Extractive industries and structural transformation

DOI:
10.26481/dis.20220518bc

Extractive Industries and Structural Transformation

Beatriz Georgina Calzada Olvera

layout and print: proefschrift-aio.nl

Extractive Industries and Structural Transformation

DISSERTATION

to obtain the degree of Doctor at the Maastricht University,
on the authority of the Rector Magnificus, Prof. dr. Pamela Habibović
in accordance with the decision of the Board of Deans,
to be defended in public
on Wednesday 18th of May 2022 at 13.00 hours

by

Beatriz Georgina Calzada Olvera
27th of October 1985 - Mexico City

Supervisor(s):
Prof.dr. Bart Verspagen
Prof.dr. Neil Foster-McGregor

Assessment Committee:
Prof.dr. Pierre Mohnen (chair)
Prof.dr. Michiko Iizuka, National Graduate Research Institute on Policy Studies (GRIPS), Japan
Dr. Nanditha Mathew
Dr. Lilia Stubrin, Centro de Investigaciones para la Transformación (CENIT), Argentina

The reverse of the title page may also contain a list of institutions and/or organisations that contributed financially to the creation of the thesis.

Abstract

The exploitation of extractive resources (i.e., mining and energy commodities) has been historically considered a curse for development due to the enclave nature of mining operations and the macroeconomic imbalances associated with the Dutch disease, among other reasons. The extractive commodities boom in the early 21st century, however, brought a renewed enthusiasm for this sector. Motivated by a number of study cases, several scholars suggested that the extractive sector could be used as a platform for structural transformation – given the new opportunities that emerge due to changes in the technological paradigm and the value chain structure. This dissertation thus explores whether extractive sectors can be drivers of structural transformation, or on the contrary, lead to unsustainable development paths, based on their macro-level performance in recent decades. This dissertation studies various aspects concerning structural transformation, such as production linkages (i.e., backward and forward), employment, diversification, and long-term economic growth linked to natural resources, i.e., extractive sectors in a cross-country setting. It explores, on the one hand, whether the long-established theorized mechanisms associated with the resource curse still hold, namely, those linked to the productive structure, i.e., Dutch disease and the enclave nature of extractive sectors. On the other, it also tests if the positive scenario linked to natural resources that emerged shortly after the onset of the 21st century is empirically substantiated, particularly amidst a scenario in which extractive commodity prices have been and are expected to remain high. This dissertation concludes that some of the mechanisms hypothesized by the Dutch disease, such as the contraction of employment in manufacturing, are no longer systematically observed. However, the expansion of commodity prices has had significant negative effects on the development of production linkages and diversification efforts, affecting the development of productive capacities in both the short- and long-term.

Acknowledgments

My deepest gratitude goes to my supervisor, Prof. Neil Foster-McGregor. This thesis would not be possible without his continuous support and thorough guidance. I have learned enormously from Neil's expertise on empirical issues but also from his flexibility, pragmatism, and approachability. Likewise, I would like to extend my sincere thanks to my other supervisor, Prof. Bart Verspagen, for his invaluable comments and insightful input. It has been a great honor to work with both of them.

My gratitude also goes to the reading committee: Prof. Pierre Mohnen, Prof. Michiko Iizuka, Dr. Nanditha Matthews, and Dr. Lilia Stubrin. Many thanks for their encouraging and constructive comments which have certainly enriched this thesis.

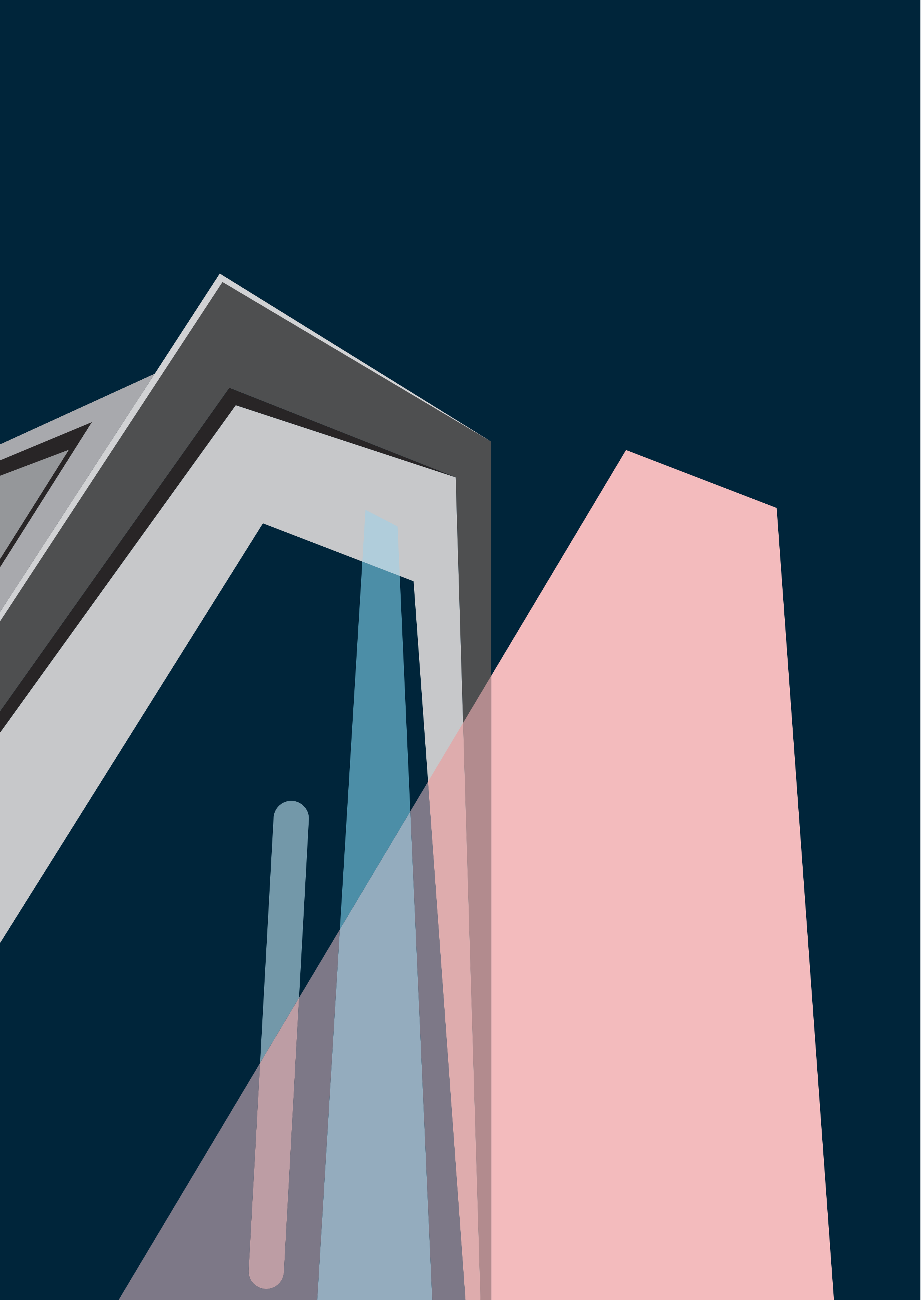
I would like to thank the open and vibrant community of students and professors at UNU-MERIT who inspired me and challenged me. I am extremely thankful for the opportunity of having done my Ph.D. at UNU-MERIT. In particular, I would like to extend my gratitude to Prof. Carlo Pietrobelli and Prof. Michiko Iizuka, for the opportunity to work with them on the Inter-American Development Bank project on mining and innovation in Latin America; and Dr. Kaj Thomsson, for the chance of working together in the Emerging Markets Program at the School of Business and Economics. I am very thankful for these enriching experiences as they were an integral part of my academic training. Moreover, I would like to extend my gratitude to Prof. Robin Cowan, Dr. Tatiana Skripka, and Dr. Micheline Goedhuys for their work in the administration of the Ph.D. program; and Dr. Önder Nomaler for his insightful comments in my last paper. I am very grateful to Prof. Eddy Szirmai, who encouraged me to study the extractive industries and to work under the guidance of Neil and Bart. I would like to extend my sincerest gratitude to Eveline in de Braek, whose competence, and support throughout the Ph.D. process are priceless.

