESTRY*	*FUEL*	*METAL*	*MINERAL*	*COAL*	*NATURAL GAS*	*PETROLEUM*
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$y_{c,t-1}$	-0.037***	-0.034***	-0.039***	-0.035***	-0.036***	-0.034***	-0.032***	-0.039***
	(0.006)	(0.006)	(0.007)	(0.006)	(0.006)	(0.006)	(0.006)	(0.007)
$NR_{c,t-1}$	1.384*	1.848	2.178**	-0.860	-2.296*	-1.295	-1.042	2.721**
	(0.798)	(3.230)	(1.054)	(1.696)	(1.395)	(5.588)	(3.153)	(1.254)
$INV_{c,t-1}$	0.096***	0.103***	0.100***	0.099***	0.102***	0.105***	0.111***	0.101***
	(0.033)	(0.033)	(0.033)	(0.033)	(0.033)	(0.034)	(0.033)	(0.033)
$OPEN_{c,t-1}$	0.011***	0.011***	0.012***	0.011***	0.011***	0.011***	0.010***	0.011***
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
$HC_{c,t-1}$	0.582**	0.463	0.710**	0.458	0.445	0.435	0.501*	0.761***
	(0.273)	(0.286)	(0.279)	(0.283)	(0.283)	(0.286)	(0.279)	(0.285)
P_t^{NR}	0.039***	0.068***	0.020***	0.044***	0.045***	0.022***	0.031***	0.022***
	(0.006)	(0.014)	(0.004)	(0.005)	(0.005)	(0.005)	(0.004)	(0.005)
No.of obs.	2,737	2,737	2,737	2,737	2,737	2,737	2,737	2,737
No. of countries	128	128	128	128	128	128	128	128
K-P rk Wald F	56552	551.2	31490	5165	3004	490.1	3141	23267
K-P rk LM	886.3	68.93	531.7	76.78	156.3	44.27	90.59	406.5
K-P rk LM (p-val)	0.000	0.000	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 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.

2) The presented types of natural resources (NR) comply with the established resource taxonomies (see Table A.4. in Appendix A).

Source: own calculations based on data from BACI CEPII (CEPII, 2023; Gaulier and Zignago, 2010), PWT 10.0 (Feenstra et al., 2015), and World Bank Commodity Price Data Annual Indices (World Bank, 2024a).

4.3. Natural Resources and Productivity Growth – the Role of Technological Specialization – econometric results (2)

To empirically examine the effect of technological specialization on the relationship between natural resources and productivity growth, we further extend the model (7) by interacting technology-related variable with NR:

$$g(y)_{ct} = \alpha + \beta_1 y_{c,t-1} + \beta_2 NR_{c,t-1} + \beta_3 TECH_{c,t-1} + \beta_4 (NRxTECH)_{c,t-1} + P_t^{NR} + \varepsilon_{ct} \quad (9)$$

where $TECH_{c,t-1}$ is the share of a country's technological exports in its total exports. Tech exports are calculated using product-level trade data from BACII CEPI (Gaulier and Zignago, 2010) and product taxonomies identifying three distinct groups of technologically advanced products[107]. To avoid potential issues of reverse causality and endogeneity, we treat the share of tech exports as a one-year lagged instrument within the two-step system GMM approach. $(NRxTECH)_{c,t-1}$ is the interaction term between the shares of resource and technological exports. Productivity effects need time to materialize, so the interaction term is also lagged by one year.

Table 4.4 presents the estimation results of model (9) 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 in the case of resource exports[108]. For instance, a 1-p.p. increase in the share of *TECH* products reinforces productivity growth rate by 2.4-p.p., whereas an increment in resource exports equals 3.3-p.p. (see estimation (3) in Table 4.4). Additionally, the negative interaction terms suggest that adding technologically advanced products to the resource-based export basket could exacerbate output per worker growth. Nevertheless, these findings are statistically insignificant. The positive influence of technological specialization is only visible in the empirical results with *MINERAL* resources (see estimation (5) in Table 4.4). Based on this evidence and the margin plots in Figure A.4 in Appendix A, it can be concluded that increasing the share of technologically advanced exports, particularly in resource-dependent countries with a high share of mineral exports, leads to reinforced productivity growth. For countries with lower shares of mineral exports (3.5% or less), the effect of technological

[107] The three groups of technologically advanced products include products related to the 4th Industrial Revolution (4IR), Information and Communication Technologies (ICT), and middle- and high-tech products (TECH). See Table A.5 in Appendix A for the sources and descriptions of the technological taxonomies used.

[108] This trend reverses in the case of the estimations involving products related to ICT technologies. Here, a 1-p.p. increase in the share of ICT exports yields a 4.2-p.p. increase in productivity growth (see estimation (3) in Table B.2 in Appendix B). For *FUEL* resources, this increase equals 2.4-p.p.

specialization is moderately positive or slightly negative. The same conclusions can be drawn for estimations with 4IR-related products, albeit more strongly (see Table B.1 in Appendix B).

The introduction of an alternative measure of resource dependence (see Table B.8 in Appendix B) confirms the enhancing role of technological specialization on the relationship between mineral resources and productivity growth, as well as its compounding effect in the case of fossil fuels. A robustness check with a variant proxy for productivity growth (see Table B.5 in Appendix B) yields similar outcomes to the primary results. The empirical evidence for the subsample of developed countries indicates that the integration of forestry resources and technologically advanced products within a country's export portfolio has the potential to enhance the growth of output per worker (see estimation (2) in Table B.11 in Appendix B). However, this effect is observed to be negative in the subsample of developing countries (see estimation (2) in Table B.14 in Appendix B).

Table 4.4. Estimation results (eq. 9) – relationship between productivity growth, dependence on natural resources[1] and TECH exports

Dependent variable: $g(y)_{ct}$	Type of NR[2]							
	TOTAL NR	*FORESTRY*	*FUEL*	*METAL*	*MINERAL*	*COAL*	*NATURAL GAS*	*PETROLEUM*
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$y_{c,t-1}$	-0.030***	-0.023***	-0.031***	-0.025***	-0.025***	-0.023***	-0.023***	-0.029***
	(0.006)	(0.005)	(0.006)	(0.006)	(0.005)	(0.005)	(0.005)	(0.006)
$NR_{c,t-1}$	2.858***	10.756	3.303***	-0.252	-4.697***	-9.858	2.576	3.542**
	(1.025)	(6.706)	(1.199)	(1.945)	(1.608)	(10.478)	(2.287)	(1.405)
$TECH_{c,t-1}$	2.686***	0.441	2.410***	-0.320	-0.859	-0.356	0.120	2.015**
	(0.996)	(0.787)	(0.901)	(0.808)	(0.845)	(0.804)	(0.789)	(0.867)
$(NRxTECH)_{c,t-1}$	-5.827	-44.208	-9.700	21.461	27.000*	72.877	-14.585	-11.561
	(5.317)	(31.118)	(6.429)	(25.205)	(16.055)	(61.113)	(15.831)	(7.532)
P_t^{NR}	0.040***	0.068***	0.022***	0.044***	0.045***	0.020***	0.040***	0.024***
	(0.007)	(0.014)	(0.004)	(0.006)	(0.006)	(0.005)	(0.004)	(0.005)
No.of obs.	3,520	3,520	3,520	3,520	3,520	3,520	3,520	3,520
No. of countries	160	160	160	160	160	160	160	160
K-P rk Wald F	6764	308.3	8734	5704	1812	35.51	1467	9428
K-P rk LM	1045	71.21	1109	478.5	267.0	18.02	144.6	1109
K-P rk LM (p-val)	0.000	0.000	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 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) – see Table A.5. in Appendix A. 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.

2) The presented types of natural resources (NR) comply with the established resource taxonomies (see Table A.4. in Appendix A).

Source: own calculations based on data from BACI CEPII (CEPII, 2023; Gaulier and Zignago, 2010), PWT 10.0 (Feenstra et al., 2015) and World Bank Commodity Price Data Annual Indices (World Bank, 2024a).

5. Diversification Trajectories of Natural Resource Exporters

This chapter is related to the paper that we co-authored[109]. It 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. The chapter is structured 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 chapter verifies three main research hypotheses (H3, H4, and H5) and demonstrates that excessive reliance on natural resources results in greater export specialization. This relationship is moderated by the high institutional quality and technological innovation, and varies by type of natural resources. Additionally, the chapter demonstrates that, at low levels of development, the excessive export specialization is mainly caused by the low heterogeneity within the non-resource product group.

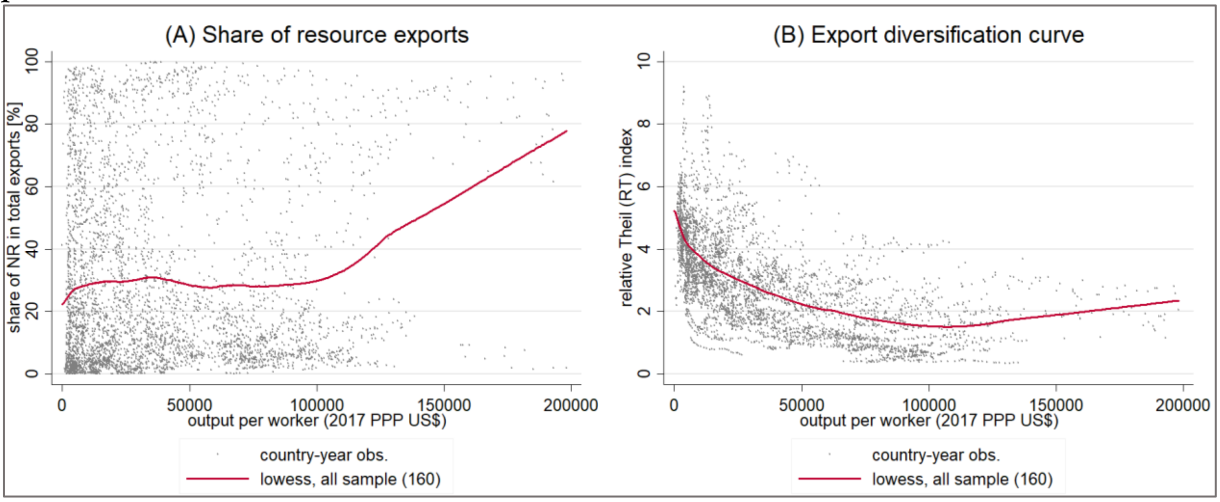
5.1. Results of Resource-based Decomposition of the Export Diversification Curve

The resource literature, reviewed in Chapter 2, typically associates excessive dependence on natural resources with low productivity and high export specialization (Auzer and Abdullah Auzer, 2017; Bahar and Santos, 2018; Inuwa et al., 2022; Awoa Awoa and Ondoa, 2023). However, as demonstrated in Figure 5.1A, at low levels of output per worker, countries can export only natural resources (up to 99% dependence on natural resources, as in Iraq) or none at all. What's more, among low-income countries, some are highly specialized while others maintain moderately low levels of export specialization (Figure 5.1B). Conversely, high-income countries, such as Saudi Arabia and Qatar, also prioritize primary products in their export portfolios, deviating from the trend of export diversification observed in more developed economies[110]. Therefore, the presentation of raw data yields inconclusive results as to the role of natural resources in development trajectories.

[109] Zarach, Z. H., & Parteka, A. (2023a). Export diversification and dependence on natural resources. *Economic Modelling*, 126, 106436. For the purpose of this thesis, the Zarach and Parteka (2023a) dataset has been updated, and the number of resource types examined has increased. Additionally, the empirical models were extended with an interaction term between natural resources and technological innovation to verify its role in the relationship between resource dependence and export diversification.

[110] The theory of structural transformation posits that countries tend to diversify as they develop, with the possibility of re-specialization at high income levels (Imbs and Wacziarg, 2003; Cadot et al., 2011a). However, when the structure of world demand is considered and the outlier resource exporters are removed from the sample, the re-specialization track disappears (Parteka and Tamberi, 2013b; Mau, 2016; Gnidchenko, 2021).

Figure 5.1. Resource exports' share and export diversification – relationship with output per worker



Notes: observations above 200k US$ were excluded; the share of resource exports was computed for the TOTAL NR group of products (see Table A.4. in Appendix A for details on the applied taxonomy); the figures' plot values calculated using the sample of 160 countries over the 1996-2021 timespan (for the list of countries see Table A.1. in Appendix A). Plot B: RT is an inverse measure of diversification so its high level corresponds to low diversification, (high specialization).
Source: author's elaboration based on trade data from BACI CEPII (CEPII, 2023; Gaulier and Zignago, 2010) and output per worker data from PWT 10.01 (Feenstra et al., 2015).

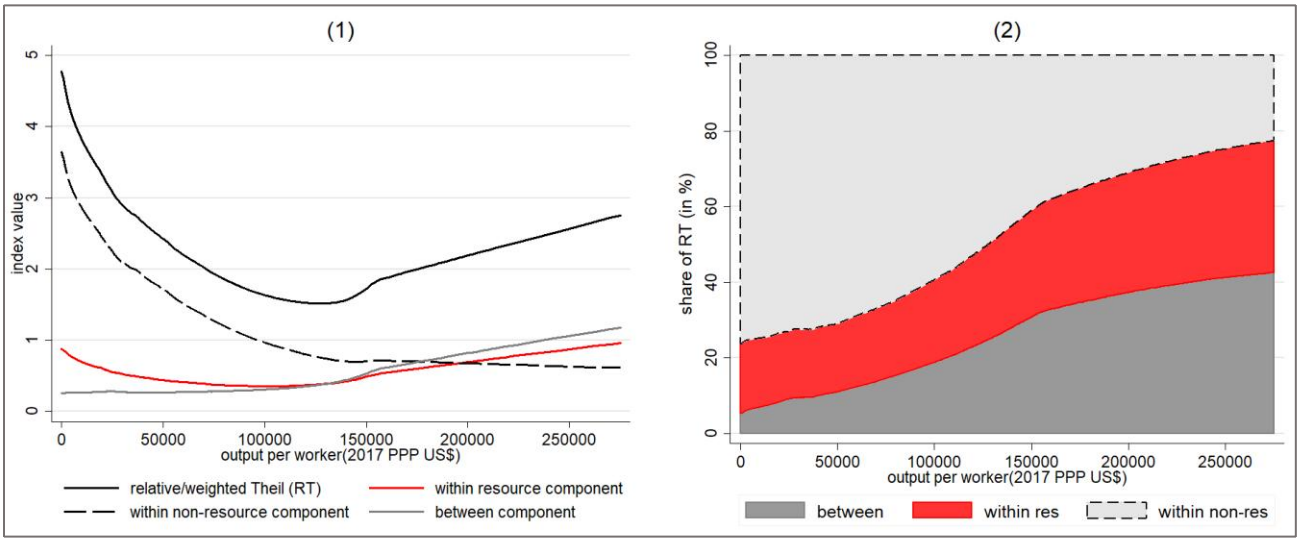
The question of whether natural resources drive the forces behind high export specialization, especially at low-income levels, can be thoroughly addressed by decomposing the relative Theil (*RT*) index[111] and presenting the results as an export diversification curve[112] using the methodology described in Section 3.4. The decomposition was conducted for *TOTAL NR* and *FUEL* groups of resource products, since results for other resource taxonomies did not contribute any valuable information to the discussion. Figure 5.2 presents the core results of the resource-based decomposition, using equation (5) and the *TOTAL NR* resource taxonomy. Overall, *RT* decreases along the development path (black solid line in Figure 5.2.1), 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

[111] The relative Theil index is an entropy measure, meaning that higher its value the stronger export specialization. See the methodological description in Section 3.4.
[112] The export diversification curve is the graphical representation of the results of the decomposition of the relative Theil index. It shows a link between the development level and the degree of export diversification plotted across country-year data points. What's more, export diversification is the exact opposite of export specialization (DIV = 1/SPEC), and these terms are used interchangeably in this dissertation.

component, a dashed line in Figure 5.2.1). 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 5.2.2). 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 5.2.2) and the rising importance of weighted diversity in resource exports (the red area in Figure 5.2.2). 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.

Figure 5.2. Resource-based decomposition[1] of the export diversification curve: relative Theil (RT) index[2] and its components (eq.5)



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 (see Table A.4. in Appendix A for details on the applied taxonomy); the figures' plot values calculated using the sample of 160 countries over the 1996-2021 timespan (for the list of countries see Table A.1. in Appendix A).
1) see eq.4 and 5 in Chapter 3 for the details on the resource-based decomposition of the export diversification curve.
2) The RT index is a weighted measure of export specialization (~1/export diversification); the higher the index value, the stronger the export concentration.
Source: author's elaboration based on trade data from BACI CEPII (CEPII, 2023; Gaulier and Zignago, 2010) and output per worker data from PWT 10.01 (Feenstra et al., 2015).

Examining the structure of the *RT* index (Table 5.1) 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[113]. 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.

Regarding the decomposition using the *FUEL* resource taxonomy (Figure A.5 in Appendix A), high export specialization at low productivity levels is driven by low weighted diversity of non-fuel exports (with the within non-fuel component accounting for around 85% of the overall *RT* index below the $50k level). The re-specialization phase is characterized by the growing importance of the between component, indicating shifts in heterogeneity between fuel and non-fuel exports. The within-fuel component does not play as important a role in diversification dynamics at high productivity levels as the within-resource component did in the *TOTAL NR*-based decomposition. Table A.13 in Appendix A also reveals that the weighted diversity of products within the *FUEL* domain (RT^c_{fuel}) is much more pronounced than that of overall resource products.

113 Since this dissertation excludes plant and animal products from the resource taxonomies (see Subchapter 3.2 for more details), the excessive reliance on agricultural exports is not considered resource dependence. This explains the low share of resource products in total exports of low-income countries. Along with rising productivity, the high share of non-resource products is due to the growing proportion of technological exports that accompany the development process.

Table 5.1. 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: see eq.4 and 5 in Chapter 3 for details on the RT decomposition; here the decomposition was prepared for the full sample and for the output per worker intervals with respect to the TOTAL NR products, which were later split into resource and non-resources groups (for more details on resource taxonomies see Table A.4. in Appendix A); the table reports average values over the sample period (160 countries, 1996-2021).
Source: author's elaboration based on trade data from BACI CEPII (CEPII, 2023; Gaulier and Zignago, 2010) and output per worker data from PWT 10.01 (Feenstra et al., 2015).

5.2. The Role of Natural Resources in Export Diversification Process – econometric results (3)

To further explore the relationship between natural resource dependence and export diversification, we estimate the following model[114] (eq.10):

$$lnRT_{ct} = \alpha + \beta_1 NR_{ct} + \beta_2 lnSIZE_{ct} + \beta_3 lnDEV_{c,t-1} + \beta_4 X_{ct} + P_t^{NR} + \varepsilon_{ct} \quad (10)$$

where *c* denotes country (c=1, .., 160) and *t* denotes time (t=1996, .., 2021). The dependent variable is computed for three groups of products: overall $(lnRT_{ct})$, non-resource[115] $(lnRT_{c,nonNR_t})$ and technological $(lnRT_{c,TECH_t})$ using equation (3) and product-level trade data from BACI CEPII (Gaulier and Zignago, 2010). Calculating the export diversification of the non-resource and technological product groups allows us to verify the effect of resource dependence on the variety of products outside the natural resource domain. Resource dependence (NR_{ct}) is calculated as the share of natural resources in a country's *c* total exports, using trade data from BACI CEPII (Gaulier and Zignago, 2010) and product-level taxonomies (Table A.4 in Appendix A). To account for the volatility of resource prices, we include the resource price index[116], P_t^{NR}, which is also regarded as a substitute for time-fixed effects[117]. Apart from the resource dependence, the baseline model (eq.10) controls for two major determinants of export diversification. The development level[118], measured by output per worker $(lnDEV_{c,t-1})$ and the country size, proxied by expenditure-side real GDP $(lnSIZE_{ct})$, are based on PWT 10.01 data (Feenstra et al., 2015). Additionally, we employ a set of control variables (X_{ct}) that describe countries' geopolitical characteristics, which potentially affect the diversification of exports. This set includes four variables describing a 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[119] $(COLONIAL_{ct})$.

Table 5.2 reports the estimation results of model (10) for the overall *RT* index. As anticipated, the degree of development and the size of a country are negatively correlated with the dependent variable. The findings indicate that, other things being equal, larger, more developed

[114] All of the models in Chapter 5 are log-log models, which account for the elasticity of export diversification with respect to the explanatory variables.
[115] The non-resource diversification index was calculated for all product groups complementary to the eight resource taxonomies (see Table A.4 in Appendix A for more details on classifications used in this dissertation). *TOTAL NR*, which collectively represents all natural resources, is the primary taxonomy employed for the estimation results in this chapter.
[116] The price indices, prepared for each resource taxonomy, come from the World Bank Commodity Price Data Annual Indices (World Bank, 2024a).
[117] The empirical models presented in this chapter exclude country fixed effects to avoid the loss of cross-country variability. For a more thorough explanation of the rationale behind this decision, please refer to Subchapter 4.2.
[118] Due to the potential for reverse causality and endogeneity between the development level and export diversification, and because the effects of *DEV* on *RT* index are not immediate, the development level is lagged by one year and used as an instrument within the two-step efficient GMM estimator framework.
[119] See Table A.7 in Appendix A and Subchapter 3.1 for more information on the control variables.

countries tend to exhibit more diverse export structures. The colonial past ($COLONIAL_{ct}$), which is of particular significance in the context of resource-dependent countries, is positively related to the value of the *RT* index. This suggests that countries that were once colonies have less diversified exports than countries that were not colonized in the past. The relationship between overall diversification and the geographical control variables is significant and positive. These results demonstrate that nations lacking access to the sea or major ports, as well as those with only a few years of newly gained independence, exhibit less diversified export portfolios. Finally, incorporating resource price indices does not alter the overall trends. The positive correlation between the dependent variables and P_t^{NR} suggests that higher natural resource prices strengthen export specialization.

Regarding the relationship between natural resource dependence and diversification of exports, a 1-p.p. increase in the share of *TOTAL NR* products in a country's total exports yields a 0.145-p.p. increase in the value of the *RT* index, ceteris paribus. Thus, excessive dependence on natural resources results in stronger specialization of overall exports. This trend holds for all types of natural resources, except for forestry products. In this case, other things being equal, a 1-p.p. increase in the share of *FORESTRY* products in a country's total exports results in a 0.421-p.p. decrease in the *RT* index value. This relationship suggests potential for export diversification in forestry-dependent economies. Forestry products can also significantly enhance the diversification of non-forestry and technologically advanced exports (see Tables 5.3 and 5.4 respectively). Furthermore, in the estimation results of the non-resource and technological *RT* index, *METAL* resources also play a fostering role in promoting export diversification. However, the observed effects are found to be rather negligible. As demonstrated in Tables 5.3 and 5.4, other categories of natural resources exhibit a negative correlation with the diversity of non-resource and technological exports, respectively. The magnitude of these effects is also greater than the effects presented for the overall *RT* index (Table 5.2). The outcomes for the control variables in Tables 5.3 and 5.4 demonstrate considerable consistency in terms of significance and magnitude.

Robustness checks for model (10) include estimations with an absolute (unweighted) version of the Theil index[120], calculated using equation (2), as well as estimations for subsamples of developed, and developing countries[121], NR exporters, and OPEC members[122]. The inclusion of an

[120] See Subchapter 3.3 and Table A.10 in Appendix A for more details on the alternative measure of export diversification.
[121] The variable *DEV* was excluded from these estimations since dividing the sample into developed and developing countries already accounts for the possible heterogeneity in levels of development. Robustness checks were conducted for all subsamples (including NR exporters and OPEC members) for the *RT* index of overall, non-resource, and technological products using the *TOTAL NR* resource taxonomy only.
[122] Natural Resource (NR) exporters are countries whose resource exports account for at least 50% of their total exports (an average from 1996 to 2021). See Table A.2 in Appendix A for a list of NR exporters and their income

alternative measure of the overall export diversification does not alter the core results of the baseline model (Table B.23 in Appendix B). In the subsample of developed economies, resource dependence exhibits the strongest negative correlation with the diversification of technologically advanced groups of exports (eq.(3) in Table B.26 in Appendix B). In the context of developing economies, the relationship between the *RT* index and the share of *TOTAL NR* resources is negative. Despite being significant, this effect is marginal (eq.(4) in Table B.26 in Appendix B). For *NR* exporters, a 1-p.p. increase in the share of natural resource exports yields a 0.272-p.p. decrease in the value of the overall *RT* index (eq. (1) in Table B.27 in Appendix B). This finding suggests that strengthening the dependence on natural resources in countries that are already heavily dependent on them promotes diversification of overall exports. Finally, the intensification of resource exports among the subsample of OPEC members reinforces the export specialization of all the examined product groups (eq. (4)-(6) in Table B.27 in Appendix B). The colonial past of OPEC members has the potential to promote export diversification, a finding that is inconsistent with all previous estimation results of model (10).

classification. OPEC members are countries which are affiliated within the Organization of the Petroleum Exporting Countries. Variable $LANDLOCK_{ct}$was excluded from estimations for OPEC countries since all of them have an access to the sea. For more details, see Table A.3 in Appendix A.

Table 5.2. Estimation results (eq. 10) – relationship between natural resource dependence[1] and export diversification

Dependent variable: $lnRT_{ct}$	Type of NR[2]							
	TOTAL NR	*FORESTRY*	*FUEL*	*METAL*	*MINERAL*	*COAL*	*NATURAL GAS*	*PETROLEUM*
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
NR_{ct}	0.145***	-0.421***	0.083***	0.092**	0.568***	0.296**	0.797***	-0.001
	(0.020)	(0.073)	(0.022)	(0.041)	(0.034)	(0.130)	(0.044)	(0.024)
$lnSIZE_{ct}$	-0.175***	-0.179***	-0.177***	-0.177***	-0.169***	-0.178***	-0.178***	-0.177***
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
$lnDEV_{c,t-1}$	-0.113***	-0.103***	-0.108***	-0.105***	-0.107***	-0.107***	-0.114***	-0.104***
	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)
$COLONIAL_{ct}$	0.117***	0.121***	0.117***	0.122***	0.115***	0.118***	0.114***	0.120***
	(0.014)	(0.014)	(0.014)	(0.014)	(0.014)	(0.014)	(0.014)	(0.014)
$LANDLOCK_{ct}$	0.074***	0.071***	0.075***	0.069***	0.070***	0.069***	0.054***	0.072***
	(0.013)	(0.013)	(0.013)	(0.013)	(0.013)	(0.013)	(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)	(0.000)	(0.000)	(0.000)	(0.000)
$NEWST_{ct}$	0.010**	0.017***	0.013***	0.016***	0.018***	0.016***	0.010**	0.017***
	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)
P_t^{NR}	0.001***	0.001*	0.000**	0.001***	0.001***	0.001***	-0.001***	0.001***
	(0.000)	(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	3,239	3,239
No. of countries	135	135	135	135	135	135	135	135
K-P rk Wald F	215589	254482	213255	247401	248080	240929	248108	223140
K-P rk LM	927.1	959.2	945.8	957.6	956.0	960.5	943.8	957.6
K-P rk LM (p-val)	0.000	0.000	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.

2) The presented types of natural resources (NR) comply with the established resource taxonomies (see Table A.4. in Appendix A).

Source: own calculations based on data from BACI CEPII (CEPII, 2023; Gaulier and Zignago, 2010), PWT 10.0 (Feenstra et al., 2015), and World Bank Commodity Price Data Annual Indices (World Bank, 2024a). For the sources of control variables, see Table A.7 in Appendix A.

Table 5.3. Estimation results (eq. 10) – relationship between natural resource dependence[1] and diversification of non-resource exports

Dependent variable: $lnRT_{c,nonNR_t}$	Type of NR[2]							
	TOTAL NR	*FORESTRY*	*FUEL*	*METAL*	*MINERAL*	*COAL*	*NATURAL GAS*	*PETROLEUM*
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
NR_{ct}	0.610***	-0.717***	0.670***	-0.082*	0.280***	0.247*	0.709***	0.624***
	(0.021)	(0.085)	(0.021)	(0.048)	(0.042)	(0.130)	(0.055)	(0.023)
$lnSIZE_{ct}$	-0.171***	-0.180***	-0.187***	-0.176***	-0.172***	-0.179***	-0.178***	-0.186***
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
$lnDEV_{c,t-1}$	-0.133***	-0.103***	-0.126***	-0.105***	-0.105***	-0.108***	-0.115***	-0.109***
	(0.007)	(0.006)	(0.007)	(0.006)	(0.006)	(0.006)	(0.006)	(0.007)
$COLONIAL_{ct}$	0.146***	0.121***	0.148***	0.116***	0.101***	0.117***	0.120***	0.152***
	(0.016)	(0.014)	(0.014)	(0.015)	(0.014)	(0.014)	(0.014)	(0.015)
$LANDLOCK_{ct}$	0.017	0.072***	0.037***	0.073***	0.065***	0.071***	0.055***	0.057***
	(0.014)	(0.013)	(0.013)	(0.013)	(0.013)	(0.013)	(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)	(0.000)	(0.000)	(0.000)	(0.000)
$NEWST_{ct}$	0.026***	0.015***	0.020***	0.016***	0.018***	0.016***	0.010**	0.020***
	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)
P_t^{NR}	0.001***	0.001*	0.001***	0.001***	0.001***	0.001***	-0.001***	0.001***
	(0.000)	(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	3,239	3,239
No. of countries	135	135	135	135	135	135	135	135
K-P rk Wald F	215589	254482	213255	247401	248080	240929	248108	223140
K-P rk LM	927.1	959.2	945.8	957.6	956.0	960.5	943.8	957.6
K-P rk LM (p-val)	0.000	0.000	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.
2) The presented types of natural resources (NR) comply with the established resource taxonomies (see Table A.4. in Appendix A).
Source: own calculations based on data from BACI CEPII (CEPII, 2023; Gaulier and Zignago, 2010), PWT 10.0 (Feenstra et al., 2015), and World Bank Commodity Price Data Annual Indices (World Bank, 2024a). For the sources of control variables, see Table A.7 in Appendix A.

Table 5.4. Estimation results (eq. 10) – relationship between natural resource dependence[1] and diversification of technological exports

Dependent variable: $lnRT_{c,TECH_t}$	Type of NR[2]							
	TOTAL NR	*FORESTRY*	*FUEL*	*METAL*	*MINERAL*	*COAL*	*NATURAL GAS*	*PETROLEUM*
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
NR_{ct}	0.620***	-1.258***	0.743***	-0.236***	-0.030	-0.191	1.553***	0.719***
	(0.027)	(0.146)	(0.028)	(0.056)	(0.061)	(0.220)	(0.083)	(0.033)
$lnSIZE_{ct}$	-0.179***	-0.194***	-0.192***	-0.187***	-0.188***	-0.188***	-0.189***	-0.191***
	(0.005)	(0.006)	(0.005)	(0.006)	(0.006)	(0.006)	(0.005)	(0.005)
$lnDEV_{c,t-1}$	-0.146***	-0.105***	-0.147***	-0.108***	-0.109***	-0.111***	-0.126***	-0.133***
	(0.009)	(0.010)	(0.008)	(0.010)	(0.010)	(0.010)	(0.009)	(0.009)
$COLONIAL_{ct}$	0.117***	0.134***	0.098***	0.122***	0.130***	0.127***	0.120***	0.106***
	(0.020)	(0.023)	(0.019)	(0.023)	(0.023)	(0.023)	(0.021)	(0.020)
$LANDLOCK_{ct}$	0.038**	0.026	0.053***	0.036*	0.031	0.028	-0.002	0.083***
	(0.019)	(0.020)	(0.019)	(0.020)	(0.020)	(0.020)	(0.019)	(0.019)
$AIRDIST_{ct}$	0.000***	0.000***	0.000***	0.000***	0.000***	0.000***	0.000***	0.000***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
$NEWST_{ct}$	0.042***	0.071***	0.037***	0.070***	0.070***	0.069***	0.058***	0.040***
	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)
P_t^{NR}	0.001***	0.002***	0.001***	0.002***	0.002***	0.002***	-0.001***	0.001***
	(0.000)	(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	3,239	3,239
No. of countries	135	135	135	135	135	135	135	135
K-P rk Wald F	215589	254482	213255	247401	248080	240929	248108	223140
K-P rk LM	927.1	959.2	945.8	957.6	956.0	960.5	943.8	957.6
K-P rk LM (p-val)	0.000	0.000	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.

2) The presented types of natural resources (NR) comply with the established resource taxonomies (see Table A.4. in Appendix A).

Source: own calculations based on data from BACI CEPII (CEPII, 2023; Gaulier and Zignago, 2010), PWT 10.0 (Feenstra et al., 2015,) and World Bank Commodity Price Data Annual Indices (World Bank, 2024a). For the sources of control variables, see Table A.7 in Appendix A.

5.3. Determinants of Diversification Trajectories in Resource-dependent Countries – econometric results (4)

To better understand why some resource exporters achieve diversification while others do not, we extend the baseline model (10) and incorporate the influence of institutions (eq. 11) and technological innovations (eq. 12):

$$lnRT_{ct} = \alpha + \beta_1 NR_{ct} + \beta_2 INST_{ct} + \beta_3 (NRxINST)_{ct} + \beta_4 lnSIZE_{ct} + \beta_5 lnDEV_{c,t-1} + \\ + \beta_6 X_{ct} + P_t^{NR} + \varepsilon_{ct} \quad (11)$$

$$lnRT_{ct} = \alpha + \beta_1 NR_{ct} + \beta_2 INNOV_{ct} + \beta_3 (NRxINNOV)_{ct} + \beta_4 lnSIZE_{ct} + \beta_5 lnDEV_{c,t-1} + \\ + \beta_6 X_{ct} + P_t^{NR} + \varepsilon_{ct} \quad (12)$$

where $INST_{ct}$ gauges the quality of institutions[123], 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 $INNOV_{ct}$ 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[124], the R&D expenditure[125] (expressed as a percentage of GDP), and patent applications[126] (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. Due to the characteristics of the $INNOV_{ct}$ variable[127], estimates for model (12) include only two dependent variables, namely, diversification of overall exports ($lnRT_{ct}$) and the diversification of non-resource exports ($lnRT_{c,nonNR_t}$).