The list would not be complete without mentioning my friends from UNU-MERIT. I am very grateful for their friendship and advice; they made the Ph.D. process bearable and (even) enjoyable. Thanks to my Ph.D. cohort: Bart, Danilo, Emmanuel, Giulia, Halefom, Joseph, Kaleab, Patima, Rose, Tamara, and Victor. I am very honored to have panicked together during our first year. Likewise, I am thankful to other Ph.D. fellows/friends from other cohorts: Cho, Clotilde, Elvis, Gintare, Hugo, Juanca, Lore, Mario, Mueid, Sheng, Stefania, and, our greatly missed friend, Ibrahima. Big thanks to my officemates, Anne-Lore, Elisa, and Solomon – who always set a good example inside and outside the office. Many thanks to the WLC members (Alison, Andrea, Danilo, Elisa, Giacomo, Iulia, Jenni, Mary, Michelle, and Paula) for the parties, the conferences, the cooking books, the professional network, and the lively debates. I would like to emphasize my gratitude to Paula, for all the support beyond the realm of UNU-MERIT; Mario, for the crucial data-driven advice; Elisa, for sharing her wisdom and expertise on a myriad of topics (except, perhaps, trip arrangements in the Bonn/Cologne area); Danilo, for being my first friend and co-author at UNU-MERIT (*¡bien, Ramiro!* back then, *¡bien, Ramiro!* now). Triple thanks to my dear friends and amazing paranymphs, Michelle and Flor (*gracias por los stickers, la fiesta, y la calidez de su amistad*).
My appreciation also goes out to my family and friends; in particular, I would like to thank my dad, who instilled a love for science in me since I was a kid; my friend Isabella (*por toda una vida de amistad y apoyo durante 'experiencias vivenciales'*); my (fiscal) partner, Jahfed (*ik ben eeuwig dankbaar voor jouw ondersteuning. Uiteindelijk ben ik er klaar mee!*); and my sister, Bilin, for her kindness, support, and being my neighbor in Maastricht for a year (*¡gracias, herms!*). Last but not least, I would like to thank my mom for having set the bar high, pushing me to go forward despite doubt, and for her endless support *(Mamá, esta tesis es tanto tuya como mía, ¡gracias!*).

Contents

List of figures

List of tables



CHAPTER 1

Introduction

1.1 Introduction and Motivation

In the early 21st century, there was a major boost to the development trajectories of natural resource-rich countries. Largely driven by the rapid economic expansion of China, commodity prices of energy and mining commodities soared to historical highs between 2002 and 2014 – only interrupted by the downturn in prices during 2008 and early 2009 due to the global financial crisis. The 2000s commodity boom allowed many developing economies across Africa, Asia, and Latin America to experience robust economic growth with some countries even experiencing double-digit per capita growth rates. More importantly, this progress allowed for the implementation of fiscal policy measures, such as higher levels of public spending on social assistance, infrastructure, and other areas, ultimately leading to important improvements in terms of poverty reduction and other social indicators. The expansion of oil and other extractive activities in all these economies had seemed to offer a new possibility for building a strong economic development pathway. But was this the case?

After the peak of commodity prices in 2011/2012, many of the economies that had thrived based on their extractive resources began to experience an economic growth slowdown due to the drop in mining and oil prices (which in any case had stayed well above pre-boom levels) (see Figure 1.1). It became evident that many commodity exporters had become more – not less – dependent on commodities[1] (UNCTAD, 2019) and thus more economically vulnerable to price fluctuations. Likewise, in many of these countries' inequality indicators remained high (or even became higher), and their inability to escape the middle-income trap became evident. However, as mineral commodity prices recovered after 2016, the economic panorama for mining resource-rich countries improved once again; though, in the case of energy, the slow price recovery has meant a lackluster economic performance for those countries depending on this commodity.

The climate change crisis is now atop of the international policy agenda, adding another layer of complexity to finding new and sustainable pathways for the expansion of economic activities, both in developed and developing nations (Andreoni & Chang, 2016; Anzolin & Lebdioui, 2021). Certainly, while fossil fuels are on the way out (or soon will be), the imminent transition to renewable energies – intensive in mining inputs – guarantees high demand, and consequently high prices, for these inputs (Hund et al., 2020; Marín & Goya, 2021). A future in which extractive commodities production remains a highly attractive endeavor, despite commodity price fluctuations, highlights the importance of undertaking a more effective strategy towards structural transformation – especially for those countries that are highly dependent on these resources.