Table 5.5 reports the estimation results for model (11), 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

[123] The quality of institutions was calculated as a mean of six indicators capturing various perceptions of governmental quality, including Control of Corruption, Government Effectiveness, Political Stability and Absence of Violence/Terrorism, Regulatory Quality, Rule of Law, Voice and Accountability. All indicators are derived from the World Governance Indicators (World Bank, 2024d). Given the absence of data for the years 1997, 1999, and 2001 in the WGI database, the variable was interpolated.

[124] The share of technologically advanced products is calculated using product-level trade data from BACII CEPI (Gaulier and Zignago, 2010) and product taxonomies that identify three groups of technologically advanced products: 4IR related products, ICT related products and middle- and high-tech products. See Table A.5 in Appendix A for more detail on technological classifications.

[125] It gauges the gross domestic capital and current expenditures in the sectors of Business enterprise, Government, Higher education, and Private non-profit (World Bank, 2024b).

[126] This variable comes from the WDI database (World Bank, 2024b) and includes patent applications filed by the residents through either the Patent Cooperation Treaty procedure or a national patent office.

[127] Since $INNOV_{ct}$ is proxied by the share of technologically advanced products in a country's total exports, exploring its relationship with the diversification of technological exports would be meaningless.

of governmental quality in the relationship between resource dependence and export diversification, we plot the predictive margins. The empirical evidence presented in Figure 5.3 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 stronger export specialization (Figure 5.3.1).

Table 5.5. Estimation results (eq. 11) – 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

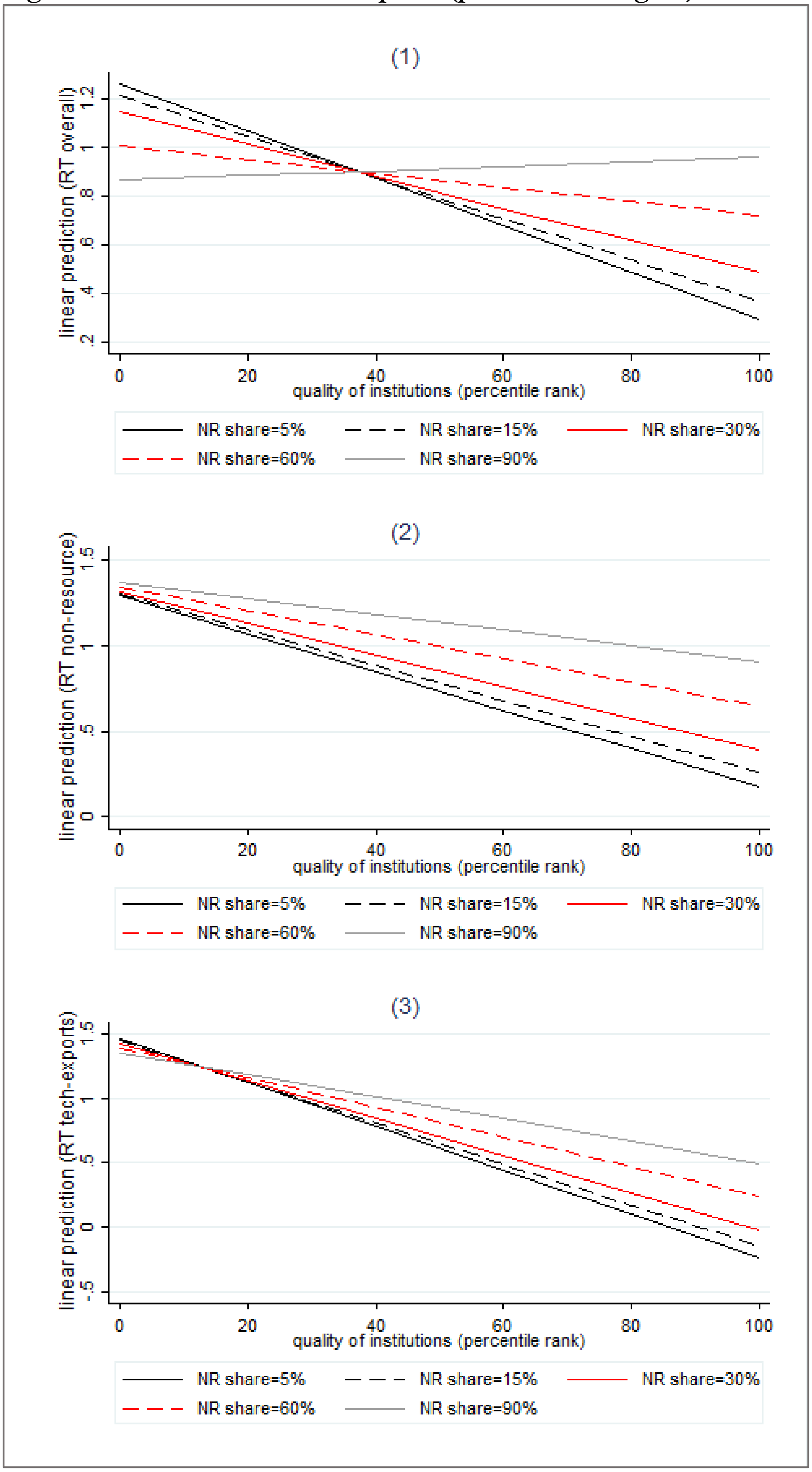
Notes: *,**,*** denote significance at the 1%, 5%, and 10% levels, respectively; robust standard errors in parentheses; all specifications contain time fixed effects in the form of NR price indices (P_t^{NR}); K-P refers to the Kleibergen-Paap test statistics. Instrumented variable: $lnDEV_{c,t-1}$. 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: own calculations based on data from BACI CEPII (CEPII, 2023; Gaulier and Zignago, 2010), PWT 10.0 (Feenstra et al., 2015), Worldwide Governance Indicators (World Bank, 2024d), and World Bank Commodity Price Data Annual Indices (World Bank, 2024a). For the sources of control variables, see Table A.7 in Appendix A.

Figure 5.3. 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.(11), 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 based on data from BACI CEPII (CEPII, 2023; Gaulier and Zignago, 2010) and Worldwide Governance Indicators (World Bank, 2024d).

The estimation results for the additional resource taxonomies are presented in Tables B.16 - B.18 in Appendix B. On average, better-quality institutions promote export heterogeneity, albeit to a limited extent, and contribute to the diversification-enhancing role of all types of natural resources. Nonetheless, this reinforcing effect is less pronounced for *FUEL*, *MINERAL,* and *PETROLEUM* resources, particularly in countries with the highest shares of aforementioned resources in total exports (90th percentile or higher). Robustness checks for model (11) include an alternative measure of export diversification (Table B.24 in Appendix B) and subgroups of developed and developing countries, as well as NR exporters and OPEC members (Table B.28 in Appendix B). The mitigating role of the institutional quality in the relationship between natural resource dependence and an alternative measure of export diversification ($lnTheil_{ct}$) is not sustained for TOTAL NR, FUEL, and PETROLEUM resources. In this case, at elevated levels of resource dependence, enhancing the quality of institutions does not result in reduced specialization of the overall exports (see equations (1),(3) and (8) in Table B.24). Ultimately, the baseline results of model (11) are not maintained in the subsample of developed economies (see equation (1) in Table B.28).

Technological innovation, as indicated by the share of technologically advanced products in total exports, 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 (see eq.(1) and (4) in Table 5.6). The margin plot, 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 5.4). 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 5.5). 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 5.5.1 and 5.5.2). 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 5.6), its mitigating role is the least significant among the three technologically advanced groups of products (Figure 5.6).

A negative relationship is also observed between technological innovation, as measured by the number of patent applications (*PATENTS*) and the share of R&D expenditures (*RD*), and the level of diversification for overall and non-resource exports (see Table B.22 in Appendix B). However, this effect is less prominent than in the case of technologically advanced exports. Predictive margins (see Figure A.6 in Appendix A) demonstrate that an increase in the number of patent applications has a diversification-enhancing role in countries with a high degree of dependency on natural resources (plots (1a) and (2a) in Figure A.6). Conversely, an augmentation in the percentage share of R&D expenditures exerts the most pronounced influence on the relationship between RT index and moderately low resource dependence (plots (1b) and (2b) in Figure A.6). However, these effects were not found to be statistically significant.

Table 5.6. Estimation results (eq. 12) – 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.

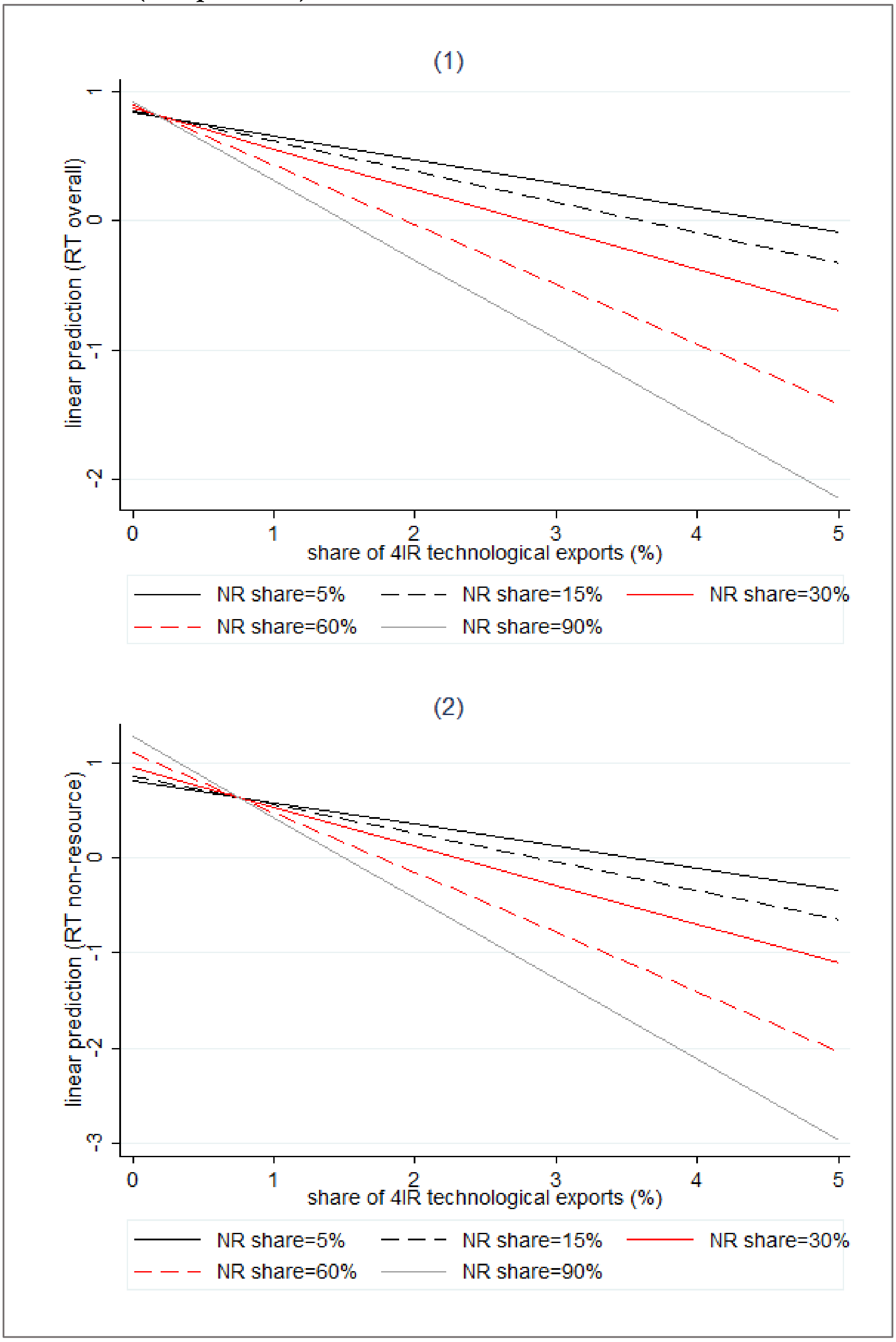
1) The resource dependence is measured by the export share of TOTAL NR resource products in total country exports, expressed as a decimal between 0 and 1.

2) INNOV is measured by the export share of various groups of technologically advanced products (see Table A.5. in Appendix A) in total country exports, expressed as a decimal between 0 and 1.

Source: own calculations based on data from BACI CEPII (CEPII, 2023; Gaulier and Zignago, 2010), PWT 10.0 (Feenstra et al., 2015), and World Bank Commodity Price Data Annual Indices (World Bank, 2024a). For the sources of control variables, see Table A.7 in Appendix A.

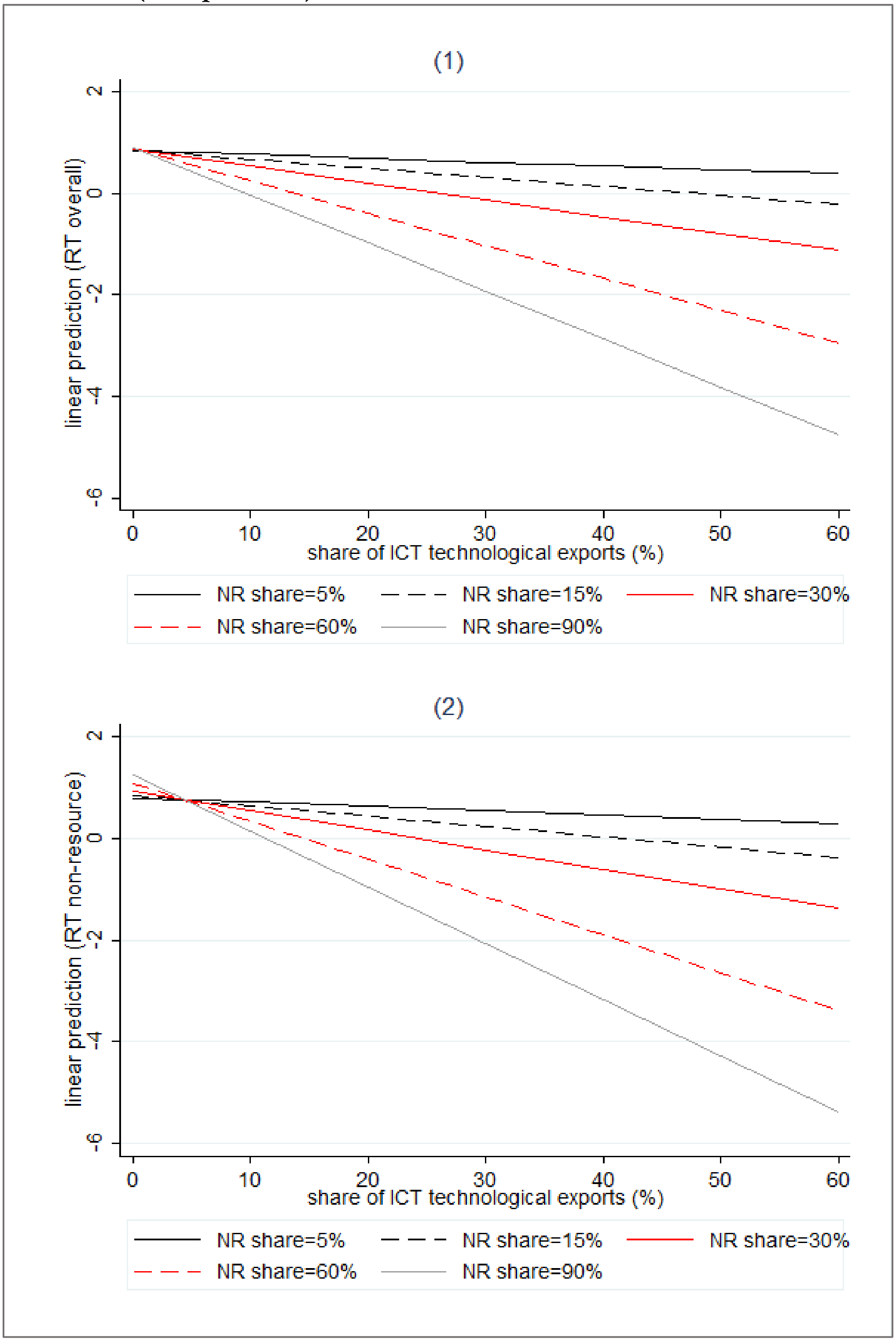
Tables B.19-B.21 in Appendix B present empirical evidence for the estimations of model (12) using supplementary resource taxonomies. In principle, the role of technological innovation in the relationship between natural resources and export diversification remains unchanged compared to the baseline results. However, increasing the share of technologically advanced products deepens the export specialization in highly metal-dependent countries (the case of 4IR-related products, see eq. (3) and (10) in Table B.19) and mineral-dependent economies (ICT and TECH-related products, see eq. (4) and (11) in Tables B.20 and B.21, respectively). The data from the subsample of developed economies indicates that the implementation of technological innovation, in any form, assists resource exporters in achieving export diversification (see Table B.29 in Appendix B). This finding is supported by negative and statistically significant empirical results for the interaction term $(NRxINNOV)_{ct}$. It is noteworthy that an increase in the share of 4IR-related products in high-income countries leads to a strengthening of the specialization of overall exports (eq.(1) in Table B.29).

Figure 5.4. Diversification of exports (predictive margins) – the role of technological innovation (4IR products)



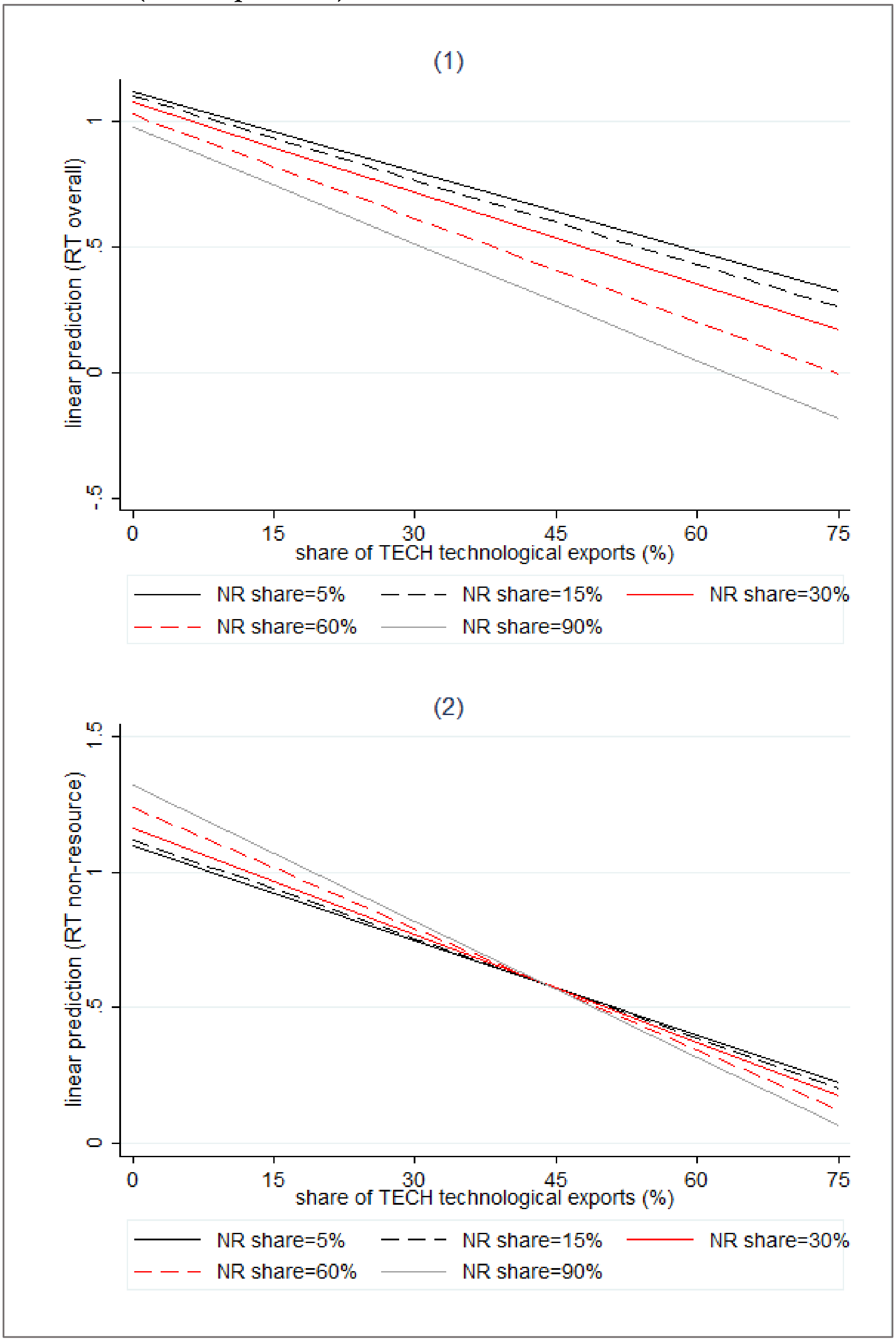
Notes: (1) all products ($lnRT_{ct}$); (2) non-resource products ($lnRT_{c,nonNR_t}$).
Margin plots computed for the estimation of eq.(12), which considers the share of TOTAL NR resource products in total country exports, as well as technological innovation, measured by the share of 4IR products in total country exports (for details on the 4IR classification, see Table A.5. in Appendix A). 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 based on data from BACI CEPII (CEPII, 2023; Gaulier and Zignago, 2010).

Figure 5.5. Diversification of exports (predictive margins) – the role of technological innovation (ICT products)



Notes: (1) all products ($lnRT_{ct}$); (2) non-resource products ($lnRT_{c,nonNR_t}$).
Margin plots computed for the estimation of eq.(12), which considers the share of TOTAL NR resource products in total country exports, as well as technological innovation, measured by the share of ICT products in total country exports (for details on the ICT classification, see Table A.5. in Appendix A). 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 based on data from BACI CEPII (CEPII, 2023; Gaulier and Zignago, 2010).

Figure 5.6. Diversification of exports (predictive margins) – the role of technological innovation (TECH products)



Notes: (1) all products ($lnRT_{ct}$); (2) non-resource products ($lnRT_{c,nonNR_t}$);.
Margin plots computed for the estimation of eq.(12), which considers the share of TOTAL NR resource products in total country exports, as well as technological innovation, measured by the share of TECH products in total country exports (for details on the TECH classification, see Table A.5. in Appendix A). 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 based on data from BACI CEPII (CEPII, 2023; Gaulier and Zignago, 2010).

6. Conclusions

The continued economic importance of natural resources is a fact, regardless of the dominant role of technology in today's world. With primary products accounting for approximately 18% of global trade (BACI, 2023) and nearly all of total exports in selected resource-dependent countries, the persistent issue of unsuccessful resource-led development needs to be addressed. Thus, this thesis, by providing a substantial set of descriptive and econometric evidence, aims to explain the intricate nature of primary products and identify factors that mitigate the effects of excessive resource dependence.

The main research 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**. 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 literature review conducted in Chapter 2 (preceded by the Introduction in Chapter 1) provides three main conclusions. Firstly, the literature on the effects of natural resources on economic growth is inconclusive. Both resource dependence and resource abundance were proven to affect growth in positive and negative ways (see among many: Papyrakis and Gerlagh, 2007; Brunnschweiler, 2008; Sultan and Haque, 2018; Awoa Awoa and Ondoa, 2023). The type of natural resources under consideration also substantially affects the empirical evidence (see among others: Olsson, 2007; Tsui, 2011; Badeeb and Lean, 2017; Ertimi et al., 2023). Furthermore, the question of why some countries with similar macroeconomic and geographical characteristics suffer from the resource curse while others do not remains unanswered. Secondly, the structural change literature lists many factors that promote the process of export diversification (see among many: Hummels and Klenow, 2005; Parteka, 2010; Cadot et al., 2011a; Mau, 2016; Basile et al., 2018; Lee and Zhang, 2022); however, natural resources are not among them. Although an early theory of trade considers resource wealth to be a potential enabler of a country's comparative advantage (Heckscher and Ohlin, 1991), modern views mostly attribute natural resources to excessive export specialization (Harvey et al., 2010; Arezki et al., 2014; following Singer, 1950 and Prebisch, 1962). Additionally, the concept of resource dependence has not received much attention in debates about diversification dynamics (see: Bahar and Santos, 2018; Ross, 2019; Zarach and Parteka, 2023a for a few exceptions). Thirdly, technology has always been regarded as a vital part of economic growth (see among others: Romer, 1986, 1990; Lucas, 1988; Aghion and Howitt, 1992; Jones, 1995a; Acemoglu, 2003; Ha and Howitt, 2007; Bloom et al., 2020; Kruse-Andersen, 2023), either by improving labor productivity and product quality or by generating new, growth-enhancing ideas (Romer, 1990; Jones, 2005; Klump et al., 2007). Nowadays, although technological innovations may replace human labor and lead to singularity (Kurzweil, 2005; Brynjolfsson and McAfee, 2014; Acemoglu and Restrepo, 2018; Roodman, 2020; Davidson, 2023; Agrawal et al., 2024), the concept of the modern productivity paradox marks its presence in the literature (Polák, 2017; Crafts, 2018; Brynjolfsson et al., 2019 & 2021; Miyagawa, 2021; Venturini, 2022). Regarding the coexistence of technology and resource dependence, the common belief is that countries rich in natural resources are excluded from the technological race (Foster-McGregor et al., 2019; Fagerberg and Verspagen, 2021). Despite a few examples of successful resource development with the smart use of technological innovations (David and Wright, 1997; De Ferranti et al., 2002; Ville and Wicken, 2013), the relationship between technology and natural resources has not been frequently addressed (see Zarach and Parteka, 2023a & 2023b, for exception).

Chapter 3 describes a research methodology based on the following four steps: (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 exported 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.

The econometric analysis of the relationship between resource dependence and productivity growth, presented in Chapter 4, reveals two main findings. Firstly, the impact of resource dependence on productivity growth varies depending on the type of natural resources. Fossil fuels, particularly petroleum oils, promote productivity growth, while mineral products hinder it. These effects persist even when control variables, an alternative measure of resource dependence, and various subsamples are considered. Secondly, on average, technological specialization positively affects productivity growth; however, the magnitude of this effect varies depending on the type of technologically advanced products. Additionally, the positive influence of technological specialization is only evident in the empirical results involving mineral resources. Estimation results for this resource type indicate that increasing the share of technologically advanced exports leads to reinforced productivity growth, particularly in resource-dependent countries with a high share of mineral exports.

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. Firstly, decomposing the export diversification curve indicates that, at lower productivity levels, export diversification is dominated by the weighted heterogeneity adjustments within the non-resource product group. At output levels per worker exceeding $120k, rising export 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. Secondly, exploring the relationship between natural resource dependence, and diversification patterns reveals that excessive dependence on natural resources results in stronger specialization of overall, non-resource and technological exports. Out of all the types of natural resources considered, only forestry products have the potential to enhance the diversification in resource-dependent economies. Finally, this chapter extends the baseline model to include institutional quality and technological innovation in order to trace and better understand the factors enabling certain resource exporters to achieve diversification. Overall, improving the quality of institutions, particularly in resource-dependent countries with a resource export share of no more than 60%, decreases the RT index, consequently lowering export specialization. On the other hand, technological innovation's supportive role in the relationship between resource dependence and export diversification is most pronounced in economies with a resource export share higher than 60%.

The answers to the research hypotheses formulated in the Introduction, 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, 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 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 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) 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 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 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 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.

References

1. Acemoglu, D. (2002). Directed Technical Change. *The Review of Economic Studies*, 69(4), 781-809.

2. Acemoglu, D. (2003). Labor‐and Capital‐augmenting Technical Change. *Journal of the European Economic Association*, 1(1), 1-37.

3. Acemoglu, D. (2009) Introduction to Modern Economic Growth. *Princeton University Press,* Princeton, New York.

4. Acemoglu, D., Aghion, P., Bursztyn, L., Hemous, D. (2012). The Environment and Directed Technical Change. *American Economic Review*, 102(1), 131-166.

5. Acemoglu, D., Aghion, P., Hémous, D. (2014). The Environment and Directed Technical Change in a North–South Model. *Oxford Review of Economic Policy,* 30(3), 513-530.

6. Acemoglu, D., Autor, D., Dorn, D., Hanson, G. H., Price, B. (2014). Return of the Solow Paradox? IT, Productivity, and Employment in US Manufacturing. *American Economic Review*, 104(5), 394-399.

7. Acemoglu, D., Restrepo, P. (2017). Secular Stagnation? The Effect of Aging on Economic Growth in the Age of Automation. *American Economic Review,* 107(5), 174-179.

8. Acemoglu, D., Restrepo, P. (2018). The Race Between Man and Machine: Implications of Technology for Growth, Factor Shares, and Employment. *American Economic Review,* 108(6), 1488-1542.

9. Acemoglu, D., Lelarge, C. Restrepo, P. (2020), Competing with Robots: Firm-level Evidence from France. *American Economic Review: Papers and Proceedings,* 110, 383–388.

10. Acemoglu, D., Autor, D., Hazell, J., Restrepo, P. (2022). Artificial Intelligence and Jobs: Evidence from Online Vacancies. *Journal of Labor Economics*, 40(S1), S293-S340.

11. Acemoglu, D., Koster, H. R., Ozgen, C. (2023). Robots and Workers: Evidence from the Netherlands. *NBER Working Paper* No. w31009.

12. Acemoglu, D. (2025). The Simple Macroeconomics of AI. *Economic Policy,* 40(121), 13-58.

13. Adabor, O., Mishra, A. (2023). The Resource Curse Paradox: The Role of Financial Inclusion in Mitigating the Adverse Effect of Natural Resource Rent on Economic Growth in Ghana. *Resources Policy*, 85, 103810.

14. Adigwe, E. O. (2022). A Comparative Analysis of Competitive Trade in a Cluster Market of the European Union: the Revealed Comparative Advantage (RCA) Index. *Our Economy*, 68(1), 14-24.

15. Aditya, A., Acharyya, R. (2015). Trade Liberalization and Export Diversification. *International Review of Economics & Finance*, 39, 390-410.

16. Aghion, P, Howitt, P. (1992). A Model of Growth Through Creative Destruction. *Econometrica,* 60 (2), 323–51.

17. Aghion, P., Howitt, P. (1998). Endogenous Growth Theory. *MIT Press*. Cambridge, Massachusetts.

18. Aghion, P., Howitt, P. W. (2009). The Economics of Growth. *MIT Press*. Cambridge, Massachusetts.

19. Aghion, P., Jones, B. F., Jones, C. I. (2019). Artificial Intelligence and Economic Growth. In: Agrawal A., Gans J. and Goldfarb A. (Eds.), *The Economics of Artificial Intelligence: An Agenda.* University of Chicago Press, pp. 237–282.

20. Agnani, B., Iza, A. (2011). Growth in an Oil Abundant Economy: The Case of Venezuela. *Journal of Applied Economics*, 14(1), 61-79.

21. Agosin, M. R., Alvarez, R., Bravo‐Ortega, C. (2012). Determinants of Export Diversification Around the World: 1962–2000. *The World Economy*, 35(3), 295-315.

22. Agrawal, A., Gans, J. S., Goldfarb, A. (2024). Artificial Intelligence Adoption and System‐wide Change. *Journal of Economics & Management Strategy,* 33(2), 327-337.

23. Ahmad, N., Ribarsky, J., Reinsdorf, M. (2017). Can Potential Mismeasurement of the Digital Economy Explain the Post-crisis Slowdown in GDP and Productivity Growth? *OECD Statistics Working Papers*. No.2017/09, OECD Publishing, Paris, https://doi.org/10.1787/a8e751b7-en.

23. Aiginger, K., Boheim, M., Gugler, K., Pffafermayr, M., Wolfmayr-Schnitzer, Y. (1999). The Competitiveness of European Industry. *Working Document of the Services of the European Commission,* Brussels.

24. Aiginger, K., Davies, S. W. (2004). Industrial Specialisation and Geographic Concentration: Two Sides of the Same Coin? Not for the European Union. *Journal of Applied Economics,* 7(2), 231-248.

25. Ajide, F. M., Soyemi, K. A. (2022). Oil Rent, Entrepreneurial Start-ups, and Institutional Quality: Insights from African Oil-rich Countries. *Entrepreneurial Business and Economics Review*, *10*(1), 35-49.

26. Akita, T. (2003). Decomposing Regional Income Inequality in China and Indonesia Using Two-Stage Nested Theil Decomposition Method. *The Annals of Regional Science, 37(1),* 55-77.

27. Al-Marhubi, F. (2000). Export Diversification and Growth: an Empirical Investigation. *Applied Economics Letters,* 7(9), 559-562.

28. Albanesi, S., Da Silva, A. D., Jimeno, J. F., Lamo, A., Wabitsch, A. (2023). New Technologies and Jobs in Europe. *NBER Working Paper* No. w31357.

29. Albassam, B. A. (2015). Economic Diversification in Saudi Arabia: Myth or Reality? *Resources Policy*, 44, 112-117.

30. Alcorta, L., Foster-McGregor, N., Szirmai, A., Verspagen, B. (Eds.). (2021). New Perspectives on Structural Change: Causes and Consequences of Structural Change in the Global Economy. *Oxford University Press.*

31. Alexeev, M., Conrad, R. (2009). The Elusive Curse of Oil. *The Review of Economics and Statistics*, 91(3), 586-598.

32. Ali, R., Alwang, J. R., Siegel, P. B. (1991). Is Export Diversification the Best Way to Achieve Export Growth and Stability?: A Look at Three African Countries (Vol. 729). *World Bank Publications*.

33. Ali, S., Murshed, S. M., Papyrakis, E. (2023). Oil, Export Diversification and Economic Growth in Sudan: Evidence from a VAR Model. *Mineral Economics*, 36(1), 77-96.

34. Aljarallah, R. A. (2020). The Economic Impacts of Natural Resource Dependency in Gulf Countries. *International Journal of Energy Economics and Policy*, *10*(6), 36-52.

35. Alkhathlan, K. A. (2013). Contribution of Oil in Economic Growth of Saudi Arabia. *Applied Economics Letters*, *20*(4), 343-348.

36. Allison, P. D. (1978). Measures of Inequality. *American Sociological Review, 865-880.*

37. Alssadek, M., Benhin, J. (2023). Natural Resource Curse: A Literature Survey and Comparative Assessment of Regional Groupings of Oil-rich Countries. *Resources Policy*, 84, 103741.

38. Altaee, H. H. A., Al-Jafari, M. K., Daya, R. (2022). Oil Resource Abundance in the Gulf Cooperation Council Countries: a Curse or a Blessing?. *Montenegrin Journal of Economics*, *18*(1), 151-160.

39. Altman, M. (2003). Staple Theory and Export-led Growth: Constructing Differential Growth. *Australian Economic History Review*, 43(3), 230-255.

40. Álvarez, J., Prado, S. (Eds.). (2022). Scandinavia and South America - A Tale of Two *Capitalisms*: Essays on Comparative Developments in Trade, Industrialisation and Inequality Since 1850. *Palgrave Macmillan*.

41. Arezki, R., Van der Ploeg, F. (2010). Trade Policies, Institutions and the Natural Resource Curse. *Applied Economics Letters*, *17*(15), 1443-1451.

42. Arezki, R., Hadri, K., Loungani, P., Rao, Y. (2014). Testing the Prebisch–Singer Hypothesis Since 1650: Evidence from Panel Techniques That Allow for Multiple Breaks. *Journal of International Money and Finance*, 42, 208-223.

43. Arrow, K. J., Chenery, H. B., Minhas, B. S., Solow, R. M. (1961). Capital-labor Substitution and Economic Efficiency. *The Review of Economics and Statistics*, 225-250.

44. Arrow, K. J. (1962). The Economic Implications of Learning by Doing. *The Review of Economic Studies*, 29(3), 155-173.

45. Artzrouni, M., Komlos, J. (1985). Population Growth Through History and the Escape from the Malthusian Trap: A Homeostatic Simulation Model. *Genus*, 21-39.

46. Ashraf, Q., Galor, O. (2011). Dynamics and Stagnation in the Malthusian Epoch. *American Economic Review*, 101(5), 2003-2041.

47. Atkinson, G., Hamilton, K. (2003). Savings, Growth and the Resource Curse Hypothesis. *World Development*, 31(11), 1793-1807.

48. Aum, S., Lee, S. Y. T., Shin, Y. (2018). Computerizing Industries and Routinizing Jobs: Explaining Trends in Aggregate Productivity. *Journal of Monetary Economics,* 97, 1-21.

49. Auty, R. M. (Eds.). (1990). Resource-based Industrialization: Sowing the Oil in Eight Developing Countries. *Oxford University Press.*

50. Auty, R. M. (Eds.). (2001). Resource Abundance and Economic Development. *Oxford University Press.*

51. Auty, R. M., & Mikesell, R. F. (1998). Sustainable Development in Mineral Economies. *Clarendon Press.*

52. Auzer, K. A. (2017). Transmission Channels of the "Resource Curse" Reappraised. In: Auzer, K. A. (Eds.), *Institutional Design and Capacity to Enhance Effective Governance of Oil and Gas Wealth: the Case of Kurdistan Region*. Springer, pp. 33-66.

53. Awoa Awoa, P., Ondoa, H. A. (2023). Natural Resources and Productivity Growth in Developing Countries. *The Journal of International Trade & Economic Development*, *32*(8), 1271-1290.

54. Bacchetta, M., Beverelli, C., Hancock, J., Keck, A., Nayyar, G., Nee, C. (2010). World Trade Report 2010, Trade in Natural Resources. *World Trade Organization*.

55. Backus, D. K., Kehoe, P. J., Kehoe, T. J. (1992). In Search of Scale Effects in Trade and Growth. *Journal of Economic Theory*, 58(2), 377-409.

56. Badeeb, R. A., Lean, H. H. (2017). Financial Development, Oil Dependence and Economic Growth: Evidence From the Republic of Yemen. *Studies in Economics and Finance*, 34(2), 281-298.

57. Badeeb, R. A., Lean, H. H., Clark, J. (2017). The Evolution of the Natural Resource Curse Thesis: A Critical Literature Survey. *Resources Policy*, 51, 123-134.

58. Badia-Miró, M., Pinilla, V., Willebald, H. (Eds.). (2015). Natural Resources and Economic Growth: Learning from History. *Routledge*.

59. Bahar, D., & Santos, M. A. (2018). One More Resource Curse: Dutch Disease and Export Concentration. *Journal of Development Economics*, 132, 102-114.

60. Balassa, B. (1965). Trade Liberalization and "Revealed" Comparative Advantage. *The Manchester School of Economic and Social Studies*, 33, 92–123.

61. Balassa, B. (1989). "Revealed" Comparative Advantage Revisited. In: Balassa B. (Eds.), *Comparative Advantage, Trade Policy and Economic Development*. New York University Press, New York, pp. 63–79.

62. Baldwin, R. E. (1956). Patterns of Development in Newly Settled Regions. *The Manchester School of Social and Economic Studies*, 24(2), 161-179.

63. Baldwin, R. E. (1966). Economic Development and Export Growth: A Study of Northern Rhodesia, 1920-1960. *University of California Press,* Berkeley and Los Angeles, California.

64. Ballance, R., Forstner, H., Murray, T. (1985). On Measuring Comparative Advantage: A Note on Bowen's Indices. *Weltwirtschaftliches Archiv*, (H. 2), 346-350.

65. Ballestar, M. T., Díaz-Chao, Á., Sainz, J., Torrent-Sellens, J. (2020). Knowledge, Robots and Productivity in SMEs: Explaining the Second Digital Wave. *Journal of Business Research*, 108, 119-131.

66. Barro, R. J., Sala-i-Martin, X. (1992). Convergence. *Journal of Political Economy,* 100(2), 223-251.

67. Barro, R. J. (2015). Convergence and Modernization. *The Economic Journal*, 125(585), 911-942.

68. Baruffaldi, S., van Beuzekom, B., Dernis, H., Harhoff, D., Rao, N., Rosenfeld, D., Squicciarini, M. (2020). Identifying and Measuring Developments in Artificial Intelligence: Making the Impossible Possible. *OECD Science, Technology and Industry Working Papers,* No. 2020/05. OECD Publishing, Paris. https://doi.org/10.1787/5f65ff7e-en.

69. Basile, R., Parteka, A., Pittiglio, R. (2018). Export Diversification and Economic Development: a Dynamic Spatial Data Analysis. *Review of International Economics*, 26(3), 634-650.

70. Bassetti, T., Galvez, Y. B., Pavesi, F., Del Sorbo, M. (2020). Artificial Intelligence: Impact on Total Factor Productivity, E-commerce & Fintech. *Publications Office of the European Union*. Luxembourg. ISBN 978-92-76-24693-0, doi:10.2760/333292, JRC122268.

71. Becker, Bastian (2019), Introducing COLDAT: The Colonial Dates Dataset, *SOCIUM/SFB1342 Working Paper Series*, 02/2019. https://www.socium.uni-bremen.de/f/51ebd445c4.pdf.

72. Belarbi, Y., Sami, L., Souam, S. (2016). The Effects of Institutions and Natural Resources in Heterogeneous Growth Regimes. *Middle East Development Journal*, 8(2), 248-265.

73. Bello, O. D., Blyde, J. S., Restuccia, D. (2011). Venezuela's Growth Experience. *Latin-American Journal of Economics*, 48(2), 199-226.

74. Ben-Salha, O., Dachraoui, H., Sebri, M. (2021). Natural Resource Rents and Economic Growth in the Top Resource-abundant Countries: a PMG Estimation. *Resources Policy*, 74, 101229.

75. Benassi, M., Grinza, E., Rentocchini, F., Rondi, L. (2022). Patenting in 4IR Technologies and Firm Performance. *Industrial and Corporate Change,* 31(1), 112-136.

76. Berisha, E., Chisadza, C., Clance, M., Gupta, R. (2021). Income Inequality and Oil Resources: Panel Evidence from the United States. *Energy Policy*, *159*, 112603.

77. Bertram, G. W. (1963). Economic Growth in Canadian Industry, 1870–1915: The Staple Model and the Take-off Hypothesis. *Canadian Journal of Economics and Political Science*, 29(2), 159-184.

78. Bianchini, S., Müller, M., Pelletier, P. (2020). Deep Learning in Science. arXiv preprint arXiv:2009.01575.

79. Bjorvatn, K., Farzanegan, M. R., Schneider, F. (2012). Resource Curse and Power Balance: Evidence from Oil-rich Countries. *World Development*, 40(7), 1308-1316.

80. Bloom, N., Jones, C. I., Van Reenen, J., Webb, M. (2020). Are Ideas Getting Harder to Find?. *American Economic Review*, 110(4), 1104-1144.

81. Bond, S. R., Malik, A. (2009). Natural Resources, Export Structure, and Investment. *Oxford Economic Papers*, 61(4), 675-702.

82. Bontadini, F. (2021). Trade Specialization and Performance in Global Value Chains. *Industrial and Corporate Change*, 30(6), 1557-1590.

83. Boschini, A., Pettersson, J., Roine, J. (2007). Resource Curse or Not: A Question of Appropriability. *Scandinavian Journal of Economics*, 109(3), 593-617.

84. Boschini, A., Pettersson, J., Roine, J. (2013). The Resource Curse and Its Potential Reversal. *World Development*, 43, 19-41.

85. Bostrom, N. (2014). Superintelligence: Paths, Dangers, Strategies. *Oxford University Press.*

86. Bowen, H. P. (1983). On the Theoretical Interpretation of Indices of Trade Intensity and Revealed Comparative Advantage. *Weltwirtschaftliches Archiv,* 119(3), 464-472.

87. BP Statistical Review of World Energy (2021). (PDF available here).

88. Bresnahan, T. F., Trajtenberg, M. (1995). General Purpose Technologies "Engines of Growth"? J*ournal of Econometrics*, 65(1), 83-108.

89. Bresnahan, T. (2019). Artificial Intelligence Technologies and Aggregate Growth Prospects. In: Diamond J. and Zodrow G. R. (Eds.), *Prospects for Economic Growth in the United States*. Cambridge, UK, pp. 72-132.

90. Brückner, M. (2010). Natural Resource Dependence, Non-tradables, and Economic Growth. *Journal of Comparative Economics*, 38(4), 461-471.

91. Brückner, M. (2023). Measuring Export Concentration for Identifying Least Developed Countries. *Committee for Development Policy, United Nations Background Paper* No. 59

92. Brunnschweiler, C.N. (2008). Cursing the Blessings? Natural Resource Abundance, Institutions, and Economic Growth. *World Development,* 36 (3), 399–419.

93. Brunnschweiler, C.N., Bulte, E.H. (2008). The Resource Curse Revisited and Revised: A Tale of Paradoxes and Red Herrings. *Journal of Environmental Economics and Management,* 55 (3), 248–264.

94. Brynjolfsson, E. (1993). The Productivity Paradox of Information Technology. *Communications of the ACM,* 36(12), 66-77.

95. Brynjolfsson, E., McAfee, A. (2014). The Second Machine Age: Work, Progress, and Prosperity *in* a Time of Brilliant Technologies. *WW Norton & Company.*

96. Brynjolfsson, E., Rock, D., Syverson, C. (2019). Artificial Intelligence and the Modern Productivity Paradox: A Clash of Expectations and Statistics. In: Agrawal A., Gans J. and Goldfarb A. (Eds.), *The Economics of Artificial Intelligence: An Agenda.* University of Chicago Press, pp. 23-57.

97. Brynjolfsson, E., Rock, D., Syverson, C. (2021). The Productivity J-curve: How Intangibles Complement General Purpose Technologies. *American Economic Journal: Macroeconomics*, 13(1), 333-372.

98. Brynjolfsson, E., Li, D. , Raymond L. R. (2023). Generative AI at Work, Technical Report. *NBER Working Paper* No. 31161.

99. Buarque, B. S., Davies, R. B., Hynes, R. M., Kogler, D. F. (2020). OK Computer: The Creation and Integration of AI in Europe. *Cambridge Journal of Regions, Economy and Society*, 13(1), 175-192.

100. Buccellato, T., Mickiewicz, T. (2009). Oil and Gas: A Blessing For the Few. Hydrocarbons and Inequality Within Regions in Russia. *Europe-Asia Studies*, 61(3), 385-407.

101. Bulte, E. H., Damania, R., Deacon, R. T. (2005). Resource Intensity, Institutions, and Development. *World Development*, 33(7), 1029-1044.

102. Butkiewicz, J. L., Yanikkaya, H. (2010). Minerals, Institutions, Openness, and Growth: An Empirical Analysis. *Land Economics*, 86(2), 313-328.

103. Byrne, D. M., Fernald, J. G., Reinsdorf, M. B. (2016). Does the United States Have a Productivity Slowdown or a Measurement Problem? *Brookings Papers on Economic Activity,* 2016(1), 109-182.

104. Cadot, O., Carrère, C., Strauss-Kahn, V. (2011a). Export Diversification: What's Behind the Hump?. *Review of Economics and Statistics, 93(2),* 590-605.

105. Cadot, O., Carrère, C., Strauss-Kahn, V. (2011b). Trade Diversification: Drivers and Impacts. *Trade and Employment: From Myths to Facts,* 253-305.

106. Cadot, O., Carrère, C., Strauss-Kahn, V. (2013). Trade Diversification, Income, and Growth: What Do We Know? *Journal of Economic Surveys, 27(4),* 790-812.

107. Campante, F., Sturzenegger, F., Velasco, A. (2021). Advanced Macroeconomics: An Easy Guide. *LSE Press.*

108. Can, M., Ahmed, Z., Ahmad, M., Oluc, I. (2024). Economic Progress in Emerging Countries: the Roles of Diversification of Import and Export Products and Energy Consumption. *Environment, Development and Sustainability*, 26(7), 18207-18229.

109. Canh, N. P., Schinckus, C., Thanh, S. D. (2020). The Natural Resources Rents: Is Economic Complexity a Solution for Resource Curse? *Resources Policy*, 69, 101800.

110. Cappelen, Å., Mjøset, L. (2009). Can Norway be a Role Model For Natural Resource Abundant Countries? In: Fosu, A.K. (Eds.), *Development Success: Historical Accounts from More Advanced Countries*. WIDER Studies in Development Economics, pp. 44-72.

111. Carbonnier, G., Wagner, N. (2015). Resource Dependence and Armed Violence: Impact on Sustainability in Developing Countries. *Defense and Peace Economics*, 26(1), 115-132.

112. Caselli, F., Koren, M., Lisicky, M., Tenreyro, S. (2020). Diversification Through Trade. *The Quarterly Journal of Economics,* 135(1), 449-502.

113. Cass, D. (1965). Optimum Growth in an Aggregative Model of Capital Accumulation. *The Review of Economic Studies*, 32(3), 233-240.

114. Castellani, D., Lamperti, F., Lavoratori, K. (2022). Measuring Adoption of Industry 4.0 Technologies via International Trade Data: Insights from European Countries. *Journal of Industrial and Business Economics,* 49(1), 51-93.

115. Cavalcanti, T. V., Mohaddes, K., Raissi, M. (2011a). Does Oil Abundance Harm Growth? *Applied Economics Letters*, 18(12), 1181-1184.

116. Cavalcanti, T. V., Mohaddes, K., Raissi, M. (2011b). Growth, Development and Natural Resources: New Evidence Using a Heterogeneous Panel Analysis. *The Quarterly Review of Economics and Finance*, 51(4), 305-318.

117. Ceccobelli, M., Gitto, S., Mancuso, P. (2012). ICT Capital and Labour Productivity Growth: A Non-parametric Analysis of 14 OECD Countries. *Telecommunications Policy,* 36(4), 282-292.

118. CEPII (2023). BACI database (202301 version) available HERE.

119. Chambers, E. J., Gordon, D. F. (1966). Primary Products and Economic Growth: An Empirical Measurement. *Journal of Political Economy*, 74(4), 315-332.

120. Charles, A., Mesagan, E., Saibu, M. (2018). Resource Endowment and Export Diversification: Implications for Growth in Nigeria. *Studies in Business & Economics*, 13(1).

121. Charles-Coll, J. A. (2011). Understanding Income Inequality: Concept, Causes and Measurement. *International Journal of Economics and Management Sciences,* 1(3), 17-28.

122. Chekouri, S. M., Chibi, A., Benbouziane, M. (2017). Algeria and the Natural Resource Curse: Oil Abundance and Economic Growth. *Middle East Development Journal*, 9(2), 233-255.

123. Chen, W. C. (2013). The Extensive and Intensive Margins of Exports: The Role of Innovation. *The World Economy*, 36(5), 607-635.

124. Chui, M., Hazan, E., Roberts, R., Singla, A., Smaje, K. (2023). The Economic Potential of Generative AI. *McKinsey & Company*. Available HERE (accessed 29 May 2025).

125. Cicerone, G., Faggian, A., Montresor, S., Rentocchini, F. (2023). Regional Artificial Intelligence and the Geography of Environmental Technologies: Does Local AI Knowledge Help Regional Green-tech Specialization? *Regional Studies,* 57(2), 330-343.

126. Cieślik, A., Parteka, A. (2021). Relative Productivity, Country Size and Export Diversification. *Structural Change and Economic Dynamics*, 57, 28-44.

127. Cirera, X., Marin, A., Markwald, R. (2015). Explaining Export Diversification Through Firm Innovation Decisions: The Case of Brazil. *Research Policy*, 44(10), 1962-1973.

128. Cleveland, W. S. (1979). Robust Locally Weighted Regression and Smoothing Scatterplots. *Journal of the American Statistical Association,* 74(368), 829-836.

129. Cobb, C. W., Douglas, P. H. (1928). A Theory of Production. *The American Economic Review*, 18(1), 139-165.

130. Corden, W. M. (1984). Booming Sector and Dutch Disease Economics: Survey and Consolidation. *Oxford Economic Papers*, 36(3), 359-380.

131. Corden, W. M., Neary, J. P. (1982). Booming Sector and De-industrialization in a Small Open Economy. *The Economic Journal*, 92(368), 825-848.

132. Corriveau, L. (1991). Entrepreneurs, Growth and Cycles. PhD dissertation. *University of Western Ontario.*

133. Cotet, A. M., Tsui, K. K. (2013). Oil, Growth, and Health: What Does the Cross-country Evidence Really Show?. *The Scandinavian Journal of Economics*, 115(4), 1107-1137.

134. Cowell, F. A. (2011). Measuring Inequality. OUP Catalogue, *Oxford University Press*, (ed. 3).

135. Cowell, F. A. (2006). Theil, Inequality Indices and Decomposition. In: Creedy, J., Kalb, G. (Eds.), *Dynamics of Inequality and Poverty (Research on Economic Inequality, Vol. 13).* Emerald Group Publishing Limited, Bingley, pp. 341–356. https://doi.org/10.1016/S1049-2585(06)13012-4.

136. Crafts, N. (2004). Productivity Growth in the Industrial Revolution: A New Growth Accounting Perspective. *The Journal of Economic History*, 64(2), 521-535.

137. Crafts, N. (2018). The Productivity Slowdown: Is It the "New Normal"? *Oxford Review of Economic Policy*, 34(3), 443-460.

138. Crutzen, B. S., Holton, S. (2011). The More the Merrier? Natural Resource Fragmentation and the Wealth of Nations. *Kyklos*, 64(4), 500-515.

139. Cuevas Ahumada, V. M., Calderón Villarreal, C. (2022). Oil Rents, Institutional Development, and Total Factor Productivity. *Investigación económica*, 81(322), 52-72.

140. Dalum, B., Laursen, K., Villumsen, G. (1998). Structural Change in OECD Export Specialization Patterns: De-specialization and "Stickiness". *International Review of Applied Economics*, 12(3), 423-443.

141. Damioli, G., Van Roy, V., Vertesy, D. (2021). The Impact of Artificial Intelligence on Labor Productivity. *Eurasian Business Review,* 11, 1-25.

142. Danesh Jafari, D., Nazemian, H., Bahrami, J., Kheiravar, M. H. (2020). Effect of Oil Revenues on Government Size in Selected Oil-exporters with an Emphasis on Iran's Economy. *International Journal of Energy Economics and Policy*, 10(5), 485-497.

143. Dauvin, M., Guerreiro, D. (2017). The Paradox of Plenty: A Meta-analysis. *World Development*, 94, 212-231.

144. David, A. P., Wright, G. (1997). Increasing Returns and the Genesis of American Resource Abundance. *Industrial and Corporate Change*, 6(2), 203-245.

145. Davidson, T. (2021). Could Advanced AI Drive Explosive Economic Growth. *Open Philanthropy*, 25.

146. Davidson, T. (2023). What a Compute-Centric Framework Says About Takeoff Speeds. Technical Report, *Open Philanthropy*.

147. De Benedictis, L., Gallegati, M., Tamberi, M. (2009). Overall Trade Specialization and Economic Development: Countries Diversify. *Review of World Economics*, 145(1), 37-55.

148. De Ferranti, D., Perry, G. E., Lederman, D., Maloney, W. E. (2002). From Natural Resources to the Knowledge Economy: Trade and Job Quality. *World Bank Publications*.

149. Debaere, P., Demiroglu, U. (2003). On the Similarity of Country Endowments and Factor Prize Equalization. *Journal of International Economics*, 59, 101-136

150. Dennis, A., Shepherd, B. (2011). Trade Facilitation and Export Diversification. *The World Economy*, 34(1), 101-122.

151. Destek, M. A., Adedoyin, F., Bekun, F. V., Aydin, S. (2023). Converting a Resource Curse Into a Resource Blessing: The Function of Institutional Quality with Different Dimensions. *Resources Policy*, 80, 103234.

152. Ding, N., Field, B. C. (2004). Natural Resource Abundance and Economic Growth. *Land Economics*, 81(4), 496-502.

153. Dinopoulos, E., Thompson, P. (1998). Schumpeterian Growth Without Scale Effects. *Journal of Economic Growth*, 3(4), 313-335.

154. Dixon, J., Hong, B., Wu, L. (2021). The Robot Revolution: Managerial and Employment Consequences for Firms. *Management Science*, 67(9), 5586-5605.

155. Dolan, B. (Eds.). (2000). Malthus, Medicine & Morality: Malthusianism After 1798. *Rodopi*. ISBN 978-90-420-0851-9.

156. Dollar, D. (1986). Technological Innovation, Capital Mobility, and the Product Cycle in North-South Trade. *The American Economic Review*, 76(1), 177-190.

157. Domar, E. D. (1946). Capital Expansion, Rate of Growth, and Employment. *Econometrica,* 14 (2), 137-147.

158. Domini, G., Grazzi, M., Moschella, D., Treibich, T. (2021). Threats and Opportunities in the Digital Era: Automation Spikes and Employment Dynamics. *Research Policy,* 50(7), 104137.

159. Dosi, G. (1982). Technological Paradigms and Technological Trajectories: A Suggested Interpretation of the Determinants and Directions of Technical Change. *Research Policy,* 11(3), 147-162.

160. Duarte, M., Restuccia, D. (2010). The Role of the Structural Transformation in Aggregate Productivity. *The Quarterly Journal of Economics*, 125(1), 129-173.

161. Dutt, P., Mihov, I., Van Zandt, T. (2013). The Effect of WTO on the Extensive and the Intensive Margins of Trade. *Journal of International Economics*, 91(2), 204-219.

162. Edwards, S. (1998). Openness, Productivity and Growth: What do We Really Know? *The Economic Journal*, 108(447), 383-398.

163. Elbadawi, I., & Soto, R. (2012, May). Resource rents, political institutions and economic growth. In *Economic research forum working paper* (Vol. 678).

164. Elbadawi, I. A., Soto, R. (2015). Resource Rents, Institutions, and Violent Civil Conflicts. *Defense and Peace Economics*, 26(1), 89-113.

165. Ellis, R. E. (2017). The Collapse of Venezuela and Its Impact on the Region. *Military Review*, 97(4), 22-33.

166. Eloundou, T., Manning, S., Mishkin, P., Rock, D. (2024). GPTs are GPTs: Labor Market Impact Potential of LLMs. *Science,* 384(6702), 1306-1308.

167. Elstner, S., Feld, L. P., & Schmidt, C. M. (2018). The German Productivity Paradox: Facts and Explanations. *CESifo Working Paper* No. 7231.

168. Eltis, W. (1984). The Classical Theory of Economic Growth. *Palgrave Macmillan UK.*

169. EPO, (2020). Patents and the Fourth Industrial Revolution: the Global Technology Trends Enabling the Data-Driven Economy. *European Patent Office*.

170. Epo, B. N., Nochi Faha, D. R. (2020). Natural Resources, Institutional Quality, and Economic Growth: An African Tale. *The European Journal of Development Research*, 32(1), 99-128.

171. Ertimi, B., Sarmidi, T., Khalid, N., Ali, M. H. (2022). Revisiting the Role of the Oil Curse and Its Transmission Channels in Shaping Petrostates' Growth: An Evidence from a Quantile Regression. *The Singapore Economic Review*, 1-35.

172. Ertimi, B., Sarmidi, T., Cahyadin, M., Oqab, B. (2023). The Conditional Curse, a Missing Dimension of the Oil Curse—Economic Sanctions Channel in a Petrostate Economy: A Curse or a Blessing. *Journal of International Commerce, Economics and Policy*, 14(03), 2350017.

173. Fagerberg, J., Verspagen, B. (2021). Technological Revolutions, Structural Change & Catching-up. In: Alcorta, L., Foster-McGregor, N., Szirmai, A., Verspagen, B. (Eds.), *New Perspectives on Structural Change: Causes and Consequences of Structural Change in the Global Economy*. Oxford University Press, pp. 131-155.

174. Farboodi, M., Veldkamp, L. (2021). A Model of the Data Economy. *NBER Working Paper* No. w28427

175. Farhadi, M., Islam, M. R., Moslehi, S. (2015). Economic Freedom and Productivity Growth in Resource-rich Economies. World Development, 72, 109-126.

176. Farzanegan, M. R., Thum, M. (2020). Does Oil Rents Dependency Reduce the Quality of Education? *Empirical Economics*, 58(4), 1863-1911.

177. Feenstra, R. C., Kee, H. L. (2008). Export Variety and Country Productivity: Estimating the Monopolistic Competition Model with Endogenous Productivity. *Journal of International Economics,* 74(2), 500-518.

178. Feenstra, R. C., Ma, H. (2014). Trade Facilitation and the Extensive Margin of Exports. *The Japanese Economic Review*, 65, 158-177.

179. Feenstra, Robert C., Robert Inklaar and Marcel P. Timmer (2015). The Next Generation of the Penn World Table. *American Economic Review,* 105(10), 3150-3182. Available HERE.

180. Findlay, R., Lundahl, M. (2001). Natural Resources and Economic Development: The 1870-1914 Experience. *Resource Abundance and Economic Development*, 95-112.

181. Foster-McGregor, N., Nomaler, Ö., Verspagen, B. (2019). Measuring the Creation and Adoption of New Technologies Using Trade and Patent Data. *Maastricht Economic and Social Research Institute on Innovation and Technology (UNU-MERIT).*

182. Fosu, A., Gafa, D. (2019). Natural Resources, Institutions and Economic Development in Africa. *African Review of Economics and Finance*, 11(1), 29-52.

183. Franck, R., Galor, O. (2022). Technology-skill Complementarity in Early Phases of Industrialisation. *The Economic Journal*, 132(642), 618-643.

184. Frankel, M. (1962). The Production Function in Allocation and Growth: A Synthesis. *The American Economic Review*, 52(5), 996-1022.

185. Frankel, J. A. (2010). The Natural Resource Curse: A Survey. *NBER Working Paper* No. 15836, pp. 1-55.

186. Freeman, C., Perez, C. (1988). Structural Crises of Adjustment: Business Cycles. In: Dosi G. (Eds.), *Technical Change and Economic Theory*. Pinter Publishers London, pp. 38-66

187. Fuinhas, J. A., Marques, A. C., Faria, S. D. S. (2017). Natural Resources, Globalization and Sustainable Economic Welfare: A Panel ARDL Approach. *Studies of Applied Economics*, 35(3), 653-672.

188. Fujita, M., Krugman, P. R., Venables, A. (2001). The Spatial Economy: Cities, Regions, and International Trade. *MIT Press,* Cambridge, Massachusetts.

189. Gallup, J. L., Sachs, J. D., Mellinger, A. D. (1999). Geography and Economic Development. *CID Working Paper* No. 1.

190. Galor, O. (2005). From Stagnation to Growth: Unified Growth Theory. In: Aghion, P., Durlauf S. (Eds.), *Handbook of Economic Growth*, 1, 171-293.

191. Galor, O. (2011). Unified Growth Theory. *Princeton University Press.* Princeton, New Jersey.

192. Galor, O., Klemp, M. (2019). Human Genealogy Reveals a Selective Advantage to Moderate Fecundity. *Nature Ecology & Evolution*, 3(5), 853-857.

193. Gelb, A. H. (1988). Oil Windfalls: Blessing or Curse?. *Oxford University Press.*

194. Gerelmaa, L., Kotani, K. (2016). Further Investigation of Natural Resources and Economic Growth: Do Natural Resources Depress Economic Growth?. *Resources Policy*, 50, 312-321.

195. Ghecham, M. A. (2021). Further Attempt to Explain the Oil Curse Mechanism Using a Debt Overhang Concept. *Journal of Economic Studies*, 48(4), 852-868.

196. Giri, R., Quayyum, M. S. N., Yin, R. (2019). Understanding Export Diversification: Key Drivers and Policy Implications. *IMF Working Papers* 19 (105).

197. Glejser, H., Goossens, K., Vanden Eede, M. (1982). Inter-industry versus Intra-industry Specialization in Exports and Imports (1959–1970–1973). *Journal of International Economics*, 12(3-4), 363-369.

198. Gnidchenko, A. A. (2021). Structural Transformation and Quality Ladders: Evidence from the New Theil's Decomposition. *Structural Change and Economic Dynamics,* 59, 281-291.

199. Goldfarb, A., Trefler, D. (2019). Artificial Intelligence and International Trade. *The Economics of Artificial Intelligence: An Agenda,* 463-492.

200. Gomułka, S. (2023). The Global Long-term Economic Growth and the Economic Transformation of Poland and Eastern Europe. *Scholar Publishing House*.

201. Gordon, R. J. (2000). Does the "New Economy" Measure up to the Great Inventions of the Past? *Journal of Economic Perspectives,* 14(4), 49-74.

202. Gordon, R. (2017). The Rise and Fall of American Growth: The US Standard of Living Since the Civil War. *Princeton University Press*. Princeton, New Jersey.

203. Gozgor, G., Can, M. (2016). Effects of the Product Diversification of Exports on Income at Different Stages of Economic Development. *Eurasian Business Review*, 6, 215-235.

204. Graetz, G., Michaels, G. (2018). Robots at Work. *Review of Economics and Statistics*, 100(5), 753-768.

205. Grossman, G. M., Helpman, E. (1989). Product Development and International Trade. *Journal of Political Economy*, 97(6), 1261-1283.

206. Grossman, G. M., Helpman, E. (1991). Quality Ladders in the Theory of Growth. *The Review of Economic Studies*, 58(1), 43-61.

207. Grossman, G. M., Helpman, E. (1993). Innovation and Growth in the Global Economy. *MIT Press.* Cambridge, Massachusetts.

208. Growiec, J. (2024). Existential Risk From Transformative AI: An Economic Perspective. *Technological and Economic Development of Economy*, 30(6), 1682-1708.

209. Growiec, J., Jabłońska, J., Parteka, A. (2024). Hardware and Software: A New Perspective on the Past and Future of Economic Growth. *Brookings Center on Regulation and Markets*. Available HERE.

210. Growiec, J., Prettner, K. (2025). The Economics of p (doom): Scenarios of Existential Risk and Economic Growth in the Age of Transformative AI. arXiv preprint arXiv: 2503.07341.

211. Gu, J., Jia, D., Zhao, C., Li, Z. (2024) Industrial Automation Promotes Diversification of Export Products of Chinese Enterprises. Available HERE.

212. Gunday, G., Ulusoy, G., Kilic, K., Alpkan, L. (2011). Effects of Innovation Types on Firm Performance. *International Journal of Production Economics*, 133(2), 662-676.