1 According to the 'UNCTAD State of Commodity Dependence 2019' report, there has been an important increase in the number of commodity dependent countries: Mining and fuel dependency was prevalent in 42 countries in 1998, but by 2017, it had increased to 65 countries.

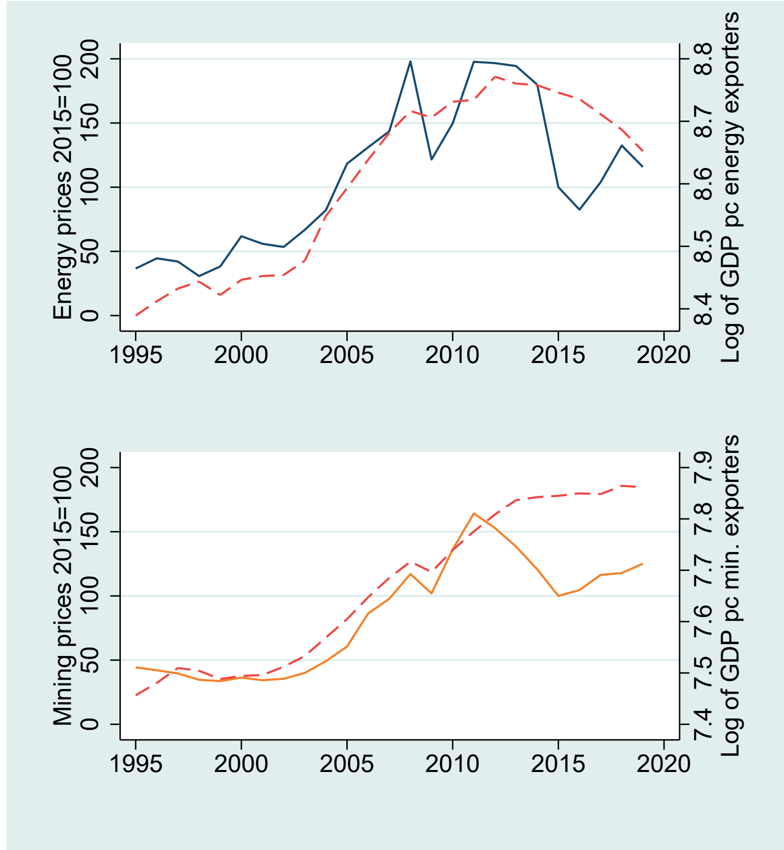


Figure 1.1. Mining and energy prices and GDP per capita (in logs) of selected mining and energy prices 1996-2019
Source: Author's elaboration with UNCTAD data on commodity prices and GDP per capita (constant 2015 USD) of selected exporters.

For several decades, conventional wisdom suggested that an abundance of natural resources, namely of the extractive type, represents a curse for development; this notion was built upon well-known arguments linked to international trade as well as industrial development and connectivity (Corden & Neary, 1982; Hirschman, 1958; Prebisch, 1950; Sachs & Warner, 1995, 2001; Singer, 1950).

Among the first and best-known arguments against resource-based economic growth is that of the declining Terms of Trade (Prebisch, 1950; Singer, 1950). This hypothesis states that the relative price of commodities in terms of manufactures has a downward trend. This argument was put forward after the Second World War when Latin American countries were highly specialized in commodities. It was built on the stylized facts of the time that the incorporation of technology was only possible in manufacturing, and that prices of commodities would inevitably fall in relation to manufactures. Singer (1950) went further to argue that extractive sectors – which emerge as the result of foreign firms' investments – in developing countries do not lead to economy-wide benefits of technical progress embedded in mining operations, because these took place in isolation from the rest of the economy, or enclaves, and, thus, have few spillovers.

More prominently, the resource curse became attributed to macroeconomic imbalances that led to de-industrialization. The term 'Dutch disease' was coined by The Economist in 1977 (The Economist, 2014) referring to the woes of the Dutch economy following the discovery of large gas reserves: the increase in demand for the guilder resulted in its appreciation resulting in the loss of competitiveness of manufactured goods and other tradeable goods, also resulting in a sharp increase of unemployment. A formalization of this phenomenon was put forth in the model of Corden and Neary (1982) which suggests that in the presence of a booming sector, there will be the reallocation of resources into the booming sector and away from other non-booming sectors (i.e., manufacturing and agricultural output) subsequently leading to lower growth rates. A few years later, Sachs and Warner (1995, 2001) provided empirical evidence that showed that countries with natural resource abundance exhibited lower growth rates than those that did not, and that the Dutch disease, which ultimately resulted in a shrinking manufacturing sector, was the main culprit.

Nonetheless, by the beginning of the 21st century, scholars' empirical contributions began to question whether natural resource abundance indeed led to subpar economic performance, motivated by the rise of welfare in many resource-rich nations and facilitated by better cross-country data and econometric modeling techniques among other factors. Several scholarly works provided empirical evidence showing that extractive sectors were not 'bad' for economic growth (Alexeev & Conrad, 2009; Brunnschweiler, 2008; Brunnschweiler & Bulte, 2008; Cavalcanti et al., 2011; Stijns, 2005). Moreover, scholarly works pointed to a large number of mediating variables upon which the ultimate outcomes of resource abundance depend, such as institutional quality and investment (Mehlum et al., 2006; van der Ploeg, 2011), human capital (Bravo-Ortega & Gregorio, 2007), and debt management (Manzano & Rigobon, 2007). Likewise, considering the potentially detrimental effects of price volatility on economic development, export diversification (Hesse, 2008; Lederman & Maloney, 2007) became widely accepted as a key policy objective in turning resources into an asset for development.

More importantly, while it was evident that market-driven reforms in the 1980s and 1990s had led to premature de-industrialization and further specialization in low added-value products in Africa and Latin America (Cimoli & Katz, 2003; McMillan & Rodrik, 2011), adopting a manufacturing-based industrial policy seemed an increasingly implausible strategy to follow for most countries – especially amidst the rise of Asian economies which were highly competitive in that sector.

In response, scholars such as de Ferranti et al. (2002), and Lin and Treichel (2012) suggested a development agenda based on public intervention to support industries in which the comparative advantages of country or regions are. In this view, public efforts would go towards supporting the development and adoption of ICTs, R&D and innovation systems, public infrastructure, and facilitating business and investment.