213. Gylfason, T. (2000). Resources, Agriculture, and Economic Growth in Economies in Transition. *CESifo Working Paper* No. 313

214. Gylfason, T., Zoega, G. (2006). Natural Resources and Economic Growth: The Role of Investment. *World Economy*, 29(8), 1091-1115.

215. Ha, J., Howitt, P. (2007). Accounting for Trends in Productivity and R&D: A Schumpeterian Critique of Semi-endogenous Growth Theory. *Journal of Money, Credit and Banking*, 39(4), 733-774.

216. Habiyaremye, A., Ziesemer, T. (2006). Absorptive Capacity and Export Diversification in Sub-Saharan African Countries. *United Nations University Paper* No. 2006-030.

217. Hagemann, H. (2009). Solow's 1956 Contribution in the Context of the Harrod-Domar Model. *History of Political Economy*, 41, 67-87.

218. Halilbasic, M., Brkic, S. (2017). Export Specialization of South-East European Countries in Their Trade with the European Union. *Economic Review: Journal of Economics and Business*, 15(1), 75-87.

219. Handoyo, R. D., Ibrahim, K. H. (2021). Determinants of Export Diversification in Developing Countries. *Industrial Engineering & Management Systems,* 20(4), 720-731.

220. Haque, M. I. (2020). Negating the Role of Institutions in the Long Run Growth of an Oil Producing Country. *International Journal of Energy Economics and Policy*, *10*(5), 503-509.

221. Harris, D. J. (2007). The Classical Theory of Economic Growth. *The New Palgrave Dictionary of Economics*, 11.

222. Harrod, R. F. (1939). An Essay in Dynamic Theory. *The Economic Journal*, 49(193), 14-33.

223. Harvey, D. I., Kellard, N. M., Madsen, J. B., Wohar, M. E. (2010). The Prebisch-Singer Hypothesis: Four Centuries of Evidence. *The Review of Economics and Statistics*, 92(2), 367-377.

224. Haskel, J., Westlake, S. (2017). Capitalism Without Capital: The Rise of the Intangible Economy. *Princeton University Press*. Princeton, New Jersey.

225. Hassler, J., Krusell, P., Olovsson, C. (2021). Directed Technical Change as a Response to Natural Resource Scarcity. *Journal of Political Economy*, 129(11), 3039-3072.

226. Hastie, T., Tibshirani, R. (1987). Generalized Additive Models: Some Applications. *Journal of the American Statistical Association,* 82(398), 371-386.

227. Hattendorff, C. (2014). Natural Resources, Export Concentration and Financial Development, *Diskussionsbeiträge*, No. 2014/34, Freie Universität Berlin.

228. Hausmann, R., Hwang, J., Rodrik, D. (2007). What You Export Matters. *Journal of Economic Growth*, 12, 1-25.

229. Havranek, T., Horvath, R., Zeynalov, A. (2016). Natural Resources and Economic Growth: A Meta-Analysis. *World Development*, 88, 134-151.

230. Heckscher, E. F., Ohlin, B. G. (1991). Heckscher-Ohlin Trade Theory. *MIT Press*. Cambridge, Massachusetts.

231. Helpman, E. (2004). The Mystery of Economic Growth. *Harvard University Press*. Cambridge, Massachusetts. https://doi.org/10.2307/j.ctv1c5cx4v.

232. Hémous, D. (2016). The Dynamic Impact of Unilateral Environmental Policies. *Journal of International Economics*, 103, 80-95.

233. Herrendorf, B., Rogerson, R., Valentinyi, A. (2014). Growth and Structural Transformation. *Handbook of Economic Growth*, 2, 855-941.

234. Hidalgo, C. A., Hausmann, R. (2009). The Building Blocks of Economic Complexity. *Proceedings of the National Academy of Sciences*, 106(26), 10570-10575.

235. Hidalgo, C. A., Balland, P. A., Mercedes Delgado, R. B., Feldman, M., Frenken, K., Glaeser, E., He, C., Kogler, D. F., Morrison, A., Neffke, F., Rigby, D., Stern, S., Zheng, S., Zhu, S. (2018). The Principle of Relatedness. In: Morales, A. J., Gershenson, C., Braha, D., Minai, A. A., Bar-Yam, Y. (Eds.), *Unifying Themes in Complex Systems IX: Proceedings of the Ninth International Conference on Complex Systems*. Springer International Publishing, pp. 451-457

236. Hilmawan, R., & Clark, J. (2019). An Investigation of the Resource Curse in Indonesia. *Resources Policy*, 64, 101483.

237. Hinloopen, J., Van Marrewijk, C. (2001). On the Empirical Distribution of the Balassa Index. *Weltwirtschaftliches Archiv,* 137(1), 1-35.

238. Hirschman, A. O. (1958). The Strategy of Economic Development. *Yale University Press*. New Haven, Connecticut.

239. Holden, S. (2013). Avoiding the Resource Curse the Case of Norway. *Energy Policy*, 63, 870-876.

240. Hong, L., Luo, R., & Wu, Y. (2025). Industrial Robot Application and Export Product Scope: Empirical Evidence from China. *Applied Economics Letters*, 32(6), 789-795.

241. Horváth, R., & Zeynalov, A. (2014). The Natural Resource Curse in Post-Soviet Countries: The Role of Institutions and Trade Policies. *IOS Working Papers* No. 341.

242. Howitt, P. (1999). Steady Endogenous Growth with Population and R&D Inputs Growing. *Journal of Political Economy*, 107(4), 715-730.

243. Hötte, K., Tarannum, T., Verendel, V. & Bennett, L. (2024). Measuring Artificial Intelligence: A Systematic Assessment and Implications for Governance. *INET Oxford Working Paper* No. 2024-02.

244. Hummels, D., & Klenow, P. J. (2005). The Variety and Quality of a Nation's Exports. *American Economic Review,* 95(3), 704-723.

245. Iapadre, P. L. (2001). Measuring International Specialization. *International Advances in Economic Research,* 7(2), 173-183.

246. Imbs, J., & Wacziarg, R. (2003). Stages of Diversification. *American Economic Review,* 93(1), 63-86.

247. Inada, K. I. (1963). On a Two-sector Model of Economic Growth: Comments and a Generalization. *The Review of Economic Studies*, 30(2), 119-127.

248. Inklaar, R., O'Mahony, M., Timmer, M. (2005). ICT and Europe's Productivity Performance: Industry-level Growth Account Comparisons with the United States. *Review of Income and Wealth,* 51(4), 505-536.

249. Innis, H. A. (1956). The Fur Trade in Canada: An Introduction to Canadian Economic History (2nd ed.). *University of Toronto Press*. Toronto, Canada.

250. Inuwa, N., Sani, M. B., Adamu, S., Modibbo, H. U., Saidu, A. M. (2022). Testing the Resource Curse Hypothesis: Evidence From Top Ten Resource-Rich Countries in Africa. *African Journal of Business and Economic Research*, 17(2), 205.

251. Isham, J., Woolcock, M., Pritchett, L., Busby, G. (2005). The Varieties of Resource Experience: Natural Resource Export Structures and the Political Economy of Economic Growth. *The World Bank Economic Review*, 19(2), 141-174.

252. Jalili, Z., Bishak, M. R. S., Azad, M. A. M., Salmani, B., Haghighat, J. (2019). Resource-Economic Growth Nexus, Role of Governance, Financial Development, Globalization, and War. *Journal of Economic Integration*, 34(3), 520-545.

253. Jetter, M., Ramírez Hassan, A. (2015). Want Export Diversification? Educate the Kids First. *Economic Inquiry*, 53(4), 1765-1782.

254. Ji, K., Magnus, J. R., Wang, W. (2014). Natural Resources, Institutional Quality, and Economic Growth in China. *Environmental and Resource Economics*, 57, 323-343.

255. Jones, C. I. (1995a) R&D-based Models of Economic Growth. *Journal of Political Economy*, 103(4), 759-784.

256. Jones, C. I. (1995b). Time Series Tests of Endogenous Growth Models. *The Quarterly Journal of Economics*, 110(2), 495-525.

257. Jones, C. I. (2002). Introduction to Economic Growth (2nd ed.). *W.W. Norton & Company,* New York.

258. Jones, C. I. (2002). Sources of US Economic Growth in a World of Ideas. *American Economic Review,* 92(1), 220-239.

259. Jones, C. I. (2005). Growth and Ideas. In: Aghion, P., Durlauf, S. (Eds.), *Handbook of Economic Growth.* Elsevier, pp. 1063-1111.

260. Jones, C. I., Tonetti, C. (2020). Nonrivalry and the Economics of Data. *American Economic Review*, 110(9), 2819-2858.

261. Jorgenson, D. W., Ho, M. S., Stiroh, K. J. (2008). A Retrospective Look at the US Productivity Growth Resurgence. *Journal of Economic Perspectives,* 22(1), 3-24.

262. Kaldor, N. (1955). Alternative Theories of Distribution. *The Review of Economic Studies*, 23(2), 83-100.

263. Kaldor, N. (1957). A Model of Economic Growth. *The Economic Journal*, 67(268), 591-624.

264. Karamelikli, H., Akalin, G., Arslan, U. (2017). Oil Exports and Non-oil Exports: Dutch Disease Effects in the Organization of Petroleum Exporting Countries (OPEC). *Journal of Economic Studies*, 44(4), 540-551.

265. Karimu, A., Adu, G., Marbuah, G., Mensah, J. T., Amuakwa-Mensah, F. (2017). Natural Resource Revenues and Public Investment in Resource-rich Economies in Sub-Saharan Africa. *Review of Development Economics*, 21(4), 107-130.

266. Karl, T. L. (2005). Understanding the Resource Curse. In: Tsalik S., Schiffrin A. (Eds.), *Covering Oil: A Guide to Energy and Development*, pp. 21-30.

267. Kehoe, T. J., Ruhl, K. J. (2013). How Important is the New Goods Margin in International Trade? *Journal of Political Economy,* 121(2), 358-392.

268. Keynes, J. M. (1936). The General Theory of Employment, Interest and Money. *Macmillan,* London.

269. Khan, U., Khan, A. M. (2023). An Analysis of the Effects of Oil and Non-oil Export Shocks on the Saudi Economy. *Investment Management & Financial Innovations*, 20(1), 127.

270. Khayati, A. (2019). The Effects of Oil and Non-oil Exports on Economic Growth in Bahrain. *International Journal of Energy Economics and Policy*, 9(3), 160-164.

271. Kim, D. H., Lin, S. C. (2017). Natural Resources and Economic Development: New Panel Evidence. *Environmental and Resource Economics*, 66, 363-391.

272. Kim, Y. E., Loayza, N. (2019). Productivity Growth: Patterns and Determinants Across the World. *World Bank Policy Research Working Paper*, (8852).

273. Klinger, B., Lederman, D. (2004). Discovery and Development: An Empirical Exploration of "New" Products. *World Bank Publications*, (3450).

274. Klinger, J., Mateos-Garcia, J., Stathoulopoulos, K. (2018). Deep Learning, Deep Change? Mapping the Development of the Artificial Intelligence General Purpose Technology. arXiv preprint arXiv:1808.06355.

275. Klump, R., McAdam, P., Willman, A. (2007). Factor Substitution and Factor-Augmenting Technical Progress in the United States: A Normalized Supply-Side System Approach. *The Review of Economics and Statistics,* 89(1), 183-192.

276. Klump, R., McAdam, P., Willman, A. (2012). The Normalized CES Production Function: Theory and Empirics. *Journal of Economic Surveys*, 26(5), 769-799.

277. Knell, M., Vannuccini, S. (2022). Tools and Concepts for Understanding Disruptive Technological Change After Schumpeter. In: Kurz, H., D., Schütz, M., Strohmaier, R., Zilian, S. S. (Eds.), *The Routledge Handbook of Smart Technologies*. Routledge, pp. 77-101.

278. Koch, M., Manuylov, I., Smolka, M. (2021). Robots and Firms. *The Economic Journal*, 131(638), 2553-2584.

279. Komlos, J. (2000). The Industrial Revolution as the Escape from the Malthusian Trap. *Journal of European Economic History*, 29, 307–331.

280. Koopmans, T.C. (1965). On the Concept of Optimal Economic Growth. In: Johansen, J. (Eds.), *The Econometric Approach to Development Planning*, North Holland, Amsterdam.

281. Korinek, A., Juelfs, M. (2022). Preparing for the (Non-existent?) Future of Work. *NBER Working Paper* No. w30172.

282. Korinek, A., Suh, D. (2024). Scenarios for the Transition to AGI. Technical Report, *NBER Working Paper* No. 32255.

283. Krist, W. (2013). Globalization and America's Trade Agreements. *Woodrow Wilson Center Press with Johns Hopkins University Press.*

284. Kromann, L., Malchow-Møller, N., Skaksen, J. R., Sørensen, A. (2020). Automation and Productivity - Cross-country, Cross-industry Comparison. *Industrial and Corporate Change*, 29(2), 265-287.

285. Kropf, A. (2010). Resource Abundance vs. Resource Dependence in Cross-country Growth Regressions. *OPEC Energy Review*, 34(2), 107-130.

286. Krugman, P. (1979). A Model of Innovation, Technology Transfer, and the World Distribution of Income. *Journal of Political Economy,* 87(2), 253-266.

287. Krugman, P. (1987). The Narrow Moving Band, the Dutch Disease, and the Competitive Consequences of Mrs. Thatcher: Notes on Trade in the Presence of Dynamic Scale Economies. *Journal of Development Economics*, 27(1-2), 41-55.

288. Krugman P. (1991) Geography and Trade. *MIT Press,* Cambridge, Massachusetts.

289. Krugman, P. (2014). Four Observations on Secular Stagnation. In: Teulings, C., Baldwin, R. (Eds.), *Secular Stagnation: Facts, Causes and Cures*, pp. 61-68.

290. Krugman, P., Venables, A. J. (1990). Integration and the Competitiveness of Peripheral Industry. *Unity with Diversity in the European Community*, 56-77.

291. Kruse-Andersen, P. K. (2023). Testing R&D-Based Endogenous Growth Models. *Oxford Bulletin of Economics and Statistics*, 85(5), 1083-1110.

292. Kurzweil, R. (2005). The Singularity is Near. In: Ronald L. Sandler, R. L. (Eds.), *Ethics and Emerging Technologies*. Palgrave Macmillan, pp. 393-406.

293. Larsen, E. R. (2005). Are Rich Countries Immune to the Resource Curse? Evidence from Norway's Management of Its Oil Riches. *Resources Policy*, 30(2), 75-86.

294. Laursen, K. (2015). Revealed Comparative Advantage and the Alternatives as Measures of International Specialization. *Eurasian Business Review,* 5, 99-115.

295. Leamer, E. E. (1995). The Heckscher-Ohlin Model in Theory and Practice. *Princeton Studies in International Finance*, 77.

296. Leamer, E. E., Levinsohn, J. (1995). International Trade Theory: The Evidence. *Handbook of International Economics*, 3, 1339-1394.

297. Lederman, D., Maloney, W. F. (2009). Trade Structure and Growth. Natural Resources: Neither Curse nor Destiny. In: Newfarmer, R., Shaw, W., Walkenhorst, P. (Eds.), *Breaking Into New Markets: Emerging Lessons for Export Diversification*. World Bank Publications, pp. 15-39.

298. Lee, R. D. (1987). Population Dynamics of Humans and Other Animals. *Demography*, 24(4), 443-465.

299. Lee, D., Zhang, H. (2022). Export Diversification in Low-income Countries and Small States: Do Country Size and Income Level Matter? *Structural Change and Economic Dynamics*, 60, 250-265.

300. Leromain, E., Orefice, G. (2014). New Revealed Comparative Advantage Index: Dataset and Empirical Distribution. *International Economics,* 139, 48-70.

301. Lewis Jr, S. R. (1989). Primary Exporting Countries. *Handbook of Development Economics*, 2, 1541-1600.

302. Lewis, W. A. (2009). Growth and Fluctuations 1870-1913. *Routledge Revivals*. Routledge.

303. Lokshin, M., Sajaia, Z. (2006). EGEN_INEQUAL: Stata Module Providing Extensions to Generate Inequality and Poverty Measures.

304. Lucas Jr, R. E. (1988). On the Mechanics of Economic Development. *Journal of Monetary Economics,* 22(1), 3-42.

305. Majumder, M. K., Raghavan, M., Vespignani, J. (2020). Oil Curse, Economic Growth and Trade Openness. *Energy Economics*, 91, 104896.

306. Malthus, T. (1798). An Essay on the Principle of Population. *J. Johnson*, London.

307. Mania, E., Rieber, A. (2019). Product Export Diversification and Sustainable Economic Growth in Developing Countries. *Structural Change and Economic Dynamics,* 51, 138-151.

308. Maris, R., Holmes, M. (2023). Economic Growth Theory and Natural Resource Constraints: A Stocktake and Critical Assessment. *Australian Economic Review*, 56(2), 255-268.

309. Mau, K. (2016). Export Diversification and Income Differences Reconsidered: The Extensive Product Margin in Theory and Application. *Review of World Economics,* 152(2), 351-381.

310. Mehlum, H., Moene, K., Torvik, R. (2006). Cursed by Resources or Institutions? *World Economy*, 29(8), 1117-1131.

311. Mellor, J. W. (1995). Agriculture on the Road to Industrialization. *Johns Hopkins University Press.* Baltimore.

312. Mesagan, E. P., Vo, X. V. (2024). The Importance of Economic Complexity in the Resource-Growth Discourse: Empirical Evidence from Africa. *Journal of the Knowledge Economy*, 15(1), 2772-2793.

313. Miyagawa, T., Tonogi, K., Ishikawa, T. (2021). Does the Productivity J-curve Exist in Japan?-Empirical Studies Based on the Multiple Q Theory. *Journal of the Japanese and International Economies,* 61, 101137.

314. Moshiri, S., Hayati, S. (2017). Natural Resources, Institutions Quality, and Economic Growth; A Cross-country Analysis. *Iranian Economic Review*, 21(3), 661-693.

315. Murshed, S. M., Serino, L. A. (2011). The Pattern of Specialization and Economic Growth: The Resource Curse Hypothesis Revisited. *Structural Change and Economic Dynamics*, 22(2), 151-161.

316. Myint, H. (1958). The "Classical Theory" of International Trade and the Underdeveloped Countries. *The Economic Journal*, 68(270), 317-337.

317. Naidoo, R. (2004). Economic Growth and Liquidation of Natural Capital: The Case of Forest Clearance. *Land Economics*, 80(2), 194-208.

318. Ndjokou, I. M. M. M., Tsopmo, P. C. (2017). The Effects on Economic Growth of Natural Resources in Sub-Saharan Africa: Does the Quality of Institutions Matters. *Economics Bulletin*, 37(1), 248-263.

319. Neary, J. P., Van Wijnbergen, S. (1986). Natural Resources and the Macro Economy. *MIT Press.* Cambridge, Massachusetts.

320. Newfarmer, R., Shaw, W., Walkenhorst, P. (Eds.). (2009). Breaking Into New Markets: Emerging Lessons for Export Diversification. *World Bank Publications*.

321. Nham, N. T. H., Bao, N. K. Q. (2023). Nonlinear Effects of Digitalization on Export Activities: An Empirical Investigation in European Countries. *Technological and Economic Development of Economy,* 29(3), 1041-1079.

322. Nkemgha, G., Engone Mve, S., Balouki Mikala, H., Tékam, H. (2022). Linking Natural Resource Dependence and Industrialization in Sub-Saharan African Countries. *International Review of Applied Economics*, 36(2), 245-263.

323. Nordhaus, W. D. (1974). Resources as a Constraint on Growth. *The American Economic Review*, 64(2), 22-26.

324. Nordhaus, W. D. (1977). Economic Growth and Climate: the Carbon Dioxide Problem. *The American Economic Review,* 67(1), 341-346.

325. Nordhaus, W. D., Stavins, R. N., Weitzman, M. L. (1992). Lethal Model 2: The Limits to Growth Revisited. *Brookings Papers on Economic Activity*, 2, 1–59.

326. Nordhaus, W. D. (2021). Are We Approaching an Economic Singularity? Information Technology and the Future of Economic Growth. *American Economic Journal: Macroeconomics*, 13(1), 299-332.

327. Noy, S., & Zhang, W. (2023). Experimental Evidence on the Productivity Effects of Generative Artificial Intelligence. *Science*, 381(6654), 187-192.

328. OECD (2011a), Globalization, Comparative Advantage and the Changing Dynamics of Trade, *OECD Publishing*, Paris, https://doi.org/10.1787/9789264113084-en.

329. OECD (2011b), OECD Guide to Measuring the Information Society 2011, *OECD Publishing*, Paris, https://doi.org/10.1787/9789264113541-en.

330. OECD (2019), Export Diversification at the Time of Slowbalization. Aid for Trade at a Glance 2019: Economic Diversification and Empowerment, *OECD Publishing*, Paris. 195–211. https://doi.org/10.1787/18ea27d8-en.

331. Ofori, P. E., Grechyna, D. (2021). Remittances, Natural Resource Rent and Economic Growth in Sub-Saharan Africa. *Cogent Economics & Finance*, 9(1), 1979305.

332. Okoye, L. U., Adeleye, B. N., Okoro, E. E., Okoh, J. I., Ezu, G. K., Anyanwu, F. A. (2022). Effect of Gas Flaring, Oil Rent and Fossil Fuel on Economic Performance: The Case of Nigeria. *Resources Policy*, 77, 102677.

333. Oliner, S. D., Sichel, D. E., Stiroh, K. J. (2008). Explaining a Productive Decade. *Journal of Policy Modeling*, 30(4), 633-673.

334. Olsson, O. (2007). Conflict Diamonds. *Journal of Development Economics*, 82(2), 267-286.

335. Oskenbayev, Y., Yilmaz, M., Abdulla, K. (2013). Resource Concentration, Institutional Quality and the Natural Resource Curse. *Economic Systems*, 37(2), 254-270.

336. Ouedraogo, R., Sourouema, W. S., Zahonogo, P. (2018). Capital Inflows and Exports Diversification in Sub-Saharan Africa During the MDGs Era. *African Development Review*, 30(1), 1-18.

337. Oumbé, H. T., Djeunankan, R., Ndzana, A. M. (2023). Does Information and Communication Technologies Affect Economic Complexity?. *SN Business & Economics*, 3(4), 92.

338. Pagergiou, C., Jahan, S., Ho, G. (2014). Sustaining Long-run Growth and Macroeconomic Stability in Low-income Countries – The Role of Structural Transformation and Diversification. *IMF Policy Papers*.

339. Papyrakis, E., Gerlagh, R. (2004). The Resource Curse Hypothesis and Its Transmission Channels. *Journal of Comparative Economics*, 32(1), 181-193.

340. Papyrakis, E., Gerlagh, R. (2007). Resource Abundance and Economic Growth in the United States. *European Economic Review*, 51(4), 1011-1039.

341. Papyrakis, E. (2017). The Resource Curse - What Have We Learned From Two Decades of Intensive Research: Introduction to the Special Issue. *The Journal of Development Studies*, 53(2), 175-185.

342. Park, B., Lee, K. K. (2006). Natural Resources, Governance, and Economic Growth in Africa. *Journal of International Economic Studies*, 10(2), 1598-2769.

343. Parteka, A. (2010). Employment and Export Specialisation Along the Development Path: Some Robust Evidence. *Review of World Economics,* 145(4), 615-640.

344. Parteka, A., Tamberi, M. (2013a). What Determines Export Diversification in the Development Process? Empirical Assessment. *The World Economy,* 36(6), 807-826.

345. Parteka, A., Tamberi, M. (2013b). Product Diversification, Relative Specialisation and Economic Development: Import–Export Analysis. *Journal of Macroeconomics,* 38, 121-135.

346. Parteka, A., Kordalska, A. (2023). Artificial Intelligence and Productivity: Global Evidence From AI Patent and Bibliometric Data. *Technovation*, 125, 102764.

347. Parteka, A., Zarach, Z. H., Kordalska, A. (2025). Technological Content of Export Diversification - Evolution Along the Economic Growth Process. *Structural Change and Economic Dynamics,* 74, 14-27.

348. Patel, P., Pavitt, K. (1997). The Technological Competencies of the World's Largest Firms: Complex and Path-Dependent, but not Much Variety. *Research Policy*, 26(2), 141-156.

349. Peng, S., Kalliamvakou, E., Cihon, P., Demirer, M. (2023). The Impact of AI on Developer Productivity: Evidence From Github Copilot. arXiv preprint arXiv:2302.06590.

350. Peretto, P. F. (1998). Technological Change and Population Growth. *Journal of Economic Growth*, 3(4), 283-311.

351. Perez-Sebastian, F., Raveh, O. (2016). The Natural Resource Curse and Fiscal Decentralization. *American Journal of Agricultural Economics*, 98(1), 212-230.

352. Pieri, F., Vecchi, M., Venturini, F. (2018). Modelling the Joint Impact of R&D and ICT on Productivity: A Frontier Analysis Approach. *Research Policy,* 47(9), 1842-1852.

353. Pilat, D., Lee, F., Van Ark, B. (2003). Production and Use of ICT: A Sectoral Perspective on Productivity Growth in the OECD Area. *OECD Economic Studies 2002,* (2), 47–78.

354. Polák, P. (2017). The Productivity Paradox: A Meta-Analysis. *Information Economics and Policy,* 38, 38-54.

355. Prebisch, R. (1950). The Economic Development of Latin America and Its Principal Problems. *Economic Bulletin for Latin America*, 7, 1-12.

356. Raifu, I. A. (2021). The Institutional Role in Oil Revenue - Economic Growth Nexus in Nigeria. *OPEC Energy Review*, 45(1), 52-84.

357. Ramsey, F. P. (1928). A Mathematical Theory of Saving. *The Economic Journal*, 38(152), 543-559.

358. Ranjbar, O., Rassekh, F. (2022). Does Economic Complexity Influence the Efficacy of Foreign Direct Investment? An Empirical Inquiry. *The Journal of International Trade & Economic Development,* 31(6), 894-910.

359. Redmond, T., Nasir, M. A. (2020). Role of Natural Resource Abundance, International Trade and Financial Development in the Economic Development of Selected Countries. *Resources Policy*, 66, 101591.

360. Regolo, J. (2013). Export Diversification: How Much Does the Choice of the Trading Partner Matter? *Journal of International Economics*, 91(2), 329-342.

361. Ricardo, D. (1817). On the Principles of Political Economy and Taxation. *J. Murray,* London.

362. Ridzuan, A. R., Shaari, M. S., Rosli, A., Jamil, A. R. M., Lestari, A., Zakaria, S. (2021). The Nexus Between Economic Growth and Natural Resource Abundance in Selected ASEAN Countries Before Pandemic Covid-19. *International Journal of Energy Economics and Policy*, 11(2), 281-292.

363. Rodriguez, F., Sachs, J. D. (1999). Why Do Resource-Abundant Economies Grow More Slowly? *Journal of Economic Growth*, 4, 277-303.

364. Roemer, M. (1970). Fishing for Growth: Export-led Development in Peru, 1950-1967. *Harvard University Press*.

365. Romer, D. (2010) Advanced Macroeconomics. 4th Edition, *McGraw-Hill.*

366. Romer, P. M. (1986). Increasing Returns and Long-Run Growth. *Journal of Political Economy*, 94(5), 1002-1037.

367. Romer, P. M. (1990). Endogenous Technological Change. *Journal of Political Economy*, 98(5, Part 2), S71-S102.

368. Roodman, D. (2020). On the Probability Distribution of Long-term Changes in the Growth Rate of the Global Economy: An Outside View. Technical report, *Open Philanthropy*.

369. Ross, M. L. (2015). What Have We Learned About the Resource Curse? *Annual Review of Political Science*, 18(1), 239-259.

370. Ross, M. L. (2019). What Do We Know About Export Diversification in Oil-Producing Countries? *The Extractive Industries and Society*, 6(3), 792-806.

371. Sachs, J. D., Warner, A. M. (1995). Natural Resource Abundance and Economic Growth. *NBER Working Paper* No. w5398.

372. Sachs, J. D., Warner, A. M. (2001). The Curse of Natural Resources. *European Economic Review*, 45(4-6), 827-838.

373. Saeed, K. A. (2021). Revisiting the Natural Resource Curse: A Cross-Country Growth Study. *Cogent Economics & Finance*, 9(1), 2000555.

374. Salari, M., Noghanibehambari, H. (2021). Natural Resources, Women and Corruption. *Resources Policy*, 74, 102412.

375. Sarmidi, T., Hook Law, S., Jafari, Y. (2014). Resource Curse: New Evidence on the Role of Institutions. *International Economic Journal*, 28(1), 191-206.

376. Sassen-Koob, S. (1979). Economic Growth and Immigration in Venezuela. *International Migration Review*, 13(3), 455-474.

377. Satti, S. L., Farooq, A., Loganathan, N., Shahbaz, M. (2014). Empirical Evidence on the Resource Curse Hypothesis in Oil-Abundant Economy. *Economic Modelling*, 42, 421-429.

378. Schott, P. K. (2003). One Size Fits All? Heckscher-Ohlin Specialization in Global Production. *American Economic Review*, 93(3), 686-708.

379. Schumpeter, J. A. (1912). Theorie der Wirtschaftlichen Entwicklung. *Duncker & Humblot, Leipzig.*

380. Schumpeter, J. A. (1942). The Theory of Economic Development. *Harvard University Press,* Cambridge, Massachusetts.

381. Schurr, S. H., Netschert, B. C., Eliasberg, V. F., Lerner, J., Landsberg, H. H. (1960). Energy in the American Economy, 1850-1975. *The Johns Hopkins Press*, Baltimore.

382. Seers, D. (1964). The Mechanism of an Open Petroleum Economy. *Social and Economic Studies,* 233-242.

383. Segerstrom, P. S., Anant, T. C., Dinopoulos, E. (1990). A Schumpeterian Model of the Product Life Cycle. *The American Economic Review*, 1077-1091.

384. Shahbaz, M., Naeem, M., Ahad, M., Tahir, I. (2018). Is Natural Resource Abundance a Stimulus for Financial Development in the USA?. *Resources Policy*, 55, 223-232.

385. Sharma, C., Pal, D. (2021). Revisiting Resource Curse Puzzle: New Evidence from Heterogeneous Panel Analysis. *Applied Economics*, 53(8), 897-912.

386. Sharma, C., Paramati, S. R. (2022). Resource Curse versus Resource Blessing: New Evidence from Resource Capital Data. *Energy Economics*, 115, 106350.

387. Sheng, L., Yang, D. T. (2016). Expanding Export Variety: The Role of Institutional Reforms in Developing Countries. *Journal of Development Economics,* 118, 45-58.

388. Shittu, W. O., Musibau, H. O., Jimoh, S. O. (2022). The Complementary Roles of Human Capital and Institutional Quality on Natural Resource – FDI – Economic Growth Nexus in the MENA Region. *Environment, Development and Sustainability*, 24(6), 7936-7957.

389. Simkins, C. (2001). Can South Africa Avoid a Malthusian Positive Check? *Daedalus*, 130(1), 123-150.

390. Singer, H. (1950). Comments to the Terms of Trade and Economic Development. *Review of Economics and Statistics*, 40(1), 84-89.

391. Skousen, M. (2015). The Big Three in Economics: Adam Smith, Karl Marx, and John Maynard Keynes. *Routledge.*

392. Smith, S. (1976). An Extension of the Vent-For-Surplus Model in Relation to Long-Run Structural Change in Nigeria. *Oxford Economic Papers*, 28(3), 426-446.

393. Smith, A. (1776). An Inquiry into the Nature and Causes of the Wealth of Nations. *W. Strahan and T. Cadell*, London.

394. Smulders, S., Toman, M., & Withagen, C. (2014). Growth Theory and "Green Growth". *Oxford Review of Economic Policy*, 30(3), 423-446.

395. Solow, R. M. (1956). A Contribution to the Theory of Economic Growth. *The Quarterly Journal of Economics*, 70(1), 65-94.

396. Solow, R. M. (1987). We'd Better Watch Out. *New York Times Book Review*, p.36.

397. Southey, C. (1978). The Staples Thesis, Common Property, and Homesteading. *The Canadian Journal of Economics*, 11(3), 547-559.

398. Stigler, G. J. (1952). The Ricardian Theory of Value and Distribution. *Journal of Political Economy*, 60(3), 187-207.

399. Stiglitz, J. (1974a). Growth with Exhaustible Natural Resources: Efficient and Optimal Growth Paths. *The Review of Economic Studies*, 41(5), 123-137.

400. Stiglitz, J. E. (1974b). Growth with Exhaustible Natural Resources: The Competitive Economy. *The Review of Economic Studies*, 41(5), 139-152.

401. Straub, S. (2008). Infrastructure and Growth in Developing Countries: Recent Advances and Research Challenges. *World Bank Policy Research Working Paper* (4460).

402. Sultan, Z. A., Haque, M. I. (2018). Oil Exports and Economic Growth: An Empirical Evidence from Saudi Arabia. *International Journal of Energy Economics and Policy*, 8(5), 281-287.

403. Summers, L. H. (2014). Reflections on the "New Secular Stagnation Hypothesis". *Secular Stagnation: Facts, Causes and Cures,* 1, 27-40.

404. Summers, L. H. (2016). The Age of Secular Stagnation: What It Ys and What to Do About It. *Foreign Affairs*, 95(2), 2-9.

405. Swan, T. W. (1956). Economic Growth and Capital Accumulation. *Economic Record*, 32(2), 334-361.

406. Syverson, C. (2017). Challenges to Mismeasurement Explanations for the US Productivity Slowdown. *Journal of Economic Perspectives*, 31(2), 165-186.

407. Tadadjeu, S., Njangang, H., Asongu, S., Nounamo, Y. (2023). Natural Resources and Wealth Inequality: A Cross-Country Analysis. *Journal of Economic and Administrative Sciences*, 39(3), 596-608.

408. Tahir, M., Burki, U., Hayat, A. (2023). Natural Resources and Economic Growth: Evidence from Brunei Darussalam. *International Journal of Emerging Markets*, 18(10), 4252-4269.

409. Theil, H. (1967). Economics and Information Theory. *North-Holland Publishing Company.*

410. Theil, H. (1972). Statistical Decomposition Analysis: With Applications in the Social and Administrative Sciences. *North-Holland Publishing Company.*

411. Timmer, M. P., Van Ark, B. (2005). Does Information and Communication Technology Drive EU-US Productivity Growth Differentials?. *Oxford Economic Papers*, 57(4), 693-716.

412. Torres, N., Afonso, O., Soares, I. (2012). Oil Abundance and Economic Growth - A Panel Data Analysis. *The Energy Journal*, 33(2), 119-148.

413. Torvik, R. (2009). Why Do Some Resource-Abundant Countries Succeed While Others Do Not? *Oxford Review of Economic Policy*, 25(2), 241-256.

414. Trammell, P., Korinek, A. (2023). Economic Growth Under Transformative AI. *NBER Working Paper* No. w31815.

415. Tseng, C. Y., Ting, P. H. (2013). Patent Analysis for Technology Development of Artificial Intelligence: A Country-level Comparative Study. *Innovation*, 15(4), 463-475.

416. Tsui, K. K. (2011). More Oil, Less Democracy: Evidence from Worldwide Crude Oil Discoveries. *The Economic Journal*, 121(551), 89-115.

417. USPTO, (2020). Inventing AI. Tracing the Diffusion of Artificial Intelligence with U.S. Patents. Available HERE.

418. Van Ark, B., O'Mahony, M., Timmer, M. P. (2008). The Productivity Gap Between Europe and the United States: Trends and Causes. *Journal of Economic Perspectives*, 22(1), 25-44.

419. Van Ark, B. (2016). The Productivity Paradox of the New Digital Economy. *International Productivity Monitor*, 31, 3-18.

420. Van Ark, B., de Vries, K., Erumban, A. (2019). Productivity & Innovation Competencies in *the* Midst of the Digital Transformation Age: A EU-US Comparison. *European Economy-Discussion Papers*, (119).

421. Van den Bijgaart, I. (2017). The Unilateral Implementation of a Sustainable Growth Path With Directed Technical Change. *European Economic Review,* 91, 305-327.

422. Van der Ploeg, F., Poelhekke, S. (2009). Volatility and the Natural Resource Curse. *Oxford Economic Papers*, 61(4), 727-760.

423. Van der Ploeg, F. (2011). Natural Resources: Curse or Blessing? *Journal of Economic Literature*, 49(2), 366-420.

424. Van der Ploeg, F., Poelhekke, S. (2017). The Impact of Natural Resources: Survey of Recent Quantitative Evidence. *The Journal of Development Studies*, 53(2), 205-216.

425. Van Roy, V., Vertesy, D., Damioli, G. (2020). AI and Robotics Innovation. In: Zimmermann, K. (Eds.). *Handbook of Labor, Human Resources and Population Economics*. Springer.

426. Venturini, F. (2022). Intelligent Technologies and Productivity Spillovers: Evidence From the Fourth Industrial Revolution. *Journal of Economic Behavior & Organization*, 194, 220-243.

427. Vergara Marezco, S. (2019). The Role of Productive and Technological Capabilities on Export Dynamics in Developing Countries. *United Nations, Department of Economics and Social Affairs*.

428. Ville, S., Wicken, O. (2013). The Dynamics of Resource-Based Economic Development: Evidence from Australia and Norway. *Industrial and Corporate Change*, 22(5), 1341-1371.

429. Ville, S., Wicken, O., Dean, J. (2019). Dynamic Paths of Innovation in Natural Resource Industries in Australia and Norway Since World War Two. *Scandinavian Economic History Review*, 67(1), 90-109.

430. Vogel, T. (2022). Structural and Policy Determinants of Export Diversification in Africa: A Bilateral Panel Approach Using Bayesian Model Averaging. *UNCTAD Economic Development in Africa Report.*

431. Wahyudi, H., Palupi, W. A. (2023). Natural Resources Curse in Indonesia. *International Journal of Energy Economics and Policy*, 13(2), 349-356.

432. Weil, D.N. (2014). Economic Growth. *Routledge*. https://doi.org/10.4324/9781315510453.

433. Weisbrot, M., Sachs, J. (2019). Punishing Civilians: US Sanctions on Venezuela. *Challenge*, 62(5), 299-321.

434. Wilhelms, C. (1967). Export Diversification in Latin America. *Intereconomics*, 2(2), 46-48.

435. WIPO. (2019). Artificial Intelligence. *World Intellectual Property Organization.*

436. Witajewski-Baltvilks, J., Fischer, C. (2023). Green Innovation and Economic Growth in a North–South Model. *Environmental and Resource Economics*, 85(3), 615-648.

437. World Bank (2024a). Commodity Markets, The World Bank Group. Link, access: January 2024

438. World Bank (2024b). World Development Indicators, The World Bank Group. Link, access: January 2024

439. World Bank (2024c). World Bank Country and Lending Groups. Link, access: January 2024

440. World Bank (2024d). Worldwide Governance Indicators, The World Bank Group. Link, access: January 2024

441. Xiang, C. (2007). Diversification Cones, Trade Costs and Factor Market Linkages. *Journal of International Economics*, 71(2), 448-466.

442. Xiao, J., Boschma, R. (2023). The Emergence of Artificial Intelligence in European Regions: The Role of a Local ICT Base. *The Annals of Regional Science*, 71(3), 747-773.

443. Yang, B. (2010). Resource Curse: The Role of Institutions versus Policies. *Applied Economics Letters*, 17(1), 61-66.

444. Yeats, A. J. (1985). On the Appropriate Interpretation of the Revealed Comparative Advantage Index: Implications of a Methodology Based on Industry Sector Analysis. *Weltwirtschaftliches Archiv*, 121(1), 61-73.

445. Zarach, Z. H., Parteka, A. (2023a). Export Diversification and Dependence on Natural Resources. *Economic Modelling,* 126, 106436.

446. Zarach, Z. H., Parteka, A. (2023b). Productivity Effects of Trade in Natural Resources - Comparison with Mechanisms of Technological Specialisation. *The World Economy*, 46(9), 2684-2706.

447. Zellner, A., Kmenta, J., Dreze, J. (1966). Specification and Estimation of Cobb-Douglas Production Function Models. Econometrica: Journal of the Econometric Society, 784-795.

448. Zhang, X., Xing, L., Fan, S., Luo, X. (2009). Resource Abundance and Regional Development in China. In: Fan, S., Kanbur, R., Zhang, X. *Regional Inequality in China: Trends, Explanations and Policy Responses*. Routledge, pp. 113-134.

449. Zhang, Q., Brouwer, R. (2020). Is China Affected by the Resource Curse? A Critical Review of the Chinese Literature. *Journal of Policy Modeling*, 42(1), 133-152.

450. Zhang, Y., Liu, W., Khan, S. U., Swallow, B., Zhou, C., Zhao, M. (2022). An Insight Into the Drag Effect of Water, Land, and Energy on Economic Growth Across Space and Time: The Application of Improved Solow Growth Model. *Environmental Science and Pollution Research*, 29(5), 6886-6899.

451. Zubikova, A. (2018). Curse or Blessing: Economic Growth and Natural Resources. Comparison of the Development of Botswana, Canada, Nigeria and Norway in the Early 21st Century. *Agricultural and Resource Economics: International Scientific E-Journal*, 4(1), 20-41.

452. Zubikova, A. (2019). The Resource Curse and Its Implications For Fiscal Policy. *Agricultural and Resource Economics: International Scientific E-Journal*, 5(1), 48-70.

A. Appendix A. Supplementary Materials

Table A.1. List of countries and their income classification

Group of countries (number of countries)		Countries
Developing (108)	Low income countries (23)	Burkina Faso, Burundi, Central African Republic, Chad, Democratic Republic of the Congo, Ethiopia, Gambia, Guinea, Guinea-Bissau, Liberia, Madagascar, Malawi, Mali, Mozambique, Niger, Rwanda, Sierra Leone, Sudan, Syria, Togo, Uganda, Yemen, Zambia
	Middle income countries (85)	Albania, Algeria, Angola, Argentina, Armenia, Azerbaijan, Bangladesh, Belarus, Belize, Benin, Bhutan, Bolivia, Bosnia and Herzegovina, Brazil, Bulgaria, Cabo Verde, Cambodia, Cameroon, China, Colombia, Comoros, Congo, Costa Rica, Côte d'Ivoire, Djibouti, Dominican Republic, Ecuador, Egypt, El Salvador, Equatorial Guinea, Fiji, Gabon, Georgia, Ghana, Grenada, Guatemala, Guyana, Haiti, Honduras, India, Indonesia, Iran, Iraq, Jamaica, Jordan, Kazakhstan, Kenya, Kyrgyzstan, Laos, Lebanon, Malaysia, Maldives, Mauritania, Mauritius, Mexico, Moldova, Mongolia, Morocco, Myanmar, Nepal, Nicaragua, Nigeria, North Macedonia, Pakistan, Paraguay, Peru, Philippines, Russian Federation, Saint Lucia, Saint Vincent and the Grenadines, Sao Tome and Principe, Senegal, Sri Lanka, Suriname, Tajikistan, Tanzania, Thailand, Tunisia, Turkey, Turkmenistan, Ukraine, Uzbekistan, Venezuela, Vietnam, Zimbabwe
Developed (52)		Australia, Austria, Bahamas, Bahrain, Barbados, Belgium and Luxembourg, Brunei Darussalam, Canada, Chile, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hong Kong, Hungary, Iceland, Ireland, Israel, Italy, Japan, Kuwait, Latvia, Lithuania, Macao, Malta, Netherlands, New Zealand, Norway, Oman, Panama, Poland, Qatar, Romania, Saudi Arabia, Singapore, Slovakia, Slovenia, South Korea, Spain, Sweden, Switzerland, Trinidad and Tobago, United States of America, United Arab Emirates, United Kingdom, Uruguay

Notes: Belgium and Luxembourg (BELX) stands for joint data for Belgium (BEL) and Luxembourg (LUX). This measure matches the trend from 1996, 1997 and 1998, when data for Belgium and Luxembourg appeared as a sum under the abbreviation BEL.
Source: the World Bank's 2021 income classification (World Bank, 2024c).

Table A.2. List of natural resource exporters

Income class (number of countries)	List of countries
High income (11)	Australia, Bahrain, Brunei Darussalam, Chile, Kuwait, Norway, Oman, Qatar, Saudi Arabia, Trinidad and Tobago, United Arab Emirates
Middle income (19)	Algeria, Angola, Azerbaijan, Bolivia, Cameroon, Congo, Equatorial Guinea, Gabon, Iran, Iraq, Jamaica, Kazakhstan, Mongolia, Nigeria, Russian Federation, Saint Lucia, Tajikistan, Turkmenistan, Venezuela
Low income (6)	Chad, Democratic Republic of the Congo, Guinea, Mozambique, Sudan, Yemen, Zambia

Notes: natural resource exporters are countries with a resource export share of at least 50% (average from 1996 to 2021).
Sources: own calculations based on trade data from BACI CEPII (CEPII, 2023; Gaulier and Zignago, 2010) and the World Bank's 2021 income classification (World Bank, 2024c).

Table A.3. List of OPEC members

Income class (number of countries)	List of countries
High income (4)	Kuwait, Qatar, Saudi Arabia, United Arab Emirates
Middle income (11)	Algeria, Angola, Congo, Ecuador, Equatorial Guinea, Gabon, Indonesia, Iran, Iraq, Nigeria, Venezuela

Notes: the term "OPEC members" refers to the countries which are affiliated with the Organization of the Petroleum Exporting Countries (OPEC).
Source: the World Bank's 2021 income classification (World Bank, 2024c).

Table A.4. Natural resources taxonomies[1]

Abbr.	Number of HS96 6digit product codes[2]	Descriptions and numbers of the WTO's divisions
FORESTRY	47	Cork and wood (no. 24) Pulp and waste paper (no.25)
FUEL	40	Coal, coke and briquettes (no. 32) Petroleum, petroleum products and related materials (no. 33) Gas, natural and manufactured (no. 34) Electric current (no. 35)
COAL	20	Coal, coke and briquettes (no.32)
NATURAL GAS	7	Gas, natural and manufactured (no. 34)
PETROLEUM OILS	12	Petroleum, petroleum products and related materials (no. 33)
METAL	121	Non-ferrous metals (no. 68)
MINERAL	120	Crude fertilizers and crude minerals (no. 27) Metalliferous ores and metal scrap (no. 28)

Notes: the main natural resource segments from the WTO classification are divided into four groups: FORESTRY, FUEL, METAL and MINERAL. The FUEL group is further divided into three subgroups: coal, natural gas and petroleum oils. Detailed information and a list of product codes corresponding to each resource group are provided in the file "*classifications_PhD.xlsx*" in the Replication Package.
1) TOTAL NR classification, which is the primary taxonomy used in this dissertation, incorporates four main resource taxonomies listed above, namely FORESTRY, FUEL, METAL and MINERAL.
2) the number of product codes presented here represents all product codes before the data cleansing process, in which a few codes that vanished throughout the 1996-2021 time span were deleted.
Source: author's elaboration based on the WTO's natural resources classification (Bacchetta et al., 2010).

Table A.5. Technological products taxonomies

Abbr.	Source	Number of HS96 6digit product codes[1]	Descriptions
4IR	Parteka et al. (2025)	32	4IR (4th Industrial Revolution) related products
ICT	UNCTAD – OECD (2011b)	112	ICT (Information and Communication Technology) products
TECH	UNCTAD - Lall (2000)	1830	Middle- and high-tech products

Notes: detailed information and a list of product codes corresponding to each technological taxonomy are provided in the file "*classifications_PhD.xlsx*" in the Replication Package.
1) the number of product codes presented here represents all product codes before the data cleansing process, in which a few codes that vanished throughout the 1996-2021 time span were deleted.
Source: author's elaboration based on the works of Parteka et al. (2025), Domini et al. (2021), Foster-McGregor et al. (2019), OECD (2011b) and Lall (2000).

Table A.6. Comparative advantage in technologically advanced products (as of 2021)

Type of technologically advanced products#	Countries:					
	Developed (52)		Developing (108)			
			Middle income (85)		Low income (23)	
	No. *	%**	No.*	%**	No.*	%**
4IR	6	19%	1	3%	0	0%
ICT	13	15%	4	5%	1	1%
TECH	312	18%	100	6%	24	1%

Notes: * mean number of product codes with RCA>1 within the group, ** share of product codes with RCA>1 in total number of TECH products (within each technological product type); # types of technologically advanced products are based on established technological taxonomies (see Table A.5. in the Appendix A).
Source: own calculations based on trade data from BACI CEPII (CEPII, 2023; Gaulier and Zignago, 2010) and the World Bank's 2021 income classification (World Bank, 2024c).

Table A.7. Summary statistics

Variables description	Variable name	Source	n	mean	st. dev.	min	max
Measures of productivity	*LABPROD_a*	PWT 10.01	3840	39100.66	37931.92	612.82	275216.4
	LABPROD_b	PWT 10.01	3840	39549.41	38952.25	612.27	280748.2
Indices of export diversification	*RT*	BACI CEPII[1]	4160	2.87	1.52	0.33	9.19
	RT_inr_RC1	BACI CEPII[1]	4160	3.11	1.62	0.30	9.20
	RT_inr_RC2	BACI CEPII[1]	4160	2.86	1.52	0.32	9.21
	RT_inr_RC3	BACI CEPII[1]	4160	3.15	1.64	0.31	9.04
	RT_inr_RC4	BACI CEPII[1]	4160	2.86	1.51	0.32	9.17
	RT_inr_RC5	BACI CEPII[1]	4160	2.84	1.50	0.32	9.36
	RT_inr_RC6	BACI CEPII[1]	4160	2.87	1.52	0.33	9.18
	RT_inr_RC7	BACI CEPII[1]	4160	2.86	1.52	0.33	9.17
	RT_inr_RC8	BACI CEPII[1]	4160	3.14	1.61	0.32	9.07
	RT_int_TC1	BACI CEPII[1]	4160	2.87	1.51	0.33	9.18
	RT_int_TC2	BACI CEPII[1]	4160	2.81	1.49	0.34	9.08
	RT_int_TC3	BACI CEPII[1]	4160	2.58	1.38	0.44	8.89
	Theil	BACI CEPII[1]	4160	4.59	1.65	1.52	8.39
Share of resource exports in total exports	*ScRC1*	BACI CEPII[1]	4160	0.29	0.29	0	0.99
	ScRC2	BACI CEPII[1]	4160	0.02	0.05	0	0.59
	ScRC3	BACI CEPII[1]	4160	0.19	0.28	0	0.99
	ScRC4	BACI CEPII[1]	4160	0.03	0.09	0	0.86
	ScRC5	BACI CEPII[1]	4160	0.05	0.09	0	0.82
	ScRC6	BACI CEPII[1]	4160	0.01	0.03	0	0.45
	ScRC7	BACI CEPII[1]	4160	0.03	0.09	0	0.84
	ScRC8	BACI CEPII[1]	4160	0.15	0.25	0	0.99
Share of technological exports in total exports	*ScTC1*	BACI CEPII[1]	4160	0.002	0.01	0	0.04
	ScTC2	BACI CEPII[1]	4160	0.04	0.09	0	0.65
	ScTC3	BACI CEPII[1]	4160	0.24	0.22	0.0006	0.86
Share of natural resource rents in GDP (%)	*coal*	WDI	4120	0.28	2.01	0	48.72
	forest	WDI	4137	1.96	4.16	0	40.41
	gas	WDI	4103	0.64	2.36	0	55.01
	mineral	WDI	4137	0.76	2.27	0	28.81
	oil	WDI	4117	3.93	9.58	0	82.78
	total	WDI	4133	7.55	11.09	0	88.59
Gross fixed capital formation	*INV*	WDI	3634	22.61	7.42	-2.42	78.01
Imports and exports (% of GDP)	*Trade*	WDI	3749	84.29	52.90	0.03	442.62
Human capital index	*hc*	WDI	3288	2.47	0.71	1.05	4.35
=1 if country has a colonial past	*Colonialism*	COLDAT Colonial Dates	4108	0.65	0.48	0	1

=1 if country is landlocked	*landlock*	Gallup's geodata[2]	3536	0.24	0.42	0	1
km to closest major port	*airdist*	Gallup's geodata[2]	3536	3915.54	2335.38	140	9590
Timing of independence	*newstate*	Gallup's geodata[2]	3536	1.37	1.12	0	3
Proxy for countries' size	*rgdpe_ep*	PWT 10.01	4160	556104.3	1864693	0	21800000
Proxy for countries' level of development	*labprod_a*	PWT 10.01	4160	39735.01	38243.90	0	275216.4
Quality of governance	*INST_ip*	WGI	4160	47.87	26.61	1.51	99.76
Patent applications, residents	*PATENTS*	WDI	4160	8293.84	64583.06	0	1426644
R&D expenditure (% of GDP)	*RD*	WDI	2074	0.98	0.98	0.005	5.71

Source: author's calculations. Detailed information regarding all variables can be found in the "*0.PhD - creation of database.do*" and "*1.PhD - data preparation.do*" files in the Replication Package.
1) the author's calculations are based on trade data from BACI CEPII (CEPII, 2023; Gaulier & Zignago, 2010).
2) the Gallup et al. (1999) working paper features a dataset that includes various geographical measures accounting for the economic, social, political, and distance aspects of countries' geography.

Table A.8. Summary statistics for decomposition variables

Variable description	Variable name	Source	n	mean	st. dev.	min	max
Relative Theil index	*RT*	BACI CEPII[1]	4160	2.87	1.52	0.33	9.19
Components of RT (RC1 classification)	*betweenRC1*	BACI CEPII[1]	4160	0.274	0.434	0	2.225
	withinRC1_r	BACI CEPII[1]	4160	0.531	0.673	0	4.652
	withinRC1_nr	BACI CEPII[1]	4160	2.067	1.521	0.009	8.954
Components of RT (RC3 classification)	*betweenRC3*	BACI CEPII[1]	4160	0.255	0.478	0	2.739
	withinRC3_r	BACI CEPII[1]	4160	0.158	0.263	0	2.268
	withinRC3_nr	BACI CEPII[1]	4160	2.458	1.661	0.013	9.043
Components of RT (TC3 classification)	*betweenTC3*	BACI CEPII[1]	4160	0.294	0.239	0	0.773
	withinTC3_t	BACI CEPII[1]	4160	0.473	0.552	0.002	5.457
	withinTC3_nt	BACI CEPII[1]	4160	2.103	1.376	0.157	8.503

Source: author's calculations. Detailed information regarding all variables can be found in the "0.PhD - creation of database.do" file in the Replication Package.
1) the author's calculations are based on trade data from BACI CEPII (CEPII, 2023; Gaulier & Zignago, 2010).

Table A.9. Pairwise correlations between different variations of labor productivity (dependent variables from Chapter 4)

	LABPROD_a	LABPROD_b	GDPperWORKER
LABPROD_a	1.0000		
LABPROD_b	0.9932***	1.0000	
GDPperWORKER	0.9475***	0.9390***	1.0000

Notes: *** denotes significance at the 1% level.
The main labor productivity variable LABPROD_a was calculated using the expenditure-side real GDP (**rgdpe**) variable from PWT 10.01. The supplemental productivity variables include LABPROD_b, which is based on the **rgdpo** variable representing the output-side real GDP from PWT 10.01) and GDP per person employed (GDPperWORKER) from WDI.
Source: PWT 10.01 (Feenstra et al., 2015) and WDI (World Bank, 2024b).

Table A.10. Pairwise correlations between relative and absolute Theil indices (dependent variables form Chapter 5)

	Absolute Theil	Relative Theil	Non-resource relative Theil	Tech relative Theil
Absolute Theil	1.0000			
Relative Theil	0.6452***	1.0000		
Non-resource relative Theil	0.8122***	0.9075***	1.0000	
Tech relative Theil	0.5357***	0.9737***	0.8354***	1.0000

Notes: *** denotes significance at the 1% level.
The non-resource relative Theil was calculated for the TOTAL NR group of natural resources (taxonomy RC1).
The tech relative Theil was calculated for TECH group of technologically advanced products (taxonomy TC3). See the "*classifications_PhD.xlsx*" file in the Replication Package for more information.
Absolute Theil refers to the *Theil* variable, and Relative Theil refers to the *RT* variable. See Table A.7. in Appendix A and the "*0.PhD - creation of database.do*" file in the Replication Package for more information.

Table A.11. Pairwise correlation for main explanatory variables

	ScRC1	ScRC2	ScRC3	ScRC4	ScRC5	ScRC6	ScRC7	ScRC8	ScTC1	ScTC2	ScTC3	INV
ScRC1	1.0000											
ScRC2	0.1029***	1.0000										
ScRC3	0.8661***	-0.0575***	1.0000									
ScRC4	0.2645***	0.0067	-0.0863***	1.0000								
ScRC5	0.2527***	0.0052	-0.1157***	0.0789***	1.0000							
ScRC6	0.1562***	-0.0216	0.0940***	0.0549***	0.1598***	1.0000						
ScRC7	0.4254***	-0.0432***	0.4933***	-0.0481***	-0.0508***	-0.0045	1.0000					
ScRC8	0.8010***	-0.0512***	0.9360***	-0.0905***	-0.1293***	-0.0059	0.1958***	1.0000				
ScTC1	-0.2795***	-0.0553***	-0.2158***	-0.0655***	-0.1402***	-0.0389**	-0.1048***	-0.1981***	1.0000			
ScTC2	-0.2832***	-0.0835***	-0.2023***	-0.0929***	-0.1503***	-0.0384**	-0.1035***	-0.1805***	0.2983***	1.0000		
ScTC3	-0.4813***	-0.1171***	-0.3578***	-0.1490***	-0.2360***	-0.0620***	-0.1853***	-0.3221***	0.6166***	0.6319***	1.0000	
INV	0.1020***	-0.0672***	0.0835***	0.0466***	0.0618***	0.0891***	0.1141***	0.0352**	0.0510***	0.1206***	0.1366***	1.0000
Trade	-0.0634***	-0.0585***	-0.0224	-0.0168	-0.0822***	-0.0512***	-0.0232	-0.0125	0.1037***	0.4164***	0.3142***	0.1573***
hc	-0.1317***	-0.1071***	-0.1077***	0.0233	-0.0722***	0.0713***	0.0362**	-0.1431***	0.5171***	0.2918***	0.5850***	0.1634***
Colonialism	0.1349***	0.0759***	0.1003***	-0.0240	0.1080***	0.0050	0.0225	0.1037***	-0.4080***	-0.1444***	-0.4340***	-0.1581***
landlock	0.0015	0.0142	-0.0769***	0.1613***	0.0629***	-0.0123	0.0720***	-0.1322***	-0.0429**	-0.1460***	-0.1405***	0.0341*
airdist	0.2265***	0.0947***	0.0965***	0.2273***	0.1466***	0.0860***	0.0111	0.0828***	-0.4825***	-0.2418***	-0.6033***	-0.1227***
newstate	0.1693***	0.0889***	0.1188***	0.0635***	0.0689***	-0.0673***	0.0829***	0.1154***	-0.2030***	-0.0962***	-0.2384***	0.0738***
rgdpe_ep	-0.1070***	-0.0633***	-0.0617***	-0.0423***	-0.0770***	0.0292*	-0.0332**	-0.0559***	0.3219***	0.2210***	0.3134***	0.1186***
labprod_a	0.0715***	-0.1199***	0.1725***	-0.0495***	-0.1690***	0.0097	0.2125***	0.1232***	0.4154***	0.2194***	0.4365***	0.0708***
INST_ip	-0.2866***	-0.0957***	-0.2355***	-0.0414***	-0.1104***	0.0383**	-0.0749***	-0.2373***	0.5109***	0.3387***	0.6089***	0.1094***
PATENTS	-0.0929***	-0.0391**	-0.0654***	-0.0260*	-0.0508***	-0.0128	-0.0319**	-0.0581***	0.2968***	0.2219***	0.2353***	0.1563***
RD	-0.2975***	0.0008	-0.2354***	-0.0657***	-0.2018***	-0.0634***	-0.0993***	-0.2151***	0.6643***	0.2740***	0.6096***	0.0843***

Notes: ***,**,* denote significance at the 1%, 5%, and 10% levels respectively; detailed information regarding all variables can be found in the "*0.PhD - creation of database.do*" and "*1.PhD - data preparation.do*" files in the Replication Package. Source: author's calculations.

Table A.11. Pairwise correlation for main explanatory variables (cont.)

	Trade	hc	Colonialism	landlock	airdist	newstate	rgdpe_ep	labprod_a	INST_ip	PATENTS	RD
Trade	1.0000										
hc	0.3236***	1.0000									
Colonialism	-0.1929***	-0.5366***	1.0000								
landlock	-0.0020	-0.0794***	-0.1849***	1.0000							
airdist	-0.2197***	-0.5126***	0.5945***	0.1105***	1.0000						
newstate	0.0916***	-0.2191***	0.0458***	0.2814***	0.1255***	1.0000					
rgdpe_ep	-0.1665***	0.2305***	-0.1082***	-0.1532***	-0.2236***	-0.2479***	1.0000				
labprod_a	0.3588***	0.6142***	-0.3273***	-0.2362***	-0.4638***	-0.3023***	0.1978***	1.0000			
INST_ip	0.3296***	0.7085***	-0.3352***	-0.2233***	-0.4351***	-0.3694***	0.1567***	0.6898***	1.0000		
PATENTS	-0.1072***	0.1435***	-0.1225***	-0.0752***	-0.1632***	-0.1392***	0.7337***	0.0725***	0.0820***	1.0000	
RD	0.0392*	0.6001***	-0.2754***	-0.2104***	-0.4816***	-0.2408***	0.3363***	0.5470***	0.6481***	0.2889***	1.0000

Notes: ***,**,* denote significance at the 1%, 5%, and 10% levels respectively; detailed information regarding all variables can be found in the "*0.PhD - creation of database.do*" and "*1.PhD - data preparation.do*" files in the Replication Package. Source: author's calculations.

Table A.12. Share of resource and technological exports – selected countries[1]

	Iran		Oman		Saudi Arabia		United Arab Emirates	
	1996	2021	1996	2021	1996	2021	1996	2021
Share of resource exports	87.1%	24.7%	90.7%	66.1%	91.2%	71.7%	87.9%	43.2%
Share of technological exports	1.1%	43.2%	4.9%	23.9%	5.9%	19.5%	4.6%	25.9%
	Australia		Iceland		Jamaica		Kazakhstan	
	1996	2021	1996	2021	1996	2021	1996	2021
Share of resource exports	36.3%	73.1%	9.4%	45.2%	40.9%	65.6%	52.6%	70.5%
Share of technological exports	18.5%	5.8%	7.1%	9.5%	2.5%	3.4%	18.4%	11.1%
	Azerbaijan		Chad		Mongolia		Mozambique	
	1996	2021	1996	2021	1996	2021	1996	2021
Share of resource exports	29.1%	89.4%	0.1%	60.8%	36.5%	73.3%	9.4%	70.9%
Share of technological exports	14.8%	3.9%	8.1%	0.2%	1.5%	0.5%	1.1%	4.9%

Note: percentage share of resource and technological exports based on TOTAL NR classification of natural resources and TECH classification of technologically advanced products (for more detail, see Table A.4. and Table A.5. in Appendix A).
1) selected countries in accordance with the examples presented in Figure 4.4 and Figure 4.5. in Chapter 4.
Source: author's calculations based on trade data from BACI CEPII (CEPII, 2023; Gaulier & Zignago, 2010).

Table A.13. Results of the relative Theil decomposition (eq. 5) with respect to fossil fuel products

	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-fuel	2.46	83.1%	3.01	85.7%	1.32	81.7%	0.97	69.8%	0.85	39.2%	1.15	46.5%	0.80	39.9%
$S^c_{non-fuel}$	0.81		0.82		0.82		0.70		0.39		0.47		0.39	
$RT^c_{non-fuel}$	3.15		3.70		1.89		1.80		2.49		3.10		3.15	
within fuel	0.16	6.4%	0.16	5.4%	0.14	7.3%	0.21	11.4%	0.35	15.3%	0.54	20.3%	0.60	23.8%
S^c_{fuel}	0.19		0.18		0.18		0.30		0.61		0.53		0.61	
RT^c_{fuel}	1.38		1.52		1.12		0.96		0.70		1.13		0.95	
between	0.26	10.5%	0.24	8.9%	0.22	11.0%	0.38	18.8%	0.95	45.5%	0.87	33.2%	0.91	36.4%

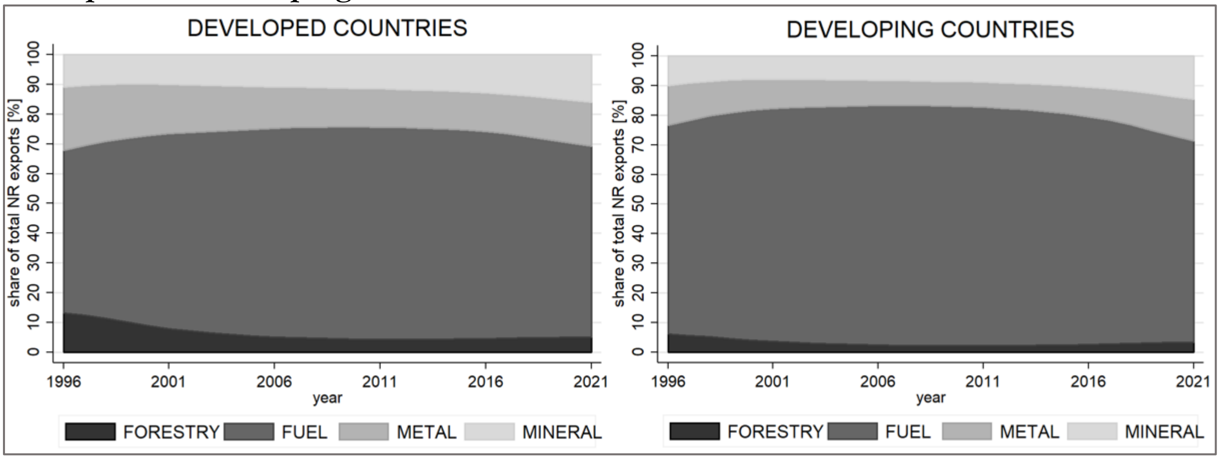
Notes: see eq.4 and 5 in Chapter 3 for details on the RT decomposition; here the decomposition was prepared for the full sample and for the output per worker intervals with respect to the FUEL products, which were later split into fuel and non-fuel groups (for more details on resource taxonomies see Table A.4. in Appendix A); the table reports average values over the sample period (160 countries, 1996-2021).
Source: author's elaboration based on trade data from BACI CEPII (CEPII, 2023; Gaulier and Zignago, 2010) and output per worker data from PWT 10.01 (Feenstra et al., 2015).