Along the same lines, other scholars (Perez, 2010; Perez et al., 2009) postulated that industrialization in the context of resource abundance is possible to realize by developing natural resource processing industries, and the incorporation of technology throughout the value chain to create high added-value goods and services. More specifically, Andersen et al. (2015) and Kaplinsky (2011) emphasized that structural change on the basis of extractive industries requires strong state intervention, in lieu of market forces alone, to develop services and industries around natural resources – via backward and forward linkages – to spur economy-wide benefits, including innovation, employment, and diversification.

A few years after the renewed enthusiasm for new development pathways, a few successful cases, e.g., Chile and Malaysia (Lebdioui et al., 2020), have emerged; yet in most developing countries key aspects, such as strong inter-industrial linkages, structural upgrading, and diversification do not seem to have materialized. The central question, thus, is whether extractive sectors can be drivers of structural transformation, or on the contrary, lead to unsustainable development paths, based on their performance at the macro-level in the past decades. This dissertation sheds light on this matter by studying various aspects concerning structural transformation, such as production linkages (i.e., backward and forward), employment, diversification, and long-term economic growth linked to natural resources, i.e., extractive sectors (including fuels and mining output) in a cross-country setting. The objective is to identify, on the one hand, whether the long-established theorized mechanisms associated with the resource curse still hold, namely, those linked to the productive structure, i.e., Dutch disease and the enclave nature of extractive sectors. On the other, it also tests if the positive scenario linked to natural resources that emerged shortly after the onset of the 21st century is empirically substantiated, particularly amidst a scenario in which commodity prices (especially of mining) have been and are expected to remain high.
Moreover, the focus lies on extractive commodities[2] because these tend to be closely associated with overall lower economic growth and other less desirable economic effects, such as export concentration.

2 Please note that the terms extractive and mining are used interchangeably – unless otherwise specified.

1.2 Contribution and Thesis Outline

Chapter 2: What is the Potential of Natural Resource-Based Industrialization in Latin America? An Input-Output Analysis of the Extractive Sectors

The strategy envisioned by several scholars and policymakers to materialize natural resource-based industrialization hinges largely upon a country's ability to develop linkages in the upstream and downstream industries, i.e., backward and forward linkages. Chapter 2 focuses on Latin America following the notion that it is a fertile ground for this type of development strategy (e.g., Lin & Treichel, 2012). Thus, this chapter explores how much Latin American countries have strengthened linkages vis-à-vis other countries with varying degrees of specialization in extractive commodities and income levels. Namely, Chapter 2 measures forward and backward linkages of mining industries (incl. oil and gas) using OECD data covering the 1995-2011 period. The sample includes 20 middle- and high-income countries in Latin America, as well as Africa, Asia, Europe, the Middle East, and North America. Two additional measures are included: backward leakages, to account for foreign inputs and to avoid the overestimation of multiplier effects; and, forward leakages, to measure how much of a country's mining sector output is absorbed by sectors abroad vs. domestically. Additionally, a sectoral breakdown of linkages is carried out to understand the type of industries linked to the mining sector. The results suggest that there has been a strong tendency of the mining sector toward enclaveness with most countries having positioned themselves as commodity producers in global mining chains – although there are exceptions (e.g., Malaysia, Norway, The Netherlands). Moreover, results reveal that the group of Latin American countries along with oil-specialized economies (e.g., Saudi Arabia) had, on average, the worst performance in terms of linkage development. Regarding the inter-industrial connectivity, the mining sector in high-income countries, and most Latin American countries, has a relatively strong connection to sectors with high levels of knowledge intensity.

Chapter 3: Commodity Prices, Linkages, and Economic Growth

Following the descriptive analysis carried out in Chapter 2, this chapter tests the empirical relationship between linkages, growth rates, and commodity prices. Specifically, two aspects linked to economic growth are explored: firstly, the effect of higher mining commodity prices on growth due to the central role these play in the Dutch disease hypothesis; and secondly, on linkages due to potentially negative and negative externalities. It is hypothesized that linkages may a) lead to higher growth due to positive multiplier effects, or on the contrary, b) reduce growth due to their potential transmission effects in the face of a negative shock (e.g., reduction in prices). In addition, Chapter 3 explores the extent to which high commodity prices provide an impetus for mining linkage formation, as hypothesized by several scholars (e.g., Morris et al., 2012). Using the framework of Collier and Goderis (2012), the analysis relies on panel error correction models which allow for the examination of short- and long-run effects of international commodity prices on output per capita and mining linkage development. The sample covers a period from 1980 to 2015 for 154 countries. Results in Chapter 3 indicate that higher commodity prices affect growth positively only in the short run; in the long run, these do not seem to play any positive or negative role. This supports the body of literature that suggests that in recent decades the effects predicted by Dutch disease are no longer observed systematically. Yet, higher linkages – like prices – exhibit short-run positive effects but no (negative nor positive) effects in the long run. This shows that these are unlikely to act as transmission channels for external negative shocks but also that, on average, increasing their strength (as measured in the analysis) does not have a significant role in long-term economic growth rates. Finally, results in Chapter 3, contrary to expectations, indicate that higher commodity prices have a strong and significant negative effect on the formation of mining linkages, suggesting that the presence of several dynamics related to prices further induce the enclaveness of mining operations.

Chapter 4: Alternative Related Variety, Macroeconomic Factors, and Diversification: Extractive vs. Non-Extractive Products

Having explored the development of linkages linked to extractive sectors in the previous chapters, Chapter 4 focuses on the dynamics between diversification and other macroeconomic factors, such as real exchange rates and commodity prices. Export diversification is seen as central in literature linked to natural resources: firstly, because diversification on its own has been empirically associated with higher growth rates (e.g., Hesse, 2008). Secondly, it is considered a necessary condition to reduce the negative effects associated with commodity price volatility (van der Ploeg & Poelhekke, 2009). Economic geography literature has focused on product relatedness to predict diversification patterns. However, while these measures capture path dependence ('what one country produces today largely determines what it will produce tomorrow'), they remain agnostic in terms of explaining differences in the diversification patterns across countries. Chapter 4 thus explores diversification at the product level, distinguishing extractive commodities from non-extractive products, conducting an econometric framework akin to that of Hausmann and Klingler (2006). Nonetheless, an alternative measure (i.e., 'related variety') is introduced to capture path dependence in the model. The related variety probability captures the co-occurrence of exports with comparative advantage – which proxies for the presence of similar productive capabilities that in turn predict how related products are. The calculation of this probability considers too the lack of exports with comparative advantage in a country (as this also provides valuable information about the productive capabilities of a country). Besides this probability measure, the econometric analysis incorporates macroeconomic variables identified in the literature, including commodity prices and real exchange rates, level of economic development, and commodity dependence, among others. The sample uses trade data covering up to 92 countries and more than 5,000 products from 1995 to 2019. Results in Chapter 4 show that diversification in both extractive and non-extractive products is strongly predicted by path dependence (proxied by related variety). Yet, the latter seems to have a less strong effect on non-extractive products, underlining that diversification in non-extractive sectors requires bigger 'jumps' in terms of developing the necessary productive capabilities. While results indicate that real exchange appreciation is not significant, higher commodity prices reveal a strong significant negative relationship with non-extractive diversification. Moreover, the effect of mining dependence is strongly and negatively associated with non-extractive diversification and positively with extractive diversification. Overall, the analysis in Chapter 4 suggests that steering diversification toward non-extractive sectors requires stronger policy efforts to materialize – especially amidst the attractive incentives that high commodity prices seem to offer.