Table A.14. Resource exports and persistence over time

	$(NR_{ct} = \alpha + \beta NR_{c,t-1} + P^{NR}_t + \varepsilon_{ct})$ where the dep. var. (NR) is:							
	TOTAL NR	*FORESTRY*	*FUEL*	*METAL*	*MINERAL*	*COAL*	*NATURAL GAS*	*PETROLEUM*
$NR_{c,t-1}$	0.970***	0.927***	0.968***	0.986***	0.958***	0.931***	0.973***	0.964***
	(0.003)	(0.034)	(0.004)	(0.012)	(0.015)	(0.046)	(0.016)	(0.005)
P^{NR}_t	0.000*	-0.000	0.000	0.000**	0.000***	0.000*	0.000***	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
α	0.003	0.001	0.004	-0.001	-0.003**	-0.000	-0.001	0.003
	(0.005)	(0.002)	(0.003)	(0.001)	(0.002)	(0.001)	(0.001)	(0.002)
R^2	0.945	0.868	0.944	0.954	0.908	0.820	0.919	0.944
No. of obs.	4000	4000	4000	4000	4000	4000	4000	4000

Notes: estimates with time fixed effects in the form of NR price indices (P^{NR}_t); types of natural resources (NR) comply with the established resource taxonomies (see Table A.4. in Appendix A).
Source: based on trade data from BACI CEPII (CEPII, 2023; Gaulier and Zignago, 2010).

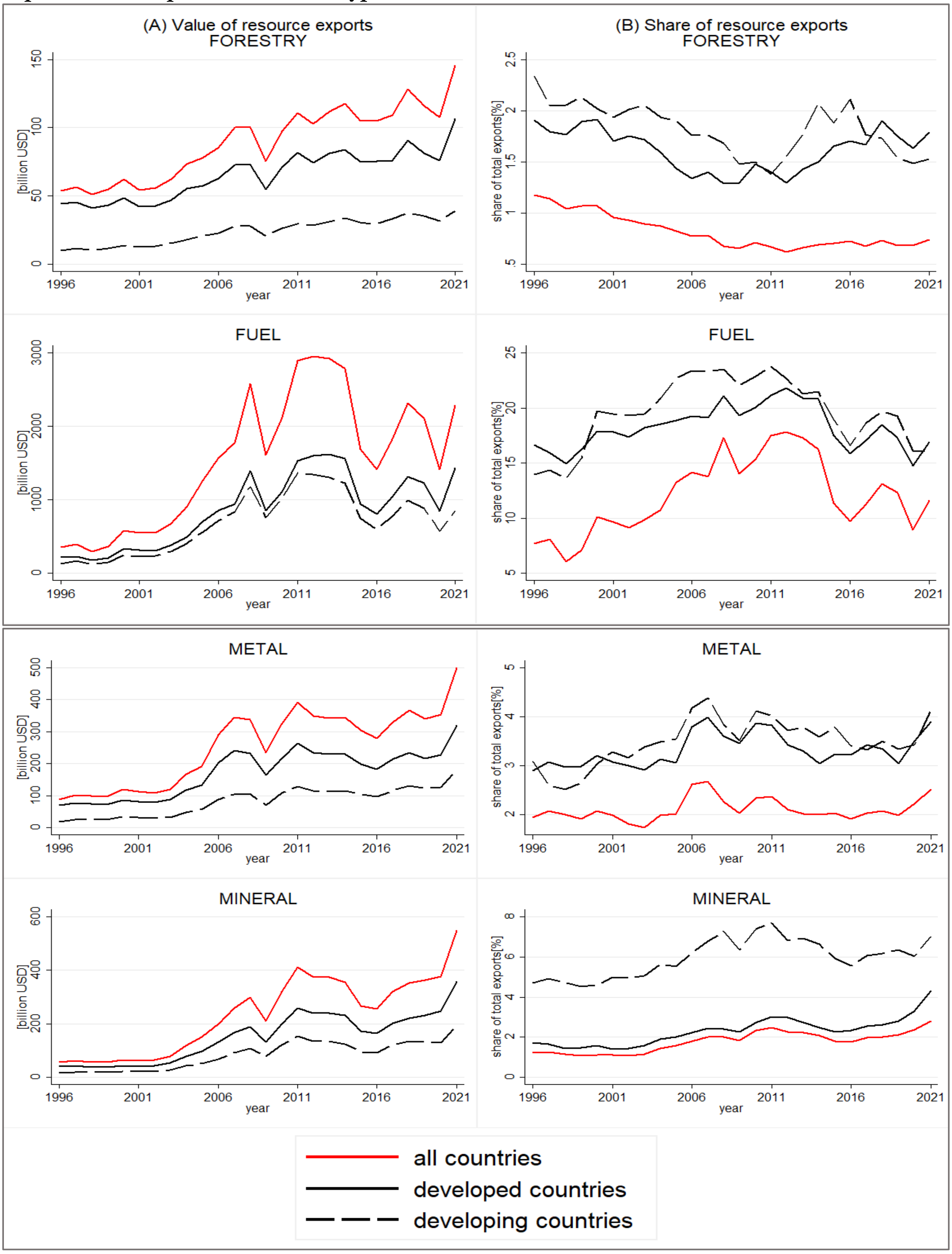
Figure A.1. The importance of resource types in total resource exports – subsamples of developed and developing countries



Notes: the sample comprises 160 countries over the 1996-2021 timespan (for the list of countries see Table A.1. in Appendix A); countries grouped using World Bank's 2021 income classification (World Bank, 2024c); types of natural resources based on the taxonomies from Table A.4. in Appendix A.

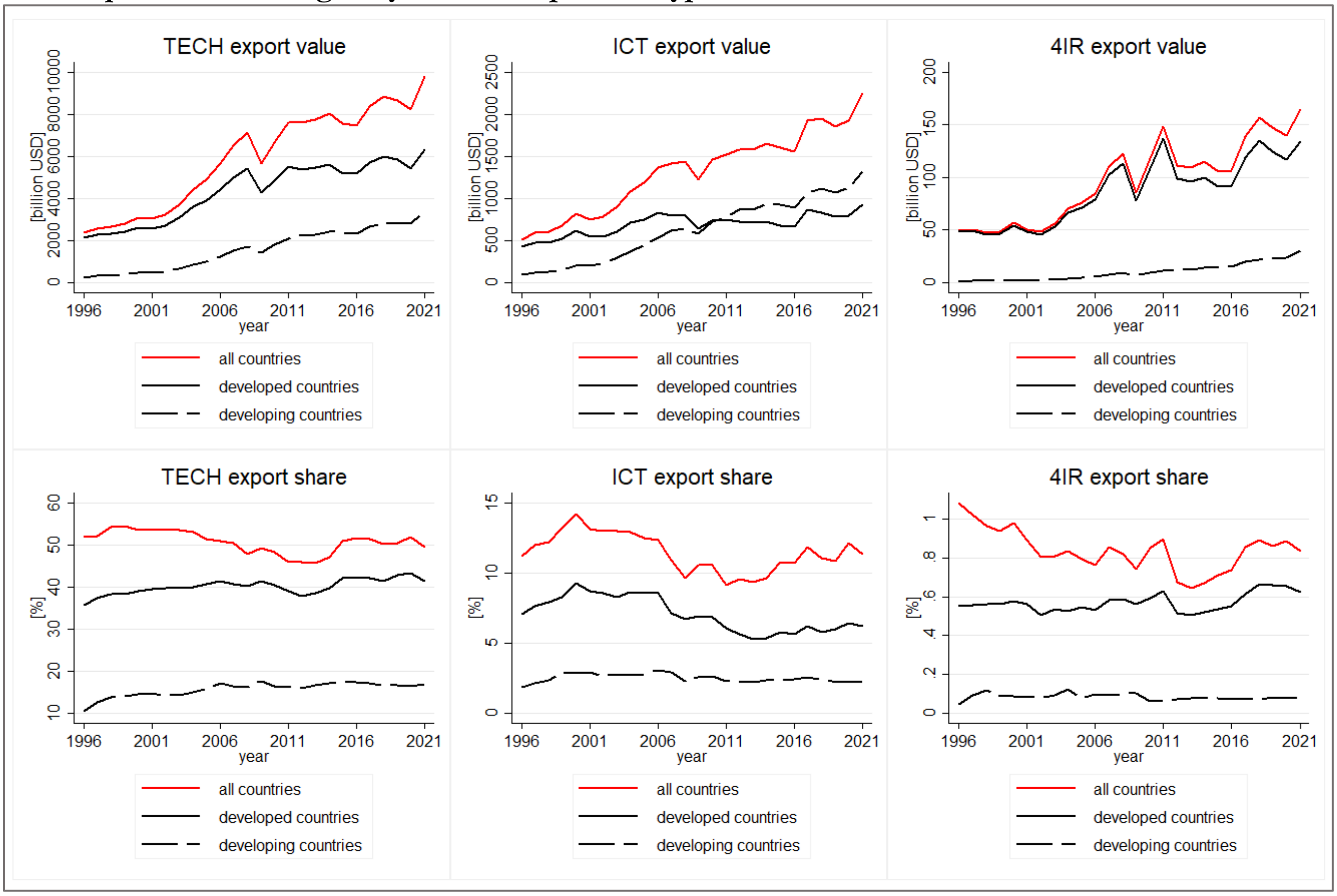
Source: author's elaboration based on trade data from BACI CEPII (CEPII, 2023; Gaulier and Zignago, 2010).

Figure A.2. Natural resource exports throughout the years - the value and the share of exports with respect to resource types



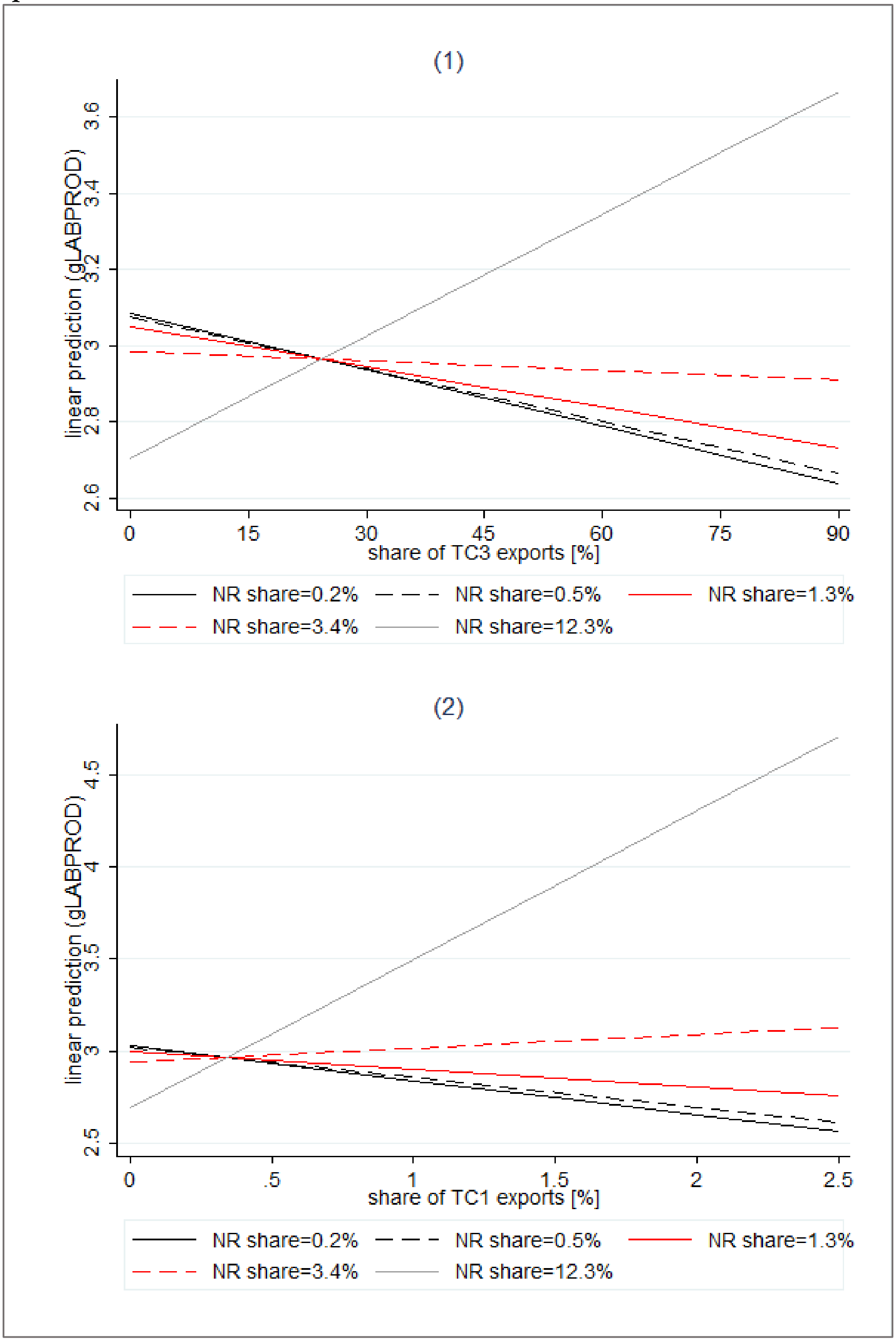
Notes: the sample comprises 160 countries over the 1996-2021 timespan (for the list of countries see Table A.1. in Appendix A); countries grouped using World Bank's 2021 income classification (World Bank, 2024c).
The share and the value of resource exports calculated for four main resource product groups, namely FORESTRY, FUEL, METAL, MINERAL (see Table A.4. in Appendix A for details on the applied taxonomies).
Source: author's elaboration based on trade data from BACI CEPII (CEPII, 2023; Gaulier and Zignago, 2010).

Figure A.3. Technological exports throughout the years - the value and the share of exports with respect to technologically advanced product types



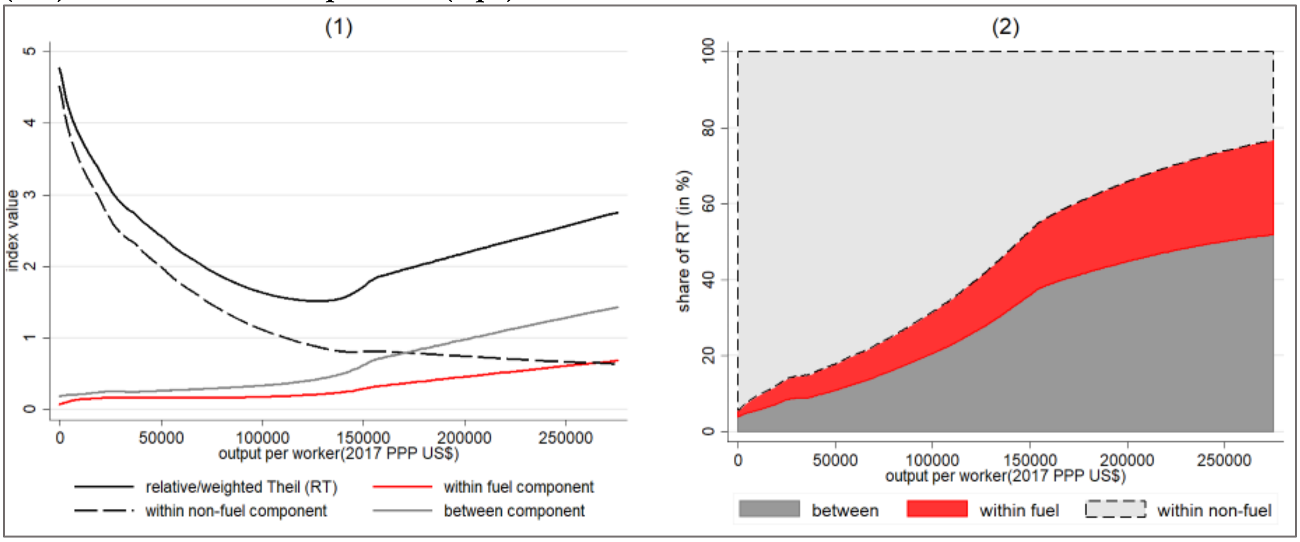
Notes: the sample comprises 160 countries over the 1996-2021 timespan (for the list of countries see Table A.1. in Appendix A); countries grouped using World Bank's 2021 income classification (World Bank, 2024c).
The share and the value of technological exports calculated for three main technologically advanced product groups, namely 4IR, ICT, TECH (see Table A.5. in Appendix A for details on the applied taxonomies).
Source: author's elaboration based on trade data from BACI CEPII (CEPII, 2023; Gaulier and Zignago, 2010).

Figure A.4. Productivity growth (predictive margins) – the role of technological specialization



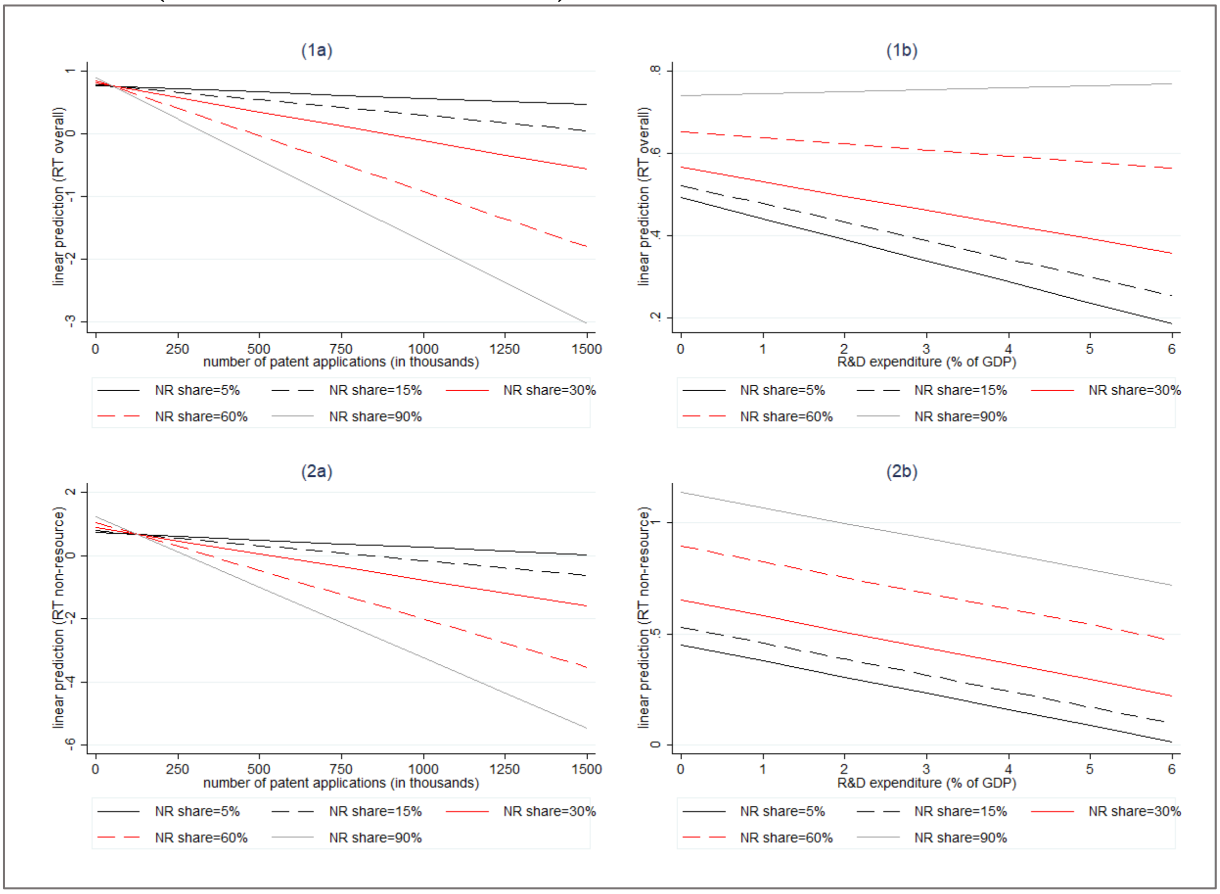
Notes: (1) TECH products; (2) 4IR products. *gLABPROD* is the growth rate of productivity (output per worker).
Margin plots computed for the estimation of eq.(9), which considers the share of MINERAL resource products in total country exports, as well as technological specialization, measured by the share of technologically advanced products in total country exports (for details on the used technological classifications, see Table A.5. in Appendix A). Threshold values for the resource shares are based on the percentiles of the variables (10th, 25th, 50th, 75th and 90th).
Source: author's elaboration based on data from BACI CEPII (CEPII, 2023; Gaulier and Zignago, 2010).

Figure A.5. Fuel-based decomposition[1] of the export diversification curve: relative Theil (RT) index[2] and its components (eq.5)



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 FUEL product group (see Table A.4. in Appendix A for details on the applied taxonomy); the sample comprises 160 countries over the 1996-2021 timespan (for the list of countries see Table A.1. in Appendix A).
1) see eq.4 and 5 in Chapter 3 for the details on the fuel-based decomposition of the export diversification curve.
2) the RT index is a weighted measure of export specialization (~1/export diversification); the higher the index value, the stronger the export concentration.
Source: author's elaboration based on trade data from BACI CEPII (CEPII, 2023; Gaulier and Zignago, 2010) and output per worker data from PWT 10.01 (Feenstra et al., 2015).

Figure A.6. Diversification of exports (predictive margins) - the role of technological innovation (PATENTS and RD variables)



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

Margin plots computed for the estimation of eq.(12), which considers the share of *TOTAL NR* resource products in total country exports, as well as technological innovation, measured by the number of patent applications submitted by residents (PATENTS) and the percentage of R&D expenditures in country's GDP (RD). 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 based on data from BACI CEPII (CEPII, 2023; Gaulier and Zignago, 2010).

B. Appendix B. Extensions and Robustness Checks

Table B.1. Estimation results (eq. 9) – relationship between productivity growth, dependence on natural resources[1] and 4IR exports

	Type of NR[2]							
Dependent variable: $g(y)_{ct}$	*TOTAL NR*	*FORESTRY*	*FUEL*	*METAL*	*MINERAL*	*COAL*	*NATURAL GAS*	*PETROLEUM*
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$y_{c,t-1}$	-0.027***	-0.021***	-0.028***	-0.024***	-0.025***	-0.022***	-0.021***	-0.027***
	(0.006)	(0.005)	(0.006)	(0.005)	(0.005)	(0.005)	(0.005)	(0.006)
$NR_{c,t-1}$	1.677**	5.662	2.173**	0.211	-4.745***	-5.796	1.398	2.413**
	(0.816)	(4.865)	(0.987)	(1.717)	(1.358)	(8.375)	(2.101)	(1.164)
$TECH_{c,t-1}$	-4.112	-33.316	18.565	-62.768	-64.181*	-40.468	-36.523	11.013
	(40.298)	(32.937)	(35.163)	(61.199)	(34.905)	(32.562)	(31.048)	(34.746)
$(NRxTECH)_{c,t-1}$	353.966	-177.172	117.026	1,846.872	3,148.889**	2,816.553	125.459	105.803
	(313.908)	(1,277.925)	(343.770)	(2,528.415)	(1,355.223)	(4,011.631)	(1,043.937)	(423.027)
P_t^{NR}	0.040***	0.068***	0.022***	0.044***	0.045***	0.019***	0.040***	0.023***
	(0.007)	(0.014)	(0.004)	(0.006)	(0.006)	(0.005)	(0.004)	(0.005)
No.of obs.	3,520	3,520	3,520	3,520	3,520	3,520	3,520	3,520
No. of countries	160	160	160	160	160	160	160	160
K-P rk Wald F	242.0	393.1	318.6	166.6	397.2	62.07	415.0	339.5
K-P rk LM	135.9	149.1	148.0	123.9	159.8	25.19	170.3	150.5
K-P rk LM (p-val)	0.000	0.000	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 a form of NR price indices (P_t^{NR}); K-P refers to Kleibergen-Paap test statistics; TECH includes products from the 4IR classification based on Parteka et al. (2025) – see Table A.5. in Appendix A. 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.
2) The presented types of natural resources (NR) comply with the established resource taxonomies (see Table A.4. in Appendix A).
Source: own calculations based on data from BACI CEPII (CEPII, 2023; Gaulier and Zignago, 2010), PWT 10.0 (Feenstra et al., 2015) and World Bank Commodity Price Data Annual Indices (World Bank, 2024a).

Table B.2. Estimation results (eq. 9) – relationship between productivity growth, dependence on natural resources[1] and ICT exports

Dependent variable: $g(y)_{ct}$	Type of NR[2]							
	TOTAL NR	*FORESTRY*	*FUEL*	*METAL*	*MINERAL*	*COAL*	*NATURAL GAS*	*PETROLEUM*
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$y_{c,t-1}$	-0.027***	-0.024***	-0.028***	-0.025***	-0.027***	-0.024***	-0.023***	-0.027***
	(0.005)	(0.005)	(0.005)	(0.004)	(0.005)	(0.005)	(0.004)	(0.005)
$NR_{c,t-1}$	2.042***	4.916	2.400**	1.151	-3.195**	-3.946	2.035	2.658**
	(0.781)	(4.543)	(0.932)	(1.475)	(1.324)	(5.806)	(1.971)	(1.113)
$TECH_{c,t-1}$	4.450***	0.894	4.186***	1.845	0.458	0.838	0.973	3.797***
	(1.570)	(1.115)	(1.315)	(1.489)	(1.379)	(1.176)	(1.126)	(1.272)
$(NRxTECH)_{c,t-1}$	-11.346	95.765	-17.175	-43.182	43.897	151.421	-49.189	-18.847
	(13.410)	(71.591)	(14.127)	(93.347)	(69.761)	(182.537)	(48.416)	(15.931)
P_t^{NR}	0.041***	0.070***	0.022***	0.045***	0.045***	0.020***	0.040***	0.024***
	(0.007)	(0.014)	(0.004)	(0.006)	(0.006)	(0.005)	(0.004)	(0.005)
No.of obs.	3,520	3,520	3,520	3,520	3,520	3,520	3,520	3,520
No. of countries	160	160	160	160	160	160	160	160
K-P rk Wald F	1834	330.3	3073	2500	2572	113.3	2165	3698
K-P rk LM	161.4	89.16	170.0	97.13	278.3	37.84	154.6	179.9
K-P rk LM (p-val)	0.000	0.000	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 a form of NR price indices (P_t^{NR}); K-P refers to Kleibergen-Paap test statistics; TECH includes products from the ICT classification based on OECD (2011) – see Table A.5. in Appendix A. 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.
2) The presented types of natural resources (NR) comply with the established resource taxonomies (see Table A.4. in Appendix A).
Source: own calculations based on data from BACI CEPII (CEPII, 2023; Gaulier and Zignago, 2010), PWT 10.0 (Feenstra et al., 2015) and World Bank Commodity Price Data Annual Indices (World Bank, 2024a).

Table B.3. Estimation results (eq. 7) – relationship between alternative measure of productivity growth[1] and dependence on natural resources[2]

Dependent variable: $g(y)_{ct}$	Type of NR[3]							
	TOTAL NR	*FORESTRY*	*FUEL*	*METAL*	*MINERAL*	*COAL*	*NATURAL GAS*	*PETROLEUM*
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$y_{c,t-1}$	-0.029***	-0.025***	-0.031***	-0.027***	-0.029***	-0.026***	-0.026***	-0.029***
	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.004)	(0.005)
$NR_{c,t-1}$	1.879**	5.121	2.351**	0.985	-3.347***	-5.473	2.758	2.595**
	(0.758)	(4.070)	(0.924)	(1.512)	(1.279)	(5.369)	(2.111)	(1.106)
P_t^{NR}	0.051***	0.072***	0.032***	0.050***	0.052***	0.029***	0.057***	0.033***
	(0.007)	(0.015)	(0.005)	(0.007)	(0.007)	(0.006)	(0.004)	(0.006)
No. of obs.	3,520	3,520	3,520	3,520	3,520	3,520	3,520	3,520
No. of countries	160	160	160	160	160	160	160	160
K-P rk Wald F	76596	713.0	52670	5899	3689	270.2	3200	39958
K-P rk LM	1297	86.26	773.2	105.9	190.2	42.93	108.2	585.7
K-P rk LM (p-val)	0.000	0.000	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 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 alternative measure of productivity growth is LABPROD_b (for more details, see Table A.9. in Appendix A).
2) 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.
3) The presented types of natural resources (NR) comply with the established resource taxonomies (see Table A.4. in Appendix A).
Source: own calculations based on data from BACI CEPII (CEPII, 2023; Gaulier and Zignago, 2010), PWT 10.0 (Feenstra et al., 2015) and World Bank Commodity Price Data Annual Indices (World Bank, 2024a).

Table B.4. Estimation results (eq. 8) – relationship between alternative measure of productivity growth[1], dependence on natural resources[2] and control variables

Dependent variable: $g(y)_{ct}$	Type of NR[3]							
	TOTAL NR	*FORESTRY*	*FUEL*	*METAL*	*MINERAL*	*COAL*	*NATURAL GAS*	*PETROLEUM*
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$y_{c,t-1}$	-0.039***	-0.035***	-0.042***	-0.036***	-0.037***	-0.035***	-0.034***	-0.041***
	(0.007)	(0.007)	(0.007)	(0.006)	(0.007)	(0.006)	(0.006)	(0.007)
$NR_{c,t-1}$	1.582*	0.430	2.380**	-0.014	-2.199	-2.887	-0.054	2.930**
	(0.830)	(3.216)	(1.089)	(1.917)	(1.466)	(5.880)	(3.068)	(1.296)
$INV_{c,t-1}$	0.074**	0.084**	0.078**	0.078**	0.082**	0.085**	0.091***	0.080**
	(0.035)	(0.036)	(0.035)	(0.035)	(0.035)	(0.036)	(0.035)	(0.035)
$OPEN_{c,t-1}$	0.010***	0.009***	0.010***	0.009***	0.009***	0.010***	0.008***	0.010***
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
$HC_{c,t-1}$	0.579*	0.433	0.714**	0.407	0.410	0.396	0.540*	0.757**
	(0.300)	(0.312)	(0.308)	(0.311)	(0.309)	(0.313)	(0.305)	(0.314)
P_t^{NR}	0.052***	0.076***	0.031***	0.052***	0.053***	0.031***	0.049***	0.034***
	(0.007)	(0.016)	(0.005)	(0.006)	(0.006)	(0.005)	(0.004)	(0.006)
No. of obs.	2,737	2,737	2,737	2,737	2,737	2,737	2,737	2,737
No. of countries	128	128	128	128	128	128	128	128
K-P rk Wald F	55845	551.1	30829	5159	3009	489.7	3055	22990
K-P rk LM	886.3	68.92	527.9	76.75	156.2	44.23	90.11	404.9
K-P rk LM (p-val)	0.000	0.000	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 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 alternative measure of productivity growth is LABPROD_b (for more details, see Table A.9. in Appendix A).
2) 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.
3) The presented types of natural resources (NR) comply with the established resource taxonomies (see Table A.4. in Appendix A).
Source: own calculations based on data from BACI CEPII (CEPII, 2023; Gaulier and Zignago, 2010), PWT 10.0 (Feenstra et al., 2015) and World Bank Commodity Price Data Annual Indices (World Bank, 2024a).

Table B.5. Estimation results (eq. 9) – relationship between alternative measure of productivity growth[1], dependence on natural resources[2] and TECH exports

Dependent variable: $g(y)_{ct}$	Type of NR[3]							
	TOTAL NR	*FORESTRY*	*FUEL*	*METAL*	*MINERAL*	*COAL*	*NATURAL GAS*	*PETROLEUM*
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$y_{c,t-1}$	-0.033***	-0.025***	-0.034***	-0.027***	-0.027***	-0.026***	-0.026***	-0.032***
	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)
$NR_{c,t-1}$	3.105***	7.366	3.694***	-0.180	-4.704***	-16.593	3.176	3.896***
	(1.064)	(5.795)	(1.237)	(2.020)	(1.661)	(10.700)	(2.625)	(1.438)
$TECH_{c,t-1}$	2.749**	0.050	2.537**	-0.466	-0.947	-0.664	0.078	2.076**
	(1.162)	(0.834)	(1.052)	(0.956)	(0.967)	(0.903)	(0.917)	(0.995)
$(NRxTECH)_{c,t-1}$	-6.633	-19.449	-11.972*	20.892	21.628	116.804*	-7.915	-14.217*
	(5.832)	(39.707)	(7.113)	(27.962)	(17.307)	(63.912)	(19.259)	(8.246)
P_t^{NR}	0.051***	0.071***	0.032***	0.050***	0.051***	0.029***	0.057***	0.035***
	(0.007)	(0.015)	(0.005)	(0.007)	(0.007)	(0.006)	(0.005)	(0.006)
No. of obs.	3,520	3,520	3,520	3,520	3,520	3,520	3,520	3,520
No. of countries	160	160	160	160	160	160	160	160
K-P rk Wald F	7060	308.2	9127	5513	1743	35.49	1384	9763
K-P rk LM	1077	71.24	1135	447.8	254.9	18.01	134.2	1123
K-P rk LM (p-val)	0.000	0.000	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 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) – see Table A.5. in Appendix A. Instrumented variables: $NR_{c,t-1}$ and $TECH_{c,t-1}$. Constant included – not reported.

1) The alternative measure of productivity growth is LABPROD_b (for more details, see Table A.9. in Appendix A).

2) 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.

3) The presented types of natural resources (NR) comply with the established resource taxonomies (see Table A.4. in Appendix A).

Source: own calculations based on data from BACI CEPII (CEPII, 2023; Gaulier and Zignago, 2010), PWT 10.0 (Feenstra et al., 2015) and World Bank Commodity Price Data Annual Indices (World Bank, 2024a).