Chapter 5: Is the Dutch Disease Well and Alive? A Cross-Country Assessment of Mining Spillovers on Employment in the 2002-2014 period

Chapter 5 investigates employment spillovers associated with the expansion of extractive sectors to shed further light on the implications this has on the productive structure of a country. The Dutch disease hypothesis predicts a reallocation of labor in which the expansion of employment in the extractive and service sectors happens at the expense of employment in the tradeable sectors, i.e., agriculture and manufacturing industries. As hypothesized by several scholars (e.g., Krugman, 1987), the reduction of employment in manufacturing leads to long-term competitiveness losses as a result of the reduced learning-by-doing opportunities which take place in that sector. Literature at the regional level in countries such as Australia, Chile, Canada, and the US, has explored the employment dynamics in the presence of a booming extractive sector; nonetheless, country-wide effects have been less investigated. Chapter 5 investigates, therefore, the employment spillovers that the expansion of the mining activity had on non-mining sectors over the 2002-2014 period. The econometric framework employed is based on Moretti (2010), and Fleming and Measham (2014), and covers 40 high- and middle-income countries from the WIOD dataset. Since the Dutch disease predicts that negative effects of this sector are mainly associated with exports, measures implemented include a distinction between employment changes due to an increase in domestic demand for mining output and changes due to an increase in foreign demand. To do this, the decomposition framework in Foster-McGregor (2019) is followed. Furthermore, the analysis includes a GMM specification to address potential endogeneity issues. The results presented in Chapter 5 suggest that, in line with previous regional studies, the expansion of mining employment (either due to increased domestic demand or exports), does not lead to negative spillovers in the manufacturing sector. However, there is some evidence that mining employment crowds out agricultural employment but enhances construction and services employment – yet these dynamics seem to be mainly driven by countries with relatively low levels of manufacturing output.

Chapter 6: Conclusion

Final remarks concerning the contribution of this dissertation to the literature on structural change and extractive sectors are discussed in Chapter 6. Likewise, it provides limitations of the analyses here presented and general policy conclusions.

Bibliography

Alexeev, M., & Conrad, R. (2009). The Elusive Curse of Oil. *Review of Economics and Statistics*, *91*(3), 586–598. https://doi.org/10.1162/rest.91.3.586

Andersen, A. D., Johnson, B. H., Marín, A., Kaplan, D., Stubrin, L., Lundvall, B.-Å., & Kaplinsky, R. (2015). *Natural resources, innovation, and development*. https://doi.org/10.5278/VBN/MISC/NRID

Andreoni, A., & Chang, H.-J. (2016). Bringing production and employment back into development: Alice Amsden's legacy for a new developmentalist agenda. *Cambridge Journal of Regions, Economy, and Society*, *10*, rsw029. https://doi.org/10.1093/cjres/rsw029

Anzolin, G., & Lebdioui, A. (2021). Three Dimensions of Green Industrial Policy in the Context of Climate Change and Sustainable Development. *The European Journal of Development Research 2021 33:2*, *33*(2), 371–405. https://doi.org/10.1057/S41287-021-00365-5

Bravo-Ortega, C., & Gregorio, J. de. (2007). The Relative Richness of the Poor? Natural Resources, Human Capital, and Economic Growth Cl. In W. F. Maloney & D. Lederman (Eds.), *Natural Resources Neither Curse nor Destiny* (pp. 71–99). The World Bank, Stanford University Press. https://doi.org/10.1596/978-0-8213-6545-8

Brunnschweiler, C. N. (2008). Cursing the Blessings? Natural Resource Abundance, Institutions, and Economic Growth. *World Development*, *36*(3), 399–419. https://doi.org/10.1016/J.WORLDDEV.2007.03.004

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. https://doi.org/10.1016/J.JEEM.2007.08.004

Cavalcanti, T., Mohaddes, K., & Raissi, M. (2011). Growth, development and natural resources: New evidence using a heterogeneous panel analysis. *Quarterly Review of Economics and Finance*, *51*(4), 305–318. https://doi.org/10.1016/j.qref.2011.07.007

Cimoli, M., & Katz, J. (2003). Structural reforms, technological gaps and economic development: a Latin American perspective. *Industrial and Corporate Change*, *12*(2), 387–411. https://doi.org/10.1093/icc/12.2.387

Collier, P., & Goderis, B. (2012). Commodity prices and growth: An empirical investigation. *European Economic Review*, *56*(6), 1241–1260. https://doi.org/10.1016/J.EUROECOREV.2012.04.002

Corden, W. M., & Neary, J. P. (1982). Booming Sector and De-Industrialisation in a Small Open Economy. *The Economic Journal*, *92*(368), 825. https://doi.org/10.2307/2232670

de Ferranti, D., Perry, G., Lederman, D., & Maloney, W. F. (2002). *From Natural Resources to the Knowledge Economy*. World Bank. http://documents.worldbank.org/curated/en/563331468088167696/pdf/multi0page.pdf

Fleming, D. A., & Measham, T. G. (2014). Local job multipliers of mining. *Resources Policy*, *41*, 9–15. https://doi.org/10.1016/J.RESOURPOL.2014.02.005

Foster-McGregor, N. (2019). Global Value Chains and Employment in Asia. *Asian Development Review*, *36*(2), 100–130. https://www.adb.org/sites/default/files/publication/525971/asian-development-review-volume-36-number-2.pdf

Hausmann, R., & Klinger, B. (2006). *Structural Transformation and Patterns of Comparative Advantage in the Product Space* (No. 128; CID Working Papers).

Hesse, H. (2008). *Export Diversification and Economic Growth* (No. 21; Commission on Growth and Development).

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

Hund, K., Porta, D. la, Fabregas, T. P., Laing, T., & Drexhage, J. (2020). *Minerals for Climate Action: The Mineral Intensity of the Clean Energy Transition. Climate-Smart Mining Facility*. www.worldbank.org

Kaplinsky, R. (2011). *Commodities for Industrial Development: Making Linkages Work* (01/2011).

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. https://doi.org/10.1016/0304-3878(87)90005-8

Lebdioui, A., Lee, K., & Pietrobelli, C. (2020). Local-foreign technology interface, resource-based development, and industrial policy: how Chile and Malaysia are escaping the middle-income trap. *Journal of Technology Transfer*, 1–26. https://doi.org/10.1007/s10961-020-09808-3

Lederman, D., & Maloney, W. F. (2007). Trade Structure and Growth. In D. Lederman & W. F. Maloney (Eds.), *Natural Resources Neither Curse nor Destiny* (pp. 15–40). The World Bank, Stanford University Press.

Lin, J., & Treichel, V. (2012). *Learning from China's rise to escape the middle-income trap - A new structural economics approach to Latin America* (No. 6165; Policy Research Working Paper).

Manzano, O., & Rigobon, R. (2007). Resource Curse or Debt Overhang? In D. Lederman & W. F. Maloney (Eds.), *Natural Resources Neither Curse nor Destiny* (pp. 41–70). The World Bank, Stanford University Press. https://doi.org/10.1596/978-0-8213-6545-8

Marín, A., & Goya, D. (2021). Mining—The dark side of the energy transition. *Environmental Innovation and Societal Transitions*. https://doi.org/10.1016/J.EIST.2021.09.011

McMillan, M., & Rodrik, D. (2011). *Globalization, Structural Change and Productivity Growth* (No. 17143; NBER Working Paper Series). https://doi.org/10.3386/w17143

Mehlum, H., Moene, K., & Torvik, R. (2006). Institutions and the Resource Curse. *The Economic Journal*, *116*(508), 1–20. https://doi.org/10.1111/j.1468-0297.2006.01045.x

Moretti, E. (2010). Local multipliers. *American Economic Review*, *100*(2), 373–377. https://doi.org/10.1257/aer.100.2.373

Morris, M., Kaplinsky, R., & Kaplan, D. (2012). "One thing leads to another"—Commodities, linkages and industrial development. *Resources Policy*, *37*(4), 408–416. https://doi.org/10.1016/J.RESOURPOL.2012.06.008

Perez, C. (2010). A Vision for Latin America : A resource-based strategy for technological dynamism and social inclusion. *Globelics. The Global Network for Economics of Learning, Innovation, and Competence Building System*, 1–32.

Perez, C., Marin, A., & Navas-Aleman, L. (2009). *The possible dynamic role of natural resource-based networks in Latin American development strategies*. https://doi.org/10.4337/9781782548683.00018

Prebisch, R. (1950). *The economic development of Latin America and its principal problems*. United Nations. E/CN.12/89/REV.1

Sachs, J., & Warner, A. (1995). Natural Resource Abundance and Economic Growth. In *National Bureau of Economic Research* (No. 5398; Vol. 3). https://doi.org/10.3386/w5398

Sachs, J., & Warner, A. (2001). The curse of natural resources. *European Economic Review*, *45*(4–6), 827–838. https://doi.org/10.1016/S0014-2921(01)00125-8

Singer, H. W. (1950). U.S. Foreign Investment in Underdeveloped Areas: The Distribution of Gains between Investing and Borrowing Countries. *American Economic Review, Papers and Proceedings*, *40*(473–85).

Stijns, J.-P. C. (2005). Natural resource abundance and economic growth revisited. *Resources Policy*, *30*(2), 107–130. https://doi.org/10.1016/J.RESOURPOL.2005.05.001

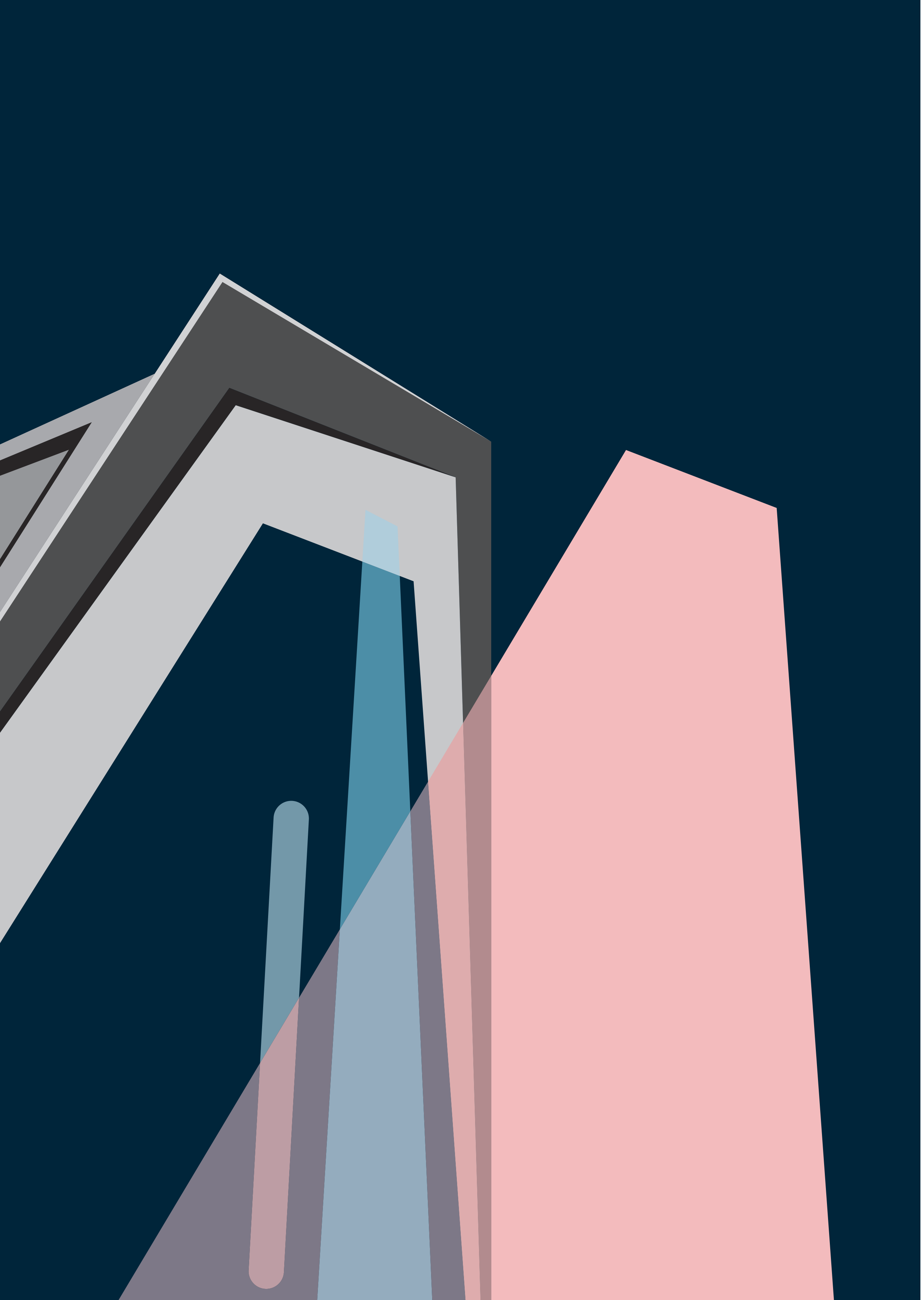
The Economist. (2014, November 5). *The Economist explains: What Dutch disease is, and why it's bad*. http://www.economist.com/blogs/economist-explains/2014/11/economist-explains-2