Table B.6. Estimation results (eq. 7) – relationship between productivity growth and alternative measure of resource dependence[1]

Dependent variable: $g(y)_{ct}$	Type of NR rents:					
	TOTAL	*COAL*	*FOREST*	*OIL*	*GAS*	*MINERAL*
	(1)	(2)	(3)	(4)	(5)	(6)
$y_{c,t-1}$	-0.021***	-0.020***	-0.026***	-0.025***	-0.021***	-0.019***
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
$NR_{c,t-1}$	0.054**	0.069	-0.128***	0.079***	0.156**	0.104*
	(0.021)	(0.059)	(0.039)	(0.027)	(0.066)	(0.062)
No. of obs.	3,502	3,492	3,507	3,483	3,474	3,507
No. of countries	160	160	160	160	159	160
K-P rk Wald F	7893	85.71	2366	6485	151.5	771.5
K-P rk LM	464.6	20.44	202.0	293.9	28.73	99.71
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; time fixed effects included; 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 rents of natural resources, expressed as a percentage of GDP.
Source: own calculations based on data from World Development Indicators (World Bank, 2024b), PWT 10.0 (Feenstra et al., 2015) and World Bank Commodity Price Data Annual Indices (World Bank, 2024a).

Table B.7. Estimation results (eq. 8) – relationship between productivity growth, alternative measure of resource dependence[1] and control variables

Dependent variable: $g(y)_{ct}$	Type of NR rents:					
	TOTAL	*COAL*	*FOREST*	*OIL*	*GAS*	*MINERAL*
	(1)	(2)	(3)	(4)	(5)	(6)
$y_{c,t-1}$	-0.035***	-0.030***	-0.032***	-0.037***	-0.034***	-0.031***
	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)
$NR_{c,t-1}$	0.054**	0.258	-0.047	0.063*	0.287*	0.022
	(0.027)	(0.222)	(0.045)	(0.033)	(0.164)	(0.078)
$INV_{c,t-1}$	0.110***	0.108***	0.112***	0.110***	0.106***	0.115***
	(0.032)	(0.035)	(0.033)	(0.032)	(0.033)	(0.034)
$OPEN_{c,t-1}$	0.011***	0.011***	0.011***	0.011***	0.011***	0.011***
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
$HC_{c,t-1}$	0.869***	0.464*	0.394	0.804***	0.612**	0.491*
	(0.284)	(0.266)	(0.293)	(0.269)	(0.267)	(0.268)
No. of obs.	2,737	2,733	2,737	2,718	2,709	2,737
No. of countries	128	128	128	128	127	128
K-P rk Wald F	5793	24.27	1357	4179	2031	604.6
K-P rk LM	302.3	9.719	118.1	184.4	79.47	74.34
K-P rk LM (p-val)	0.000	0.001	0.000	0.000	0.000	0.000

Notes: *,**,*** denote significance at the 1%, 5%, and 10% levels respectively; robust standard errors in parentheses; time fixed effects included; 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 rents of natural resources, expressed as a percentage of GDP.
Source: own calculations based on data from World Development Indicators (World Bank, 2024b), PWT 10.0 (Feenstra et al., 2015) and World Bank Commodity Price Data Annual Indices (World Bank, 2024a).

Table B.8. Estimation results (eq. 9) – relationship between productivity growth, alternative measure of resource dependence[1] and TECH exports

Dependent variable: $g(y)_{ct}$	Type of NR rents:					
	TOTAL	*COAL*	*FOREST*	*OIL*	*GAS*	*MINERAL*
	(1)	(2)	(3)	(4)	(5)	(6)
$y_{c,t-1}$	-0.025***	-0.018***	-0.023***	-0.028***	-0.020***	-0.016***
	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)
$NR_{c,t-1}$	0.085***	0.067	-0.132***	0.114***	0.209**	0.014
	(0.030)	(0.138)	(0.047)	(0.039)	(0.089)	(0.069)
$TECH_{c,t-1}$	1.810**	-0.844	-1.078	1.358*	-0.233	-1.019
	(0.902)	(0.701)	(0.717)	(0.778)	(0.725)	(0.751)
$(NRxTECH)_{c,t-1}$	-0.268*	0.020	-0.027	-0.442	-0.989**	1.588**
	(0.152)	(0.472)	(0.217)	(0.328)	(0.496)	(0.714)
No. of obs.	3,502	3,492	3,507	3,483	3,474	3,507
No. of countries	160	160	160	160	159	160
K-P rk Wald F	2489	13.43	2015	2790	46.10	293.8
K-P rk LM	517.2	15.82	380.2	403.8	18.70	79.55
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; time fixed effects included; K-P refers to Kleibergen-Paap test statistics; TECH includes products from the middle- and high-tech classification based on Lall (2000) – see Table A.5. in Appendix A. Instrumented variables: $NR_{c,t-1}$ and $TECH_{c,t-1}$. Constant included – not reported.

1) The resource dependence is measured by the rents of natural resources, expressed as a percentage of GDP.

Source: own calculations based on data from World Development Indicators (World Bank, 2024b), PWT 10.0 (Feenstra et al., 2015) and World Bank Commodity Price Data Annual Indices (World Bank, 2024a).

Table B.9. Estimation results (eq. 7) – relationship between productivity growth and dependence on natural resources[1] – developed countries

Dependent variable: $g(y)_{ct}$	Type of NR[2]							
	TOTAL NR	*FORESTRY*	*FUEL*	*METAL*	*MINERAL*	*COAL*	*NATURAL GAS*	*PETROLEUM*
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$y_{c,t-1}$	-0.042***	-0.035***	-0.044***	-0.038***	-0.038***	-0.035***	-0.040***	-0.041***
	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)
$NR_{c,t-1}$	2.035*	0.059	2.699*	-2.419	-8.486***	-2.528	5.472	2.972*
	(1.199)	(4.689)	(1.402)	(3.003)	(3.217)	(3.892)	(4.497)	(1.698)
P_t^{NR}	0.022**	0.024	0.009	0.030***	0.032***	0.009	0.027***	0.007
	(0.009)	(0.018)	(0.006)	(0.008)	(0.008)	(0.008)	(0.005)	(0.007)
No. of obs.	1,144	1,144	1,144	1,144	1,144	1,144	1,144	1,144
No. of countries	52	52	52	52	52	52	52	52
K-P rk Wald F	24463	2189	17640	3561	2164	1345	2463	10411
K-P rk LM	369.0	69.83	254.4	65.15	41.60	23.02	86.26	178.6
K-P rk LM (p-val)	0.000	0.000	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; subsample of developed countries (see Table A.1. in Appendix A); 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.
2) The presented types of natural resources (NR) comply with the established resource taxonomies (see Table A.4. in Appendix A).
Source: own calculations based on data from BACI CEPII (CEPII, 2023; Gaulier and Zignago, 2010), PWT 10.0 (Feenstra et al., 2015) and World Bank Commodity Price Data Annual Indices (World Bank, 2024a).

Table B.10. Estimation results (eq. 8) – relationship between productivity growth, dependence on natural resources[1] and control variables – developed countries

Dependent variable: $g(y)_{ct}$	Type of NR[2]							
	TOTAL NR	*FORESTRY*	*FUEL*	*METAL*	*MINERAL*	*COAL*	*NATURAL GAS*	*PETROLEUM*
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$y_{c,t-1}$	-0.036***	-0.031***	-0.037***	-0.036***	-0.036***	-0.034***	-0.035***	-0.036***
	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)
$NR_{c,t-1}$	0.690	5.643	1.385	-1.896	-4.310	3.448	3.652	1.347
	(1.176)	(4.052)	(1.624)	(2.966)	(3.235)	(3.977)	(5.427)	(2.080)
$INV_{c,t-1}$	0.023	0.021	0.023	0.024	0.028	0.021	0.007	0.026
	(0.041)	(0.041)	(0.041)	(0.041)	(0.041)	(0.042)	(0.041)	(0.042)
$OPEN_{c,t-1}$	0.005***	0.005***	0.006***	0.005**	0.004**	0.005**	0.006***	0.005***
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
$HC_{c,t-1}$	-0.933**	-0.983*	-0.778	-1.199**	-1.163**	-1.064**	-0.711	-0.780
	(0.470)	(0.519)	(0.483)	(0.504)	(0.505)	(0.522)	(0.499)	(0.489)
P_t^{NR}	0.023***	0.034**	0.009*	0.032***	0.033***	0.013**	0.018***	0.009
	(0.008)	(0.016)	(0.005)	(0.007)	(0.007)	(0.007)	(0.005)	(0.006)
No. of obs.	1,029	1,029	1,029	1,029	1,029	1,029	1,029	1,029
No. of countries	47	47	47	47	47	47	47	47
K-P rk Wald F	12947	2115	7293	3537	2082	1380	3407	3362
K-P rk LM	304.6	68.50	186.4	67.27	43.10	24.57	48.41	146.0
K-P rk LM (p-val)	0.000	0.000	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; subsample of developed countries (see Table A.1. in Appendix A); 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.
2) The presented types of natural resources (NR) comply with the established resource taxonomies (see Table A.4. in Appendix A).
Source: own calculations based on data from BACI CEPII (CEPII, 2023; Gaulier and Zignago, 2010), PWT 10.0 (Feenstra et al., 2015) and World Bank Commodity Price Data Annual Indices (World Bank, 2024a).

Table B.11. Estimation results (eq. 9) – relationship between productivity growth, dependence on natural resources[1] and TECH exports – developed countries

Dependent variable: $g(y)_{ct}$	Type of NR[2] *TOTAL NR*	*FORESTRY*	*FUEL*	*METAL*	*MINERAL*	*COAL*	*NATURAL GAS*	*PETROLEUM*
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$y_{c,t-1}$	-0.045***	-0.039***	-0.050***	-0.042***	-0.043***	-0.037***	-0.042***	-0.045***
	(0.009)	(0.009)	(0.010)	(0.009)	(0.009)	(0.009)	(0.009)	(0.010)
$NR_{c,t-1}$	3.706*	-20.332**	5.779**	-10.152	-21.012***	-9.141	9.261	6.362**
	(2.227)	(9.798)	(2.266)	(6.548)	(7.582)	(9.695)	(7.178)	(2.723)
$TECH_{c,t-1}$	0.692	-3.103**	1.167	-3.657**	-4.034***	-2.486**	-1.491	0.667
	(1.585)	(1.303)	(1.121)	(1.427)	(1.331)	(1.137)	(1.126)	(1.118)
$(NRxTECH)_{c,t-1}$	-21.124***	66.817***	-29.077***	35.220	77.095	18.857	-61.765*	-32.001***
	(7.582)	(24.646)	(8.860)	(41.317)	(63.149)	(54.641)	(37.247)	(10.026)
P_t^{NR}	0.030***	0.029	0.016***	0.033***	0.034***	0.011	0.027***	0.015**
	(0.009)	(0.018)	(0.006)	(0.008)	(0.008)	(0.007)	(0.005)	(0.007)
No. of obs.	1,144	1,144	1,144	1,144	1,144	1,144	1,144	1,144
No. of countries	52	52	52	52	52	52	52	52
K-P rk Wald F	7419	358.7	5828	1027	430.5	255.8	711.5	2679
K-P rk LM	280.6	63.63	185.4	139.0	65.43	25.90	89.16	119.7
K-P rk LM (p-val)	0.000	0.000	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; subsample of developed countries (see Table A.1. in Appendix A); 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) – see Table A.5. in Appendix A. 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.

2) The presented types of natural resources (NR) comply with the established resource taxonomies (see Table A.5. in Appendix A).

Source: own calculations based on data from BACI CEPII (CEPII, 2023; Gaulier and Zignago, 2010), PWT 10.0 (Feenstra et al., 2015) and World Bank Commodity Price Data Annual Indices (World Bank, 2024a).

Table B.12. Estimation results (eq. 7) – relationship between productivity growth and dependence on natural resources[1] – developing countries

Dependent variable: $g(y)_{ct}$	Type of NR[2]							
	TOTAL NR	*FORESTRY*	*FUEL*	*METAL*	*MINERAL*	*COAL*	*NATURAL GAS*	*PETROLEUM*
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$y_{c,t-1}$	-0.056***	-0.043***	-0.062***	-0.047***	-0.050***	-0.044***	-0.035***	-0.059***
	(0.014)	(0.014)	(0.015)	(0.013)	(0.013)	(0.014)	(0.013)	(0.014)
$NR_{c,t-1}$	2.259**	5.156	2.827**	1.116	-2.541*	-3.299	1.709	3.013**
	(0.908)	(4.862)	(1.157)	(1.586)	(1.330)	(6.842)	(2.036)	(1.332)
P_t^{NR}	0.056***	0.100***	0.033***	0.056***	0.057***	0.029***	0.047***	0.037***
	(0.009)	(0.018)	(0.006)	(0.008)	(0.008)	(0.007)	(0.006)	(0.007)
No. of obs.	2,376	2,376	2,376	2,376	2,376	2,376	2,376	2,376
No. of countries	108	108	108	108	108	108	108	108
K-P rk Wald F	42910	538.6	27786	4337	3261	153.8	1749	24821
K-P rk LM	973.6	66.11	543.5	78.39	170.6	26.88	62.54	427.5
K-P rk LM (p-val)	0.000	0.000	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; subsample of developing countries (see Table A.1. in Appendix A); 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.
2) The presented types of natural resources (NR) comply with the established resource taxonomies (see Table A.4. in Appendix A).
Source: own calculations based on data from BACI CEPII (CEPII, 2023; Gaulier and Zignago, 2010), PWT 10.0 (Feenstra et al., 2015) and World Bank Commodity Price Data Annual Indices (World Bank, 2024a).

Table B.13. Estimation results (eq. 8) – relationship between productivity growth, dependence on natural resources[1] and control variables – developing countries

Dependent variable: $g(y)_{ct}$	Type of NR[2]							
	TOTAL NR	*FORESTRY*	*FUEL*	*METAL*	*MINERAL*	*COAL*	*NATURAL GAS*	*PETROLEUM*
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$y_{c,t-1}$	-0.092***	-0.078***	-0.113***	-0.084***	-0.084***	-0.078***	-0.067***	-0.115***
	(0.016)	(0.017)	(0.018)	(0.017)	(0.017)	(0.017)	(0.017)	(0.018)
$NR_{c,t-1}$	2.078**	0.049	3.747***	-2.769	-2.767*	-0.933	-2.939	4.402***
	(0.969)	(3.802)	(1.324)	(1.972)	(1.507)	(7.833)	(3.878)	(1.503)
$INV_{c,t-1}$	0.106***	0.115***	0.113***	0.112***	0.115***	0.117***	0.136***	0.114***
	(0.040)	(0.040)	(0.040)	(0.039)	(0.040)	(0.041)	(0.039)	(0.040)
$OPEN_{c,t-1}$	0.022***	0.021***	0.021***	0.022***	0.022***	0.023***	0.017**	0.021***
	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)
$HC_{c,t-1}$	0.797*	0.712	1.145***	0.788*	0.715	0.633	0.852*	1.268***
	(0.425)	(0.446)	(0.416)	(0.446)	(0.443)	(0.451)	(0.439)	(0.424)
P_t^{NR}	0.056***	0.100***	0.032***	0.058***	0.059***	0.034***	0.039***	0.037***
	(0.009)	(0.021)	(0.006)	(0.008)	(0.008)	(0.007)	(0.006)	(0.007)
No. of obs.	1,708	1,708	1,708	1,708	1,708	1,708	1,708	1,708
No. of countries	81	81	81	81	81	81	81	81
K-P rk Wald F	33567	391.5	16404	3078	2428	249.9	1316	14313
K-P rk LM	685.0	50.68	403.5	46.22	132.1	25.96	51.93	323.7
K-P rk LM (p-val)	0.000	0.000	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; subsample of developing countries (see Table A.1. in Appendix A); 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.
2) The presented types of natural resources (NR) comply with the established resource taxonomies (see Table A.4. in Appendix A).
Source: own calculations based on data from BACI CEPII (CEPII, 2023; Gaulier and Zignago, 2010), PWT 10.0 (Feenstra et al., 2015) and World Bank Commodity Price Data Annual Indices (World Bank, 2024a).

Table B.14. Estimation results (eq. 9) – relationship between productivity growth, dependence on natural resources[1] and TECH exports – developing countries

Dependent variable: $g(y)_{ct}$	Type of NR[2]							
	TOTAL NR	*FORESTRY*	*FUEL*	*METAL*	*MINERAL*	*COAL*	*NATURAL GAS*	*PETROLEUM*
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$y_{c,t-1}$	-0.065***	-0.044***	-0.071***	-0.050***	-0.048***	-0.044***	-0.035**	-0.066***
	(0.016)	(0.015)	(0.017)	(0.015)	(0.015)	(0.015)	(0.015)	(0.016)
$NR_{c,t-1}$	3.021***	12.727*	3.469**	-0.907	-4.144**	-9.239	2.045	3.606**
	(1.171)	(7.162)	(1.426)	(2.195)	(1.717)	(12.437)	(2.340)	(1.628)
$TECH_{c,t-1}$	2.769*	0.955	2.435*	-0.598	-1.187	-0.235	0.188	2.131
	(1.511)	(1.111)	(1.397)	(1.187)	(1.301)	(1.170)	(1.224)	(1.314)
$(NRxTECH)_{c,t-1}$	-2.081	-75.971**	-2.085	51.809	30.663*	75.755	-8.831	-3.355
	(7.892)	(38.290)	(9.941)	(41.247)	(17.825)	(78.109)	(17.755)	(11.756)
P_t^{NR}	0.055***	0.099***	0.032***	0.056***	0.057***	0.029***	0.047***	0.037***
	(0.009)	(0.018)	(0.006)	(0.008)	(0.008)	(0.007)	(0.006)	(0.007)
No. of obs.	2,376	2,376	2,376	2,376	2,376	2,376	2,376	2,376
No. of countries	108	108	108	108	108	108	108	108
K-P rk Wald F	1443	290.7	2025	2398	2233	27.25	2650	2145
K-P rk LM	302.6	70.08	350.0	438.2	443.3	12.81	368.4	376.9
K-P rk LM (p-val)	0.000	0.000	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; subsample of developing countries (see Table A.1. in Appendix A); 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) – see Table A.5. in Appendix A. 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.

2) The presented types of natural resources (NR) comply with the established resource taxonomies (see Table A.4. in Appendix A).

Source: own calculations based on data from BACI CEPII (CEPII, 2023; Gaulier and Zignago, 2010), PWT 10.0 (Feenstra et al., 2015) and World Bank Commodity Price Data Annual Indices (World Bank, 2024a).

Table B.15. Estimation results (eq. 7) – relationship between productivity growth and dependence on natural resources[1] – NR exporters[2]

Dependent variable: $g(y)_{ct}$	Type of NR[3]							
	TOTAL NR	*FORESTRY*	*FUEL*	*METAL*	*MINERAL*	*COAL*	*NATURAL GAS*	*PETROLEUM*
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$y_{c,t-1}$	-0.040***	-0.036***	-0.046***	-0.041***	-0.044***	-0.036***	-0.040***	-0.041***
	(0.010)	(0.010)	(0.011)	(0.010)	(0.010)	(0.009)	(0.009)	(0.010)
$NR_{c,t-1}$	2.801	2.430	3.106**	-2.481	-8.301***	-3.428	0.731	3.080**
	(2.869)	(17.080)	(1.527)	(2.019)	(2.191)	(5.652)	(2.327)	(1.568)
P_t^{NR}	0.057**	0.051	0.039***	0.066***	0.069***	0.023	0.114***	0.035**
	(0.023)	(0.044)	(0.013)	(0.019)	(0.019)	(0.017)	(0.013)	(0.016)
No. of obs.	814	814	814	814	814	814	814	814
No. of countries	37	37	37	37	37	37	37	37
K-P rk Wald F	1153	672.0	12052	4677	1914	288.3	2436	20217
K-P rk LM	196.1	40.84	459.2	97.02	113.1	23.88	78.21	500.4
K-P rk LM (p-val)	0.000	0.000	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; subsample of NR exporters (for more details, see Table A.2. in Appendix A); 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.
2) NR exporters are countries with a share of resource exports of at least 50% (average from 1996 to 2021).
3) The presented types of natural resources (NR) comply with the established resource taxonomies (see Table A.4. in Appendix A).
Source: own calculations based on data from BACI CEPII (CEPII, 2023; Gaulier and Zignago, 2010), PWT 10.0 (Feenstra et al., 2015) and World Bank Commodity Price Data Annual Indices (World Bank, 2024a).

Table B.16. Estimation results (eq. 11) – relationship between natural resource dependence[1] and diversification of exports – the role of institutional quality[2]

Dependent variable: $lnRT_{ct}$	Type of NR[3]						
	FORESTRY	*FUEL*	*METAL*	*MINERAL*	*COAL*	*NATURAL GAS*	*PETROLEUM*
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
NR_{ct}	-0.695***	-0.409***	-0.610***	-0.301***	-0.999***	0.222***	-0.481***
	(0.097)	(0.034)	(0.095)	(0.073)	(0.143)	(0.061)	(0.034)
$INST_{ct}$	-0.007***	-0.009***	-0.007***	-0.007***	-0.007***	-0.006***	-0.009***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
$(NRxINST)_{ct}$	0.018***	0.008***	0.023***	0.024***	0.030***	0.011***	0.008***
	(0.003)	(0.001)	(0.002)	(0.001)	(0.003)	(0.002)	(0.001)
$lnSIZE_{ct}$	-0.187***	-0.183***	-0.188***	-0.181***	-0.188***	-0.186***	-0.185***
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
$lnDEV_{c,t-1}$	-0.002	0.027***	-0.001	-0.003	-0.006	-0.020***	0.030***
	(0.007)	(0.008)	(0.007)	(0.006)	(0.007)	(0.007)	(0.007)
$COLONIAL_{ct}$	0.095***	0.094***	0.087***	0.078***	0.085***	0.084***	0.096***
	(0.013)	(0.013)	(0.013)	(0.012)	(0.013)	(0.013)	(0.013)
$LANDLOCK_{ct}$	0.081***	0.075***	0.073***	0.068***	0.068***	0.063***	0.060***
	(0.012)	(0.012)	(0.012)	(0.012)	(0.012)	(0.012)	(0.012)
$AIRDIST_{ct}$	0.000***	0.000***	0.000***	0.000***	0.000***	0.000***	0.000***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
$NEWST_{ct}$	-0.016***	-0.012***	-0.011***	-0.012***	-0.013***	-0.013***	-0.012***
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
P_t^{NR}	-0.000	-0.000	0.000*	0.000	0.001***	-0.001***	-0.000
	(0.000)	(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	3,239
No. of countries	135	135	135	135	135	135	135
K-P rk Wald F	136826	114561	133167	133630	132216	122531	127864
K-P rk LM	1042	1019	1047	1044	1042	1004	1030
K-P rk LM (p-val)	0.000	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 a form of NR price indices (P_t^{NR}); K-P refers to 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.

2) INST is expressed as a percentile rank indicating the country's rank among all countries, with 0 corresponding to lowest rank (the weakest institutions) and 100 to highest rank (the strongest institutions).

3) The presented types of natural resources (NR) comply with the established resource taxonomies (see Table A.4. in Appendix A).

Source: own calculations based on data from BACI CEPII (CEPII, 2023; Gaulier and Zignago, 2010), PWT 10.0 (Feenstra et al., 2015), Worldwide Governance Indicators (World Bank, 2024d) and World Bank Commodity Price Data Annual Indices (World Bank, 2024a). For the sources of control variables, see Table A.7. in Appendix A.

Table B.17. Estimation results (eq. 11) – relationship between natural resource dependence[1] and diversification of non-resource exports – the role of institutional quality[2]

Dependent variable: $lnRT_{c,nonNR_t}$	Type of NR[3]						
	FORESTRY	*FUEL*	*METAL*	*MINERAL*	*COAL*	*NATURAL GAS*	*PETROLEUM*
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
NR_{ct}	-1.000***	0.268***	-0.682***	-0.631***	-0.809***	0.098	0.176***
	(0.111)	(0.033)	(0.114)	(0.073)	(0.166)	(0.075)	(0.033)
$INST_{ct}$	-0.007***	-0.009***	-0.007***	-0.008***	-0.007***	-0.006***	-0.009***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
$(NRxINST)_{ct}$	0.018***	0.005***	0.020***	0.025***	0.025***	0.012***	0.006***
	(0.003)	(0.001)	(0.003)	(0.002)	(0.003)	(0.002)	(0.001)
$lnSIZE_{ct}$	-0.188***	-0.195***	-0.187***	-0.184***	-0.189***	-0.185***	-0.195***
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
$lnDEV_{c,t-1}$	-0.003	0.014*	0.000	0.000	-0.006	-0.019***	0.030***
	(0.007)	(0.008)	(0.007)	(0.007)	(0.007)	(0.007)	(0.008)
$COLONIAL_{ct}$	0.095***	0.123***	0.082***	0.064***	0.084***	0.089***	0.125***
	(0.013)	(0.013)	(0.013)	(0.012)	(0.013)	(0.013)	(0.013)
$LANDLOCK_{ct}$	0.082***	0.035***	0.076***	0.062***	0.070***	0.064***	0.043***
	(0.012)	(0.012)	(0.012)	(0.012)	(0.012)	(0.012)	(0.012)
$AIRDIST_{ct}$	0.000***	0.000***	0.000***	0.000***	0.000***	0.000***	0.000***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
$NEWST_{ct}$	-0.017***	-0.005	-0.011***	-0.012***	-0.014***	-0.014***	-0.010**
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
P_t^{NR}	0.000	0.000	0.000	0.000	0.001***	-0.001***	0.000
	(0.000)	(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	3,239
No. of countries	135	135	135	135	135	135	135
K-P rk Wald F	136826	114561	133167	133630	132216	122531	127864
K-P rk LM	1042	1019	1047	1044	1042	1004	1030
K-P rk LM (p-val)	0.000	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 a form of NR price indices (P_t^{NR}); K-P refers to 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.

2) INST is expressed as a percentile rank indicating the country's rank among all countries, with 0 corresponding to lowest rank (the weakest institutions) and 100 to highest rank (the strongest institutions).

3) The presented types of natural resources (NR) comply with the established resource taxonomies (see Table A.4. in Appendix A).

Source: own calculations based on data from BACI CEPII (CEPII, 2023; Gaulier and Zignago, 2010), PWT 10.0 (Feenstra et al., 2015), Worldwide Governance Indicators (World Bank, 2024d) and World Bank Commodity Price Data Annual Indices (World Bank, 2024a). For the sources of control variables, see Table A.7. in Appendix A.

Table B.18. Estimation results (eq. 11) – relationship between natural resource dependence[1] and diversification of technological exports – the role of institutional quality[2]

Dependent variable: $lnRT_{c,TECH_t}$	Type of NR[3] *FORESTRY* (1)	*FUEL* (2)	*METAL* (3)	*MINERAL* (4)	*COAL* (5)	*NATURAL GAS* (6)	*PETROLEUM* (7)
NR_{ct}	-1.651***	0.080**	-1.199***	-0.856***	1.529***	0.101	0.005
	(0.160)	(0.041)	(0.100)	(0.107)	(0.443)	(0.077)	(0.043)
$INST_{ct}$	-0.017***	-0.015***	-0.017***	-0.017***	-0.016***	-0.016***	-0.016***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
$(NRxINST)_{ct}$	0.032***	0.007***	0.034***	0.025***	-0.029***	0.026***	0.008***
	(0.005)	(0.001)	(0.003)	(0.003)	(0.007)	(0.002)	(0.001)
$lnSIZE_{ct}$	-0.216***	-0.208***	-0.214***	-0.214***	-0.214***	-0.210***	-0.208***
	(0.005)	(0.004)	(0.004)	(0.005)	(0.005)	(0.004)	(0.004)
$lnDEV_{c,t-1}$	0.149***	0.099***	0.153***	0.149***	0.152***	0.122***	0.112***
	(0.009)	(0.010)	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)
$COLONIAL_{ct}$	0.064***	0.054***	0.041**	0.046***	0.055***	0.042**	0.058***
	(0.017)	(0.016)	(0.017)	(0.017)	(0.017)	(0.017)	(0.017)
$LANDLOCK_{ct}$	0.045***	0.047***	0.041**	0.030*	0.035**	0.021	0.057***
	(0.016)	(0.016)	(0.017)	(0.016)	(0.016)	(0.017)	(0.016)
$AIRDIST_{ct}$	0.000***	0.000***	0.000***	0.000***	0.000***	0.000***	0.000***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
$NEWST_{ct}$	-0.009	-0.008	-0.001	-0.005	-0.008	-0.004	-0.010*
	(0.005)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.005)
P_t^{NR}	-0.000	0.000	0.000	0.000	0.000**	-0.001***	0.000
	(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	3,239
No. of countries	135	135	135	135	135	135	135
K-P rk Wald F	136826	114561	133167	133630	132216	122531	127864
K-P rk LM	1042	1019	1047	1044	1042	1004	1030
K-P rk LM (p-val)	0.000	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 a form of NR price indices (P_t^{NR}); K-P refers to 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.

2) INST is expressed as a percentile rank indicating the country's rank among all countries, with 0 corresponding to lowest rank (the weakest institutions) and 100 to highest rank (the strongest institutions).

3) The presented types of natural resources (NR) comply with the established resource taxonomies (see Table A.4. in Appendix A).

Source: own calculations based on data from BACI CEPII (CEPII, 2023; Gaulier and Zignago, 2010), PWT 10.0 (Feenstra et al., 2015), Worldwide Governance Indicators (World Bank, 2024d) and World Bank Commodity Price Data Annual Indices (World Bank, 2024a). For the sources of control variables, see Table A.7. in Appendix A.

Table B.19. Estimation results (eq. 12) – relationship between natural resource dependence[1] and export diversification – the role of technological innovation[2] (4IR products)

	A. Dependent variable: $lnRT_{ct}$							B. Dependent variable: $lnRT_{c,nonNR_t}$						
Type of INNOV: 4IR	*FORESTRY*	*FUEL*	*METAL*	*MINERAL*	*COAL*	*N. GAS*	*PETROL*	*FORESTRY*	*FUEL*	*METAL*	*MINERAL*	*COAL*	*N. GAS*	*PETROL*
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
NR_{ct}	-0.107	0.022	0.001	0.547***	0.658***	0.676***	-0.058**	-0.390***	0.609***	-0.171***	0.242***	0.706***	0.587***	0.559***
	(0.080)	(0.023)	(0.041)	(0.040)	(0.166)	(0.044)	(0.024)	(0.093)	(0.022)	(0.048)	(0.046)	(0.160)	(0.057)	(0.023)
$INNOV_{ct}$	-19.181***	-18.485***	-27.634***	-20.592***	-19.288***	-18.765***	-19.381***	-18.978***	-18.742***	-27.576***	-21.632***	-19.072***	-19.354***	-20.831***
	(2.317)	(2.524)	(3.238)	(2.362)	(2.260)	(2.181)	(2.514)	(2.301)	(2.512)	(3.266)	(2.404)	(2.256)	(2.202)	(2.602)
$(NRxINNOV)_{ct}$	-262.983***	-77.873***	353.600***	-3.125	-749.954***	-59.135	-110.081***	-282.218***	-84.490***	347.673***	31.446	-886.241***	-70.621	-93.947***
	(67.713)	(22.489)	(90.801)	(55.591)	(171.129)	(55.381)	(27.941)	(69.385)	(22.806)	(93.443)	(46.797)	(176.577)	(50.699)	(29.269)
$lnSIZE_{ct}$	-0.168***	-0.164***	-0.163***	-0.157***	-0.164***	-0.167***	-0.163***	-0.169***	-0.174***	-0.161***	-0.160***	-0.164***	-0.166***	-0.172***
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
$lnDEV_{c,t-1}$	-0.085***	-0.085***	-0.093***	-0.093***	-0.090***	-0.099***	-0.082***	-0.085***	-0.102***	-0.093***	-0.091***	-0.090***	-0.100***	-0.086***
	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.007)	(0.006)	(0.006)	(0.006)	(0.006)	(0.007)
$COLONIAL_{ct}$	0.097***	0.100***	0.109***	0.097***	0.103***	0.099***	0.101***	0.097***	0.130***	0.104***	0.083***	0.102***	0.104***	0.132***
	(0.013)	(0.013)	(0.013)	(0.013)	(0.013)	(0.013)	(0.013)	(0.013)	(0.013)	(0.013)	(0.013)	(0.013)	(0.013)	(0.013)
$LANDLOCK_{ct}$	0.092***	0.092***	0.096***	0.095***	0.093***	0.079***	0.083***	0.093***	0.054***	0.099***	0.091***	0.095***	0.080***	0.071***
	(0.013)	(0.013)	(0.013)	(0.013)	(0.013)	(0.013)	(0.013)	(0.013)	(0.013)	(0.013)	(0.013)	(0.013)	(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***	0.000***	0.000***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
$NEWST_{ct}$	0.013***	0.012***	0.013***	0.013***	0.012***	0.006	0.016***	0.011**	0.019***	0.014***	0.013***	0.012***	0.006	0.019***
	(0.004)	(0.005)	(0.004)	(0.004)	(0.004)	(0.004)	(0.005)	(0.004)	(0.005)	(0.005)	(0.005)	(0.004)	(0.004)	(0.005)
P_t^{NR}	0.000	0.000*	0.001***	0.001**	0.001***	-0.001***	0.000**	0.000	0.000***	0.001***	0.001***	0.001***	-0.001***	0.001***
	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(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	3,239	3,239	3,239	3,239	3,239	3,239	3,239	3,239
No. of countries	135	135	135	135	135	135	135	135	135	135	135	135	135	135
K-P rk Wald F	244089	191903	236780	237451	229989	234363	204253	244089	191903	236780	237451	229989	234363	204253
K-P rk LM	1018	1019	1015	1013	1018	1006	1030	1018	1019	1015	1013	1018	1006	1030
K-P rk LM (p-val)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	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 a form of NR price indices (P_t^{NR}); K-P refers to Kleibergen-Paap test statistics.
Instrumented variable: $lnDEV_{c,t-1}$. Constant included – not reported. The presented types of natural resources (NR) comply with the established resource taxonomies (see Table A.4. in Appendix A).
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.
2) Technological innovation is measured by the export share of various groups of technologically advanced products (see Table A.5. in Appendix A) in total country exports, expressed as a decimal between 0 and 1.
Source: own calculations based on data from BACI CEPII (CEPII, 2023; Gaulier and Zignago, 2010), PWT 10.0 (Feenstra et al., 2015) and World Bank Commodity Price Data Annual Indices (World Bank, 2024a). For the sources of control variables, see Table A.7. in Appendix A.