UNCTAD. (2019). *The State of Commodity Dependence 2019*.

van der Ploeg, F. (2011). Natural Resources: Curse or Blessing? *Journal of Economic Literature*, *49*(2), 366–420. https://doi.org/10.1257/jel.49.2.366

van der Ploeg, F., & Poelhekke, S. (2009). Volatility and the natural resource curse. *Oxford Economic Papers*, *61*(4), 727–760. https://doi.org/10.1093/oep/gpp027

1



CHAPTER 2

What is the Potential of Natural Resource-Based Industrialization in Latin America? An Input-Output Analysis of the Extractive Sectors

Abstract

Several case studies have analyzed the potential of natural resource-based industrialization, a process based on diversification towards high value-added products, in the Latin American region. However, there is limited evidence on how the development of productive linkages – a key aspect of this strategy – behaves at the country level. Based on input-output (IO) analysis, this paper provides a clearer picture of the extent and evolution of productive linkages of NR sectors across a sample of middle- and high-income countries in Latin America as well as in other developing and developed regions. The paper focuses on the degree to which extractive industries, i.e., oil, gas, and mining, are connected to the rest of the economy by studying both backward and forward linkages using OECD IO data. It also makes a distinction between local and foreign inputs to account for the level of integration that these sectors have into global value chains and/or import dependence. Furthermore, it identifies whether the importance of the extractive sectors in exports and total economic output is related to the level of intersectoral linkages. We find that in most countries intersectoral linkages have become smaller despite the expansion of the extractive sector suggesting a higher level of enclaveness as predicted by the resource curse literature.

2.1 Introduction

Historically, exploitation of mining resources has been associated with weak production linkages to local sectors, concentration in natural resource exports, and low industrialization prospects (Auty, 1993; Sachs & Warner, 1995; Singer, 1950) – hence its reputation as a curse for development. However, the commodity bonanza that many emerging economies experienced during the 2000s and mid-2010s, renewed the interest of many scholars in the potential of natural resources as a platform for structural change – especially in resource-rich middle-income countries. This strategy has been particularly appealing for the Latin America region whose revealed international competitive advantage lies mainly in natural resources but also includes scientific knowledge and skilled labor (Lin & Treichel, 2012). Furthermore, the experience of Norway and Australia[3], in successfully moving from natural resources to knowledge-based economies has also strengthened the idea that the so-called resource curse is not necessarily a curse but potentially a blessing.

These factors, along with changes in the technological paradigm (Andersen et al., 2015; Perez, 2010; Perez et al., 2009), have supported the case for a natural-resource based industrialization strategy – mainly characterized by the adoption of state-of-the-art technologies throughout extractive processes and, most importantly, diversification toward high value-added products. According to this view, structural change is not the result of the extraction of commodities itself but rather of the development of inter-industrial linkages - especially with medium and high knowledge intensity sectors which ultimately allow for knowledge and technological accumulation of local firms (Farooki & Kaplinsky, 2014; Kaplinsky, 2011). Moreover, other scholars have also considered that the increasing outsourcing of tasks along the mining value chains, a process that began in the 1990s, could boost the development of win-win linkages between extractive sectors and the rest of the economy (Morris et al., 2012; Morris & Fessehaie, 2014). The development of spin-off industries that are suppliers of services and inputs (i.e., upstream industries) as well as commodity processing industries (i.e., downstream industries) is essential for diversification, employment generation, improvement of social capabilities, and the overall resilience of the economy.

In other words, linkage development is paramount for avoiding the resource curse – which, among other adverse economic effects, predicts a high degree of 'enclaveness' of the mining sector and the weakening of manufacturing industries. Therefore, the promotion of inter-industrial linkages from and to the extractive sectors has become one of the main policy objectives of mineral-based economy development since the beginning of the 2000s (Castaño et al., 2019; Dietsche, 2014).

3 For instance, see Ville & Wicken (2012).

Several case studies in Latin America and other developing regions have shown the potential of natural resources to catalyze broad-based growth[4]. In particular, case studies on the mining sector in Sub-Saharan Africa have emphasized the crucial role that mining linkages can play in supporting the industrialization and diversification of resource-rich developing countries (Morris et al., 2012; UNIDO, 2012). While these studies highlight the importance of inter-industrial linkages, there are only a few that have studied this matter from a quantitative perspective. Existing evidence-based on Chile, Ghana, and South Africa[5], nonetheless, shows that the mining sector in developing countries has remained operating as an enclave.