Table B.20. Estimation results (eq. 12) – relationship between natural resource dependence[1] and export diversification – the role of technological innovation[2] (ICT products)

	A. Dependent variable: $lnRT_{ct}$							B. Dependent variable: $lnRT_{c,nonNR_t}$						
Type of INNOV: ICT	*FORESTRY*	*FUEL*	*METAL*	*MINERAL*	*COAL*	*N. GAS*	*PETROL*	*FORESTRY*	*FUEL*	*METAL*	*MINERAL*	*COAL*	*N. GAS*	*PETROL*
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
NR_{ct}	-0.218***	0.012	0.090**	0.463***	0.397***	0.712***	-0.072***	-0.505***	0.598***	-0.088*	0.172***	0.396***	0.617***	0.552***
	(0.074)	(0.021)	(0.043)	(0.034)	(0.151)	(0.040)	(0.023)	(0.087)	(0.020)	(0.050)	(0.043)	(0.151)	(0.051)	(0.021)
$INNOV_{ct}$	-1.008***	-0.515***	-1.048***	-1.255***	-1.045***	-0.911***	-0.647***	-1.007***	-0.499***	-1.082***	-1.277***	-1.025***	-0.952***	-0.661***
	(0.080)	(0.075)	(0.101)	(0.067)	(0.071)	(0.076)	(0.078)	(0.080)	(0.071)	(0.097)	(0.068)	(0.070)	(0.077)	(0.076)
$(NRxINNOV)_{ct}$	-27.162***	-11.957***	-9.296	12.601***	-41.462***	-21.450***	-13.190***	-28.469***	-12.685***	-7.800	13.316***	-48.733***	-20.537***	-13.516***
	(4.592)	(0.864)	(6.855)	(4.207)	(11.423)	(2.760)	(1.095)	(4.905)	(0.904)	(6.432)	(4.356)	(11.705)	(2.802)	(1.020)
$lnSIZE_{ct}$	-0.164***	-0.159***	-0.159***	-0.153***	-0.158***	-0.161***	-0.159***	-0.165***	-0.169***	-0.157***	-0.156***	-0.158***	-0.160***	-0.168***
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
$lnDEV_{c,t-1}$	-0.097***	-0.084***	-0.103***	-0.104***	-0.105***	-0.108***	-0.081***	-0.096***	-0.100***	-0.102***	-0.102***	-0.107***	-0.109***	-0.085***
	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)
$COLONIAL_{ct}$	0.133***	0.155***	0.141***	0.131***	0.139***	0.138***	0.156***	0.133***	0.188***	0.136***	0.118***	0.138***	0.144***	0.188***
	(0.013)	(0.013)	(0.013)	(0.013)	(0.013)	(0.013)	(0.013)	(0.013)	(0.013)	(0.014)	(0.013)	(0.013)	(0.013)	(0.013)
$LANDLOCK_{ct}$	0.062***	0.066***	0.069***	0.069***	0.064***	0.053***	0.058***	0.064***	0.028**	0.072***	0.063***	0.065***	0.054***	0.043***
	(0.012)	(0.012)	(0.012)	(0.012)	(0.012)	(0.012)	(0.012)	(0.012)	(0.012)	(0.012)	(0.012)	(0.012)	(0.012)	(0.012)
$AIRDIST_{ct}$	0.000***	0.000***	0.000***	0.000***	0.000***	0.000***	0.000***	0.000***	0.000***	0.000***	0.000***	0.000***	0.000***	0.000***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
$NEWST_{ct}$	0.027***	0.032***	0.023***	0.024***	0.026***	0.019***	0.034***	0.025***	0.040***	0.024***	0.024***	0.026***	0.019***	0.038***
	(0.004)	(0.005)	(0.004)	(0.004)	(0.004)	(0.004)	(0.005)	(0.004)	(0.005)	(0.004)	(0.004)	(0.004)	(0.004)	(0.005)
P_t^{NR}	0.000	0.000*	0.001***	0.000*	0.001***	-0.001***	0.000**	0.000	0.000***	0.001***	0.000**	0.001***	-0.001***	0.001***
	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(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	3,239	3,239	3,239	3,239	3,239	3,239	3,239	3,239
No. of countries	135	135	135	135	135	135	135	135	135	135	135	135	135	135
K-P rk Wald F	248040	194792	246425	246969	240679	243146	206117	248040	194792	246425	246969	240679	243146	206117
K-P rk LM	951.7	940.2	950.6	940.1	961.3	937.0	960.4	951.7	940.2	950.6	940.1	961.3	937.0	960.4
K-P rk LM (p-val)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Notes as under Table B.19.

Table B.21. Estimation results (eq. 12) – relationship between natural resource dependence[1] and export diversification – the role of technological innovation[2] (TECH products)

	A. Dependent variable: $lnRT_{ct}$							B. Dependent variable: $lnRT_{c,nonNR_t}$						
Type of INNOV: TECH	*FORESTRY*	*FUEL*	*METAL*	*MINERAL*	*COAL*	*N. GAS*	*PETROL*	*FORESTRY*	*FUEL*	*METAL*	*MINERAL*	*COAL*	*N. GAS*	*PETROL*
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
NR_{ct}	-0.314***	-0.205***	0.170***	0.196***	0.377***	0.438***	-0.278***	-0.610***	0.390***	-0.016	-0.096**	0.532***	0.301***	0.338***
	(0.097)	(0.025)	(0.049)	(0.035)	(0.122)	(0.047)	(0.025)	(0.111)	(0.023)	(0.055)	(0.047)	(0.116)	(0.058)	(0.023)
$INNOV_{ct}$	-0.885***	-1.069***	-0.853***	-0.918***	-0.871***	-0.826***	-1.079***	-0.882***	-1.044***	-0.866***	-0.932***	-0.869***	-0.846***	-1.099***
	(0.031)	(0.044)	(0.032)	(0.031)	(0.031)	(0.031)	(0.041)	(0.031)	(0.042)	(0.032)	(0.032)	(0.031)	(0.031)	(0.041)
$(NRxINNOV)_{ct}$	0.038	-1.178***	-3.317***	3.129***	-7.081***	-1.889**	-1.126***	0.031	-1.191***	-3.070***	3.157***	-9.634***	-1.083	-1.050***
	(0.844)	(0.231)	(0.957)	(0.426)	(1.236)	(0.757)	(0.257)	(0.912)	(0.240)	(1.018)	(0.438)	(1.259)	(0.849)	(0.256)
$lnSIZE_{ct}$	-0.152***	-0.141***	-0.150***	-0.145***	-0.149***	-0.152***	-0.142***	-0.153***	-0.152***	-0.148***	-0.148***	-0.148***	-0.151***	-0.150***
	(0.003)	(0.004)	(0.003)	(0.004)	(0.003)	(0.003)	(0.004)	(0.004)	(0.004)	(0.003)	(0.004)	(0.003)	(0.004)	(0.004)
$lnDEV_{c,t-1}$	-0.077***	-0.049***	-0.077***	-0.078***	-0.080***	-0.081***	-0.054***	-0.077***	-0.068***	-0.076***	-0.076***	-0.081***	-0.082***	-0.058***
	(0.005)	(0.006)	(0.005)	(0.005)	(0.005)	(0.006)	(0.006)	(0.006)	(0.006)	(0.005)	(0.005)	(0.005)	(0.006)	(0.006)
$COLONIAL_{ct}$	0.078***	0.074***	0.070***	0.080***	0.078***	0.079***	0.073***	0.078***	0.106***	0.064***	0.066***	0.078***	0.083***	0.104***
	(0.012)	(0.013)	(0.013)	(0.013)	(0.012)	(0.012)	(0.013)	(0.012)	(0.013)	(0.013)	(0.012)	(0.012)	(0.012)	(0.013)
$LANDLOCK_{ct}$	0.081***	0.072***	0.079***	0.085***	0.077***	0.073***	0.056***	0.083***	0.034***	0.083***	0.080***	0.078***	0.074***	0.041***
	(0.011)	(0.011)	(0.012)	(0.011)	(0.011)	(0.011)	(0.011)	(0.011)	(0.012)	(0.012)	(0.012)	(0.011)	(0.012)	(0.012)
$AIRDIST_{ct}$	0.000***	0.000***	0.000***	0.000***	0.000***	0.000***	0.000***	0.000***	0.000***	0.000***	0.000***	0.000***	0.000***	0.000***
	(0.000)	(0.000)	(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**	0.021***	0.008**	0.008**	0.010**	0.007	0.022***	0.007*	0.028***	0.009**	0.008*	0.010**	0.007	0.025***
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
P_t^{NR}	0.001*	0.000***	0.001***	0.001***	0.001***	-0.001***	0.001***	0.001*	0.001***	0.001***	0.001***	0.001***	-0.001***	0.001***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(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	3,239	3,239	3,239	3,239	3,239	3,239	3,239	3,239
No. of countries	135	135	135	135	135	135	135	135	135	135	135	135	135	135
K-P rk Wald F	221779	157471	218279	213937	211960	202793	179080	221779	157471	218279	213937	211960	202793	179080
K-P rk LM	956.0	913.2	975.7	945.0	957.5	934.3	953.4	956.0	913.2	975.7	945.0	957.5	934.3	953.4
K-P rk LM (p-val)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Notes as under Table B.19.

Table B.22. Estimation results (eq. 12) – relationship between natural resource dependence[1] and diversification of exports – the role of technological innovation

	A. Dependent variable: $lnRT_{ct}$		B. Dependent variable: $lnRT_{c,nonNR_t}$	
Type of INNOV[2]	PATENTS	RD	PATENTS	RD
	(1)	(2)	(3)	(4)
NR_{ct}	0.147***	0.292***	0.612***	0.817***
	(0.020)	(0.032)	(0.021)	(0.035)
$INNOV_{ct}$	-0.000	-0.054***	-0.000***	-0.071***
	(0.000)	(0.012)	(0.000)	(0.014)
$(NRxINNOV)_{ct}$	-0.003	0.059	-0.005**	-0.006
	(0.000)	(0.043)	(0.000)	(0.049)
$lnSIZE_{ct}$	-0.171***	-0.177***	-0.162***	-0.176***
	(0.004)	(0.004)	(0.004)	(0.005)
$lnDEV_{c,t-1}$	-0.117***	-0.118***	-0.140***	-0.113***
	(0.007)	(0.010)	(0.007)	(0.011)
$COLONIAL_{ct}$	0.117***	0.062***	0.144***	0.122***
	(0.014)	(0.016)	(0.015)	(0.018)
$LANDLOCK_{ct}$	0.074***	0.044**	0.017	0.026
	(0.013)	(0.017)	(0.014)	(0.020)
$AIRDIST_{ct}$	0.000***	0.000***	0.000***	0.000***
	(0.000)	(0.000)	(0.000)	(0.000)
$NEWST_{ct}$	0.010**	0.011*	0.025***	0.024***
	(0.005)	(0.006)	(0.005)	(0.006)
P_t^{NR}	0.001***	0.001***	0.001***	0.001**
	(0.000)	(0.000)	(0.000)	(0.000)
No.of obs.	3,239	1,827	3,239	1,827
No. of countries	135	118	135	118
K-P rk Wald F	210661	193379	210661	193379
K-P rk LM	896.9	532.4	896.9	532.4
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: $lnDEV_{c,t-1}$. 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 number of patent applications submitted by residents (PATENTS) and by the percentage of R&D expenditures in country's GDP (RD).
Source: own calculations based on data from BACI CEPII (CEPII, 2023; Gaulier and Zignago, 2010), PWT 10.0 (Feenstra et al., 2015), World Development Indicators (World Bank, 2024b) and World Bank Commodity Price Data Annual Indices (World Bank, 2024a). For the sources of control variables, see Table A.7. in Appendix A.

Table B.23. Estimation results (eq. 10) – relationship between natural resource dependence[1] and alternative measure of export diversification[2]

Dependent variable: $lnTheil_{ct}$	Type of NR[3]							
	TOTAL NR	*FORESTRY*	*FUEL*	*METAL*	*MINERAL*	*COAL*	*NATURAL GAS*	*PETROLEUM*
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
NR_{ct}	0.742***	-0.579***	0.800***	-0.052	0.239***	0.416***	1.104***	0.836***
	(0.012)	(0.066)	(0.012)	(0.033)	(0.029)	(0.144)	(0.056)	(0.015)
$lnSIZE_{ct}$	-0.066***	-0.079***	-0.081***	-0.076***	-0.072***	-0.076***	-0.077***	-0.080***
	(0.002)	(0.004)	(0.002)	(0.004)	(0.004)	(0.004)	(0.003)	(0.002)
$lnDEV_{c,t-1}$	-0.057***	-0.010	-0.054***	-0.012*	-0.012*	-0.013*	-0.024***	-0.041***
	(0.004)	(0.007)	(0.004)	(0.007)	(0.007)	(0.007)	(0.006)	(0.004)
$COLONIAL_{ct}$	0.152***	0.170***	0.133***	0.166***	0.166***	0.168***	0.161***	0.140***
	(0.009)	(0.014)	(0.008)	(0.015)	(0.015)	(0.015)	(0.013)	(0.009)
$LANDLOCK_{ct}$	0.106***	0.095***	0.120***	0.099***	0.097***	0.096***	0.074***	0.158***
	(0.011)	(0.012)	(0.010)	(0.012)	(0.012)	(0.012)	(0.012)	(0.010)
$AIRDIST_{ct}$	0.000***	0.000***	0.000***	0.000***	0.000***	0.000***	0.000***	0.000***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
$NEWST_{ct}$	-0.001	0.033***	-0.004	0.032***	0.033***	0.032***	0.023***	-0.003
	(0.003)	(0.005)	(0.003)	(0.005)	(0.005)	(0.005)	(0.004)	(0.003)
P_t^{NR}	0.000**	0.002***	0.000***	0.001***	0.001***	0.001***	-0.000	0.001***
	(0.000)	(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	3,239	3,239
No. of countries	135	135	135	135	135	135	135	135
K-P rk Wald F	215589	254482	213255	247401	248080	240929	248108	223140
K-P rk LM	927.1	959.2	945.8	957.6	956.0	960.5	943.8	957.6
K-P rk LM (p-val)	0.000	0.000	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 a form of NR price indices (P_t^{NR}); K-P refers to 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.
2) The alternative measure of export diversification $lnTheil_{ct}$ (for more details, see Table A.10. in Appendix A).
3) The presented types of natural resources (NR) comply with the established resource taxonomies (see Table A.4. in Appendix A).
Source: own calculations based on data from BACI CEPII (CEPII, 2023; Gaulier and Zignago, 2010), PWT 10.0 (Feenstra et al., 2015) and World Bank Commodity Price Data Annual Indices (World Bank, 2024a). For the sources of control variables, see Table A.7. in Appendix A.

Table B.24. Estimation results (eq. 11) – relationship between natural resource dependence[1] and alternative measure of export diversification[2] – the role of institutional quality[3]

Dependent variable: $lnTheil_{ct}$	Type of NR[4]							
	TOTAL NR	*FORESTRY*	*FUEL*	*METAL*	*MINERAL*	*COAL*	*NATURAL GAS*	*PETROLEUM*
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
NR_{ct}	0.488***	-0.330***	0.530***	-0.546***	-0.291***	-0.265	-0.063	0.489***
	(0.020)	(0.065)	(0.018)	(0.081)	(0.054)	(0.192)	(0.044)	(0.020)
$INST_{ct}$	-0.005***	-0.008***	-0.004***	-0.009***	-0.009***	-0.009***	-0.008***	-0.005***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
$(NRxINST)_{ct}$	0.004***	-0.003	0.006***	0.017***	0.016***	0.018***	0.032***	0.008***
	(0.000)	(0.003)	(0.000)	(0.002)	(0.001)	(0.003)	(0.002)	(0.001)
$lnSIZE_{ct}$	-0.072***	-0.092***	-0.082***	-0.090***	-0.086***	-0.090***	-0.085***	-0.082***
	(0.002)	(0.003)	(0.002)	(0.003)	(0.003)	(0.003)	(0.003)	(0.002)
$lnDEV_{c,t-1}$	0.014**	0.125***	-0.004	0.126***	0.124***	0.124***	0.097***	0.019***
	(0.005)	(0.007)	(0.005)	(0.007)	(0.007)	(0.007)	(0.007)	(0.006)
$COLONIAL_{ct}$	0.136***	0.127***	0.125***	0.123***	0.121***	0.126***	0.115***	0.131***
	(0.009)	(0.012)	(0.008)	(0.012)	(0.012)	(0.012)	(0.011)	(0.008)
$LANDLOCK_{ct}$	0.110***	0.096***	0.122***	0.101***	0.096***	0.097***	0.088***	0.155***
	(0.010)	(0.011)	(0.009)	(0.011)	(0.010)	(0.011)	(0.011)	(0.009)
$AIRDIST_{ct}$	0.000***	0.000***	0.000***	0.000***	0.000***	0.000***	0.000***	0.000***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
$NEWST_{ct}$	-0.014***	-0.008**	-0.013***	-0.006	-0.007*	-0.008**	-0.004	-0.017***
	(0.003)	(0.004)	(0.003)	(0.004)	(0.004)	(0.004)	(0.004)	(0.003)
P_t^{NR}	0.000	0.000	0.000**	0.000	0.000	0.000	0.000	0.000***
	(0.000)	(0.000)	(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	3,239	3,239
No. of countries	135	135	135	135	135	135	135	135
K-P rk Wald F	122913	136826	114561	133167	133630	132216	122531	127864
K-P rk LM	1058	1042	1019	1047	1044	1042	1004	1030
K-P rk LM (p-val)	0.000	0.000	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 a form of NR price indices (P_t^{NR}); K-P refers to 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.
2) The alternative measure of export diversification $lnTheil_{ct}$ (for more details, see Table A.10. in Appendix A).
3) INST is expressed as a percentile rank indicating the country's rank among all countries, with 0 corresponding to lowest rank (the weakest institutions) and 100 to highest rank (the strongest institutions).
4) The presented types of natural resources (NR) comply with the established resource taxonomies (see Table A.4. in Appendix A).
Source: own calculations based on data from BACI CEPII (CEPII, 2023; Gaulier and Zignago, 2010), PWT 10.0 (Feenstra et al., 2015), Worldwide Governance Indicators (World Bank, 2024d) and World Bank Commodity Price Data Annual Indices (World Bank, 2024a). For the sources of control variables, see Table A.7. in Appendix A.

Table B.25. Estimation results (eq. 12) – relationship between natural resource dependence[1] alternative measure of export diversification[2] – the role of technological innovation[3]

Dependent variable: $lnTheil_{ct}$	Type of NR: **TOTAL NR**				
Type of INNOV:	4IR	ICT	TECH	PATENTS	RD
	(1)	(2)	(3)	(4)	(5)
NR_{ct}	0.721***	0.758***	0.665***	0.737***	0.910***
	(0.012)	(0.012)	(0.017)	(0.012)	(0.020)
$INNOV_{ct}$	-6.874***	0.520***	-0.274***	-0.000	0.005
	(1.673)	(0.052)	(0.038)	(0.000)	(0.008)
$(NRxINNOV)_{ct}$	-33.673***	-5.207***	-0.364***	0.007***	-0.019
	(10.338)	(0.502)	(0.120)	(0.002)	(0.029)
$lnSIZE_{ct}$	-0.062***	-0.068***	-0.059***	-0.072***	-0.058***
	(0.002)	(0.002)	(0.003)	(0.003)	(0.003)
$lnDEV_{c,t-1}$	-0.046***	-0.050***	-0.040***	-0.054***	-0.033***
	(0.004)	(0.004)	(0.005)	(0.004)	(0.007)
$COLONIAL_{ct}$	0.142***	0.156***	0.136***	0.151***	0.173***
	(0.009)	(0.010)	(0.010)	(0.010)	(0.010)
$LANDLOCK_{ct}$	0.112***	0.103***	0.105***	0.105***	0.147***
	(0.010)	(0.011)	(0.010)	(0.011)	(0.014)
$AIRDIST_{ct}$	0.000***	0.000***	0.000***	0.000***	0.000***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
$NEWST_{ct}$	-0.001	0.002	0.001	-0.001	0.008**
	(0.003)	(0.003)	(0.003)	(0.003)	(0.004)
P_t^{NR}	0.000**	0.001***	0.000***	0.000**	0.001***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
No.of obs.	3,239	3,239	3,239	3,239	1,827
No. of countries	135	135	135	135	118
K-P rk Wald F	199583	197795	156549	210661	193379
K-P rk LM	977.5	932.0	878.1	896.9	532.4
K-P rk LM (p-val)	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 a form of NR price indices (P_t^{NR}); K-P refers to 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) The alternative measure of export diversification $lnTheil_{ct}$ (for more details, see Table A.10. in Appendix A).

3) Technological innovation is measured by the number of patent applications submitted by residents (PATENTS), the percentage of R&D expenditures in country's GDP (RD) and by the export share of various groups of technologically advanced products (see Table A.5. in Appendix A) in total country exports, expressed as a decimal between 0 and 1.

Source: own calculations based on data from BACI CEPII (CEPII, 2023; Gaulier and Zignago, 2010), PWT 10.0 (Feenstra et al., 2015), World Development Indicators (World Bank, 2024b) and World Bank Commodity Price Data Annual Indices (World Bank, 2024a). For the sources of control variables, see Table A.7. in Appendix A.

Table B.26. Estimation results (eq. 10) – relationship between natural resource dependence[1] and export diversification – developed and developing countries

Type of NR: *TOTAL NR*	Developed countries			Developing countries		
	$lnRT_{ct}$	$lnRT_{c,nonNR_t}$	$lnRT_{c,TECH_t}$	$lnRT_{ct}$	$lnRT_{c,nonNR_t}$	$lnRT_{c,TECH_t}$
	(1)	(2)	(3)	(4)	(5)	(6)
NR_{ct}	0.406***	0.799***	0.990***	-0.054***	0.401***	0.343***
	(0.033)	(0.040)	(0.049)	(0.017)	(0.018)	(0.022)
$lnSIZE_{ct}$	-0.222***	-0.261***	-0.311***	-0.175***	-0.166***	-0.160***
	(0.006)	(0.008)	(0.010)	(0.003)	(0.004)	(0.005)
$COLONIAL_{ct}$	0.002	0.070***	0.049	0.126***	0.138***	0.083***
	(0.021)	(0.026)	(0.033)	(0.014)	(0.016)	(0.019)
$LANDLOCK_{ct}$	0.030	0.004	0.044	0.150***	0.089***	0.119***
	(0.023)	(0.025)	(0.030)	(0.012)	(0.013)	(0.017)
$AIRDIST_{ct}$	0.000***	0.000***	0.000***	0.000***	0.000***	-0.000**
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
$NEWST_{ct}$	-0.040***	-0.055***	-0.053***	0.017***	0.032***	0.031***
	(0.007)	(0.008)	(0.010)	(0.005)	(0.006)	(0.007)
P_t^{NR}	0.001	0.001	0.001	-0.000	-0.000	0.000
	(0.000)	(0.000)	(0.001)	(0.000)	(0.000)	(0.000)
No.of obs.	1,092	1,092	1,092	2,417	2,417	2,417
No. of countries	42	42	42	93	93	93

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}); standard OLS regression.
Constant included – not reported. Division into development groups in compliance with Table A.1. in Appendix A.
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.
Source: own calculations based on data from BACI CEPII (CEPII, 2023; Gaulier and Zignago, 2010), PWT 10.0 (Feenstra et al., 2015) and World Bank Commodity Price Data Annual Indices (World Bank, 2024a). For the sources of control variables, see Table A.7. in Appendix A.

Table B.27. Estimation results (eq. 10) – relationship between natural resource dependence[1] and export diversification – NR exporters[2] and OPEC members[3]

	NR exporters			OPEC members		
Type of NR: *TOTAL NR*	$lnRT_{ct}$	$lnRT_{c,nonNR_t}$	$lnRT_{c,TECH_t}$	$lnRT_{ct}$	$lnRT_{c,nonNR_t}$	$lnRT_{c,TECH_t}$
	(1)	(2)	(3)	(4)	(5)	(6)
NR_{ct}	-0.272***	0.423***	0.484***	0.388***	0.896***	1.382***
	(0.055)	(0.066)	(0.089)	(0.086)	(0.107)	(0.115)
$lnSIZE_{ct}$	-0.115***	-0.080***	-0.072***	-0.076***	-0.104***	-0.094***
	(0.007)	(0.008)	(0.011)	(0.012)	(0.018)	(0.017)
$lnDEV_{c,t-1}$	-0.051***	-0.099***	-0.113***	-0.064***	-0.150***	-0.139***
	(0.011)	(0.014)	(0.017)	(0.014)	(0.022)	(0.021)
$COLONIAL_{ct}$	0.057**	0.091***	0.002	-0.133***	-0.181***	-0.347***
	(0.024)	(0.024)	(0.036)	(0.034)	(0.046)	(0.056)
$LANDLOCK_{ct}$	0.125***	0.055***	0.009			
	(0.025)	(0.019)	(0.034)			
$AIRDIST_{ct}$	0.000***	-0.000***	-0.000***	-0.000*	-0.000***	-0.000***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
$NEWST_{ct}$	0.011	0.082***	0.109***	-0.041**	-0.027	-0.031
	(0.010)	(0.010)	(0.016)	(0.017)	(0.023)	(0.022)
P_t^{NR}	-0.001*	0.001	0.001**	-0.003***	0.003***	0.003***
	(0.000)	(0.000)	(0.001)	(0.001)	(0.001)	(0.001)
No.of obs.	743	743	743	311	311	311
No. of countries	31	31	31	13	13	13
K-P rk Wald F	21705	21705	21705	6486	6486	6486
K-P rk LM	242.2	242.2	242.2	91.09	91.09	91.09
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 a form of NR price indices (P_t^{NR}).
Instrumented variable: $lnDEV_{c,t-1}$. Constant included – not reported. Subsample of NR exporters (for more details, see Table A.2. in Appendix A).
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) NR exporters are countries with a share of resource exports of at least 50% (average from 1996 to 2021).
3) OPEC members are countries which are affiliated within the Organization of the Petroleum Exporting Countries (for more details, see Table A.3. in Appendix A).
Source: own calculations based on data from BACI CEPII (CEPII, 2023; Gaulier and Zignago, 2010), PWT 10.0 (Feenstra et al., 2015) and World Bank Commodity Price Data Annual Indices (World Bank, 2024a). For the sources of control variables, see Table A.7. in Appendix A.

Table B.28. Estimation results (eq. 11) – relationship between natural resource dependence[1] and export diversification within country subgroups – the role of institutional quality[2]

Type of dependent variable: $lnRT_{ct}$	Type of NR: *TOTAL NR*			
	Developed	Developing	NR exporters	OPEC members
	(1)	(2)	(3)	(4)
NR_{ct}	0.054	-0.462***	-0.584***	-0.418***
	(0.127)	(0.038)	(0.064)	(0.144)
$INST_{ct}$	-0.005***	-0.008***	-0.009***	-0.023***
	(0.001)	(0.000)	(0.002)	(0.003)
$(NRxINST)_{ct}$	0.004**	0.013***	0.011***	0.020***
	(0.002)	(0.001)	(0.002)	(0.004)
$lnSIZE_{ct}$	-0.218***	-0.166***	-0.113***	-0.063***
	(0.006)	(0.003)	(0.008)	(0.011)
$lnDEV_{c,t-1}$			-0.040***	0.042***
			(0.014)	(0.014)
$COLONIAL_{ct}$	0.002	0.124***	0.083***	0.008
	(0.019)	(0.013)	(0.023)	(0.030)
$LANDLOCK_{ct}$	0.044*	0.115***	0.140***	
	(0.025)	(0.012)	(0.024)	
$AIRDIST_{ct}$	0.000***	0.000***	0.000***	0.000
	(0.000)	(0.000)	(0.000)	(0.000)
$NEWST_{ct}$	-0.052***	0.016***	-0.004	-0.025
	(0.007)	(0.005)	(0.011)	(0.015)
P_t^{NR}	0.001	-0.000	-0.001***	-0.004***
	(0.000)	(0.000)	(0.000)	(0.001)
No.of obs.	1,092	2,417	743	311
No. of countries	42	93	31	13
K-P rk Wald F			12681	1868
K-P rk LM			210.6	46.67
K-P rk LM (p-val)			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. GMM regression (eq.3 and eq.4), instrumented variable: $lnDEV_{c,t-1}$. Standard OLS regression in eq.1 and eq.2. Constant included – not reported. Division into development groups in compliance with Table A.1. in Appendix A. For more details on OPEC members and NR exporters subsamples see Table A.3. and Table A.2. in Appendix A.
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 lowest rank (the weakest institutions) and 100 to highest rank (the strongest institutions).
Source: own calculations based on data from BACI CEPII (CEPII, 2023; Gaulier and Zignago, 2010), PWT 10.0 (Feenstra et al., 2015), Worldwide Governance Indicators (World Bank, 2024d) and World Bank Commodity Price Data Annual Indices (World Bank, 2024a). For the sources of control variables, see Table A.7. in Appendix A..

Table B.29. Estimation results (eq. 12) – relationship between natural resource dependence[1] and export diversification in developed and developing countries – the role of technological innovation[2]

Type of NR: *TOTAL NR*	Developed countries					Developing countries				
Type of dependent variable: $\ln RT_{ct}$	4IR	ICT	TECH	PATENTS	RD	4IR	ICT	TECH	PATENTS	RD
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
NR_{ct}	0.502***	0.472***	0.482***	0.440***	0.568***	-0.095***	-0.122***	-0.236***	-0.069***	-0.000
	(0.040)	(0.036)	(0.063)	(0.035)	(0.049)	(0.026)	(0.016)	(0.020)	(0.018)	(0.036)
$INNOV_{ct}$	9.101***	1.233***	-0.249***	0.002***	0.052***	-37.529**	-0.640***	-0.868***	-0.001***	-0.215***
	(1.759)	(0.152)	(0.089)	(0.000)	(0.011)	(15.588)	(0.088)	(0.051)	(0.000)	(0.033)
$(NRxINNOV)_{ct}$	-46.956***	-16.349***	-2.426***	-0.009***	-0.152***	-20.473	-8.197***	-0.533**	0.011***	0.271***
	(13.666)	(1.115)	(0.361)	(0.000)	(0.047)	(48.310)	(0.678)	(0.215)	(0.000)	(0.061)
$lnSIZE_{ct}$	-0.239***	-0.221***	-0.214***	-0.245***	-0.239***	-0.169***	-0.150***	-0.148***	-0.175***	-0.158***
	(0.007)	(0.006)	(0.008)	(0.007)	(0.007)	(0.004)	(0.003)	(0.004)	(0.004)	(0.007)
$COLONIAL_{ct}$	0.022	0.041**	0.041*	0.001	-0.010	0.096***	0.159***	0.062***	0.133***	0.103***
	(0.021)	(0.018)	(0.023)	(0.023)	(0.020)	(0.015)	(0.013)	(0.014)	(0.014)	(0.023)
$LANDLOCK_{ct}$	-0.004	-0.036	0.009	0.053**	-0.028	0.130***	0.149***	0.114***	0.153***	0.136***
	(0.021)	(0.026)	(0.025)	(0.024)	(0.020)	(0.012)	(0.011)	(0.012)	(0.012)	(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)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
$NEWST_{ct}$	-0.046***	-0.015**	-0.025***	-0.048***	-0.044***	0.023***	0.026***	0.018***	0.018***	0.028***
	(0.007)	(0.007)	(0.007)	(0.007)	(0.008)	(0.005)	(0.005)	(0.004)	(0.005)	(0.008)
P_t^{NR}	0.001**	0.001***	0.001***	0.001**	0.001*	-0.000	-0.000	0.000*	-0.000	-0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
No.of obs.	1,092	1,092	1,092	1,092	967	2,417	2,417	2,417	2,417	975
No. of countries	42	42	42	42	42	93	93	93	93	76

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}); standard OLS regression. Constant included – not reported. Division into development groups in compliance with Table A.1. in Appendix A.

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 number of patent applications submitted by residents (PATENTS), the percentage of R&D expenditures in country's GDP (RD) and by the export share of various groups of technologically advanced products (see Table A.5. in Appendix A) in total country exports, expressed as a decimal between 0 and 1.

Source: own calculations based on data from BACI CEPII (CEPII, 2023; Gaulier and Zignago, 2010), PWT 10.0 (Feenstra et al., 2015), World Development Indicators (World Bank, 2024b) and World Bank Commodity Price Data Annual Indices (World Bank, 2024a). For the sources of control variables, see Table A.7. in Appendix A.

List of Figures

List of Tables