The objective of this paper is thus to provide an outline of the topology of the inter-industrial linkages of the mining sector, i.e., oil, gas, and mining commodities, and its recent evolution across a sample of middle- and high-income countries in Latin America and other regions.
For this purpose, we utilize an input-output framework (i.e., backward, and forward linkages), which allows for a country-level assessment of inter-industrial linkages, and ultimately, for a better understanding, of how the productive structure is affected by changes in the demand and supply of the mining sector. This paper provides a detailed account of how inter-industrial linkages have evolved from the mid-1990s to the peak of the commodities boom in 2011. Likewise, our analysis identifies the industries that the mining sector connects to more strongly as well as the degree to which inputs demanded and supplied by this sector are absorbed by foreign industries.

This descriptive analysis sheds further light on the evolution of extractive related industries in resource-rich countries during a key period – not only because of changes in commodity prices but also because of a high level of integration into global value chains. Finally, we complement the descriptive analysis using a panel econometric setup to test whether the expansion of extractive sectors, i.e., as a share of GDP or as exports, is statistically associated with higher or lower inter-industrial connectivity of the mining sector.
The chapter is structured as follows: Section 2.2 describes the methodology, sample, and data utilized. Section 2.3 presents the evolution of the mining sector and section 2.4 presents the empirical results. Section 2.5 concludes.

4 Some of the case studies on Latin America include: Salmon (Katz, 2006; Maggi, 2003), wine (Benavente, 2006; Giuliani, 2011), coffee (Giovannucci et al., 2002), cassava and flowers (Mytelka & Bortagaray, 2006) and mining (McMahon & Remy, 2002).

5 For example, Nchor & Konderla (2016) analyze linkages before and after the beginning of oil production in Ghana in 2010. They find that despite the large economic contribution of this sector, production linkages (i.e., backward, and forward linkages) remain low. Their conclusions are in line with older studies: Stilwell et al., (Stilwell et al., 2000) and Aroca (2001) who had studied mining linkages in South Africa and the main mining region of Chile, respectively in decades prior to the 2000s boom.

2.2 Methodology

In the chapter, we utilize an input-output framework that measures the interdependencies in the structure of production by calculating backward and forward linkages. The former is based on the Leontief inverse matrix and captures the demand relationship between sectors. A backward linkage coefficient measures how much supplier industries will increase their demand when sector *i* increases its output. The latter is based on the Ghosh coefficient matrix and captures the supply relation between sectors: when output in sector *i* increases there is higher availability of product *i* to be used as an input in other industries[6].

Both provide an insight into the different levels of interindustry connectivity: while backward linkages indicate how much other sectors' demand will grow as sector *i* expands, forward linkages describe how much other sectors depend on the output of sector *i* for their own productive activities[7].

Using the framework of Reis & Rua (2006) as a reference, a third measure is also considered to make a distinction between the demand for domestic and foreign products by measuring backward leakages. This captures the extent to which non-domestic sectors are stimulated when sector *i* increases its demand. So, if sector *i* has a high level of backward leakages, as it expands, it will generate additional imports to support it. This distinction between domestic and imported inputs is made in order to avoid the overestimation of multiplier effects (Dietzenbacher et al., 2005) as well as to see where the demand is generated, i.e. domestically or abroad.

Finally, we introduce a fourth measure, forward leakages, to estimate the supply relation between a domestic sector and non-domestic sectors. Namely, it measures changes in the availability of primary inputs from sector *i* in all non-domestic sectors when sector *i* increases its output. Our measure is different to the forward leakage measure by Dietzenbacher, Albino, & Kuehtz (2005) which describes the impact of imports on the availability of primary inputs for a domestic sector. Our measure allows us to compare how much of the output of a given sector is absorbed as primary input domestically in relation to the rest of the world.

6 The Ghosh model is considered appropriate for obtaining the forward linkage measure (Miller & Blair, 2009). Dietzenbacher (1997) suggested that the Ghosh model should be interpreted as a Leontief price model, instead of a quantity model. Nonetheless, this is also debatable: De Mesnard (2001) and Davar (2005) show that this interpretation is erroneous as it would only be valid under strong, unrealistic assumptions (i.e., for prices to be determined in the Ghosh model, all quantities would have to be fixed in relation to all prices in both the Ghosh and Leontief value models).

7 For a detailed explanation of the input-output framework, namely of the Leontief and Gosh coefficients (see Miller & Blair, 2009).

2.2.1 Backward Linkages

Say we have n sectors in an economy and the equilibrium between total supply and total demand for each product i is:

$$x_i + m_i = z_{i1} + z_{i2} + \ldots + z_{in} + y_i \qquad (1)$$

where x_i is the domestic output of sector i, m_i represents the imports of product i, z_{ij} is sector i´s product absorbed by sector j, and y_i is the total final demand of sector i. We can further define m_i as:

$$m_i = \sum z_{ij}^m + y_i^m \qquad (2)$$

where z_{ij}^m is sector i´s imported inputs absorbed by sector j and y_i^m is sector i´s total final demand of imports.

Since the domestic output of sector i, x_i, is equal to the demand for i (as intermediate input) across all domestic sectors, z_{ij}^d, plus final domestic consumption of i, y_i^d, then (1) can be rewritten as:

$$x_i = z_{i1}^d + z_{i2}^d + \ldots + z_{in}^d + y_i^d \qquad (3)$$

We obtain a set of n equations for each of the n sectors:

$$\begin{aligned} x_1 &= z_{11}^d + z_{12}^d + \ldots + z_{1n}^d + y_1^d \\ x_2 &= z_{21}^d + z_{22}^d + \ldots + z_{2n}^d + y_2^d \\ &\vdots \\ x_n &= z_{n1}^d + z_{n2}^d + \ldots + z_{nn}^d + y_1^d \end{aligned} \qquad (4)$$

The domestic direct input coefficient, which captures the ratio of input i to sector j output, is defined as:

$$a_{ij}^d = \frac{z_{ij}^d}{x_j} \qquad (5)$$

The domestic direct input coefficient (5) can then be substituted into the system of equations given by (4) to give:

$$\begin{aligned} x_1 &= a_{11}^d x_1 + a_{12}^d x_1 + \ldots + a_{1n}^d x_1 + y_1^d \\ x_2 &= a_{21}^d x_2 + a_{22}^d x_2 + \ldots + a_{2n}^d x_2 + y_2^d \\ &\vdots \\ x_n &= a_{n1}^d x_n + a_{n2}^d x_n + \ldots + a_{nn}^d x_n + y_n^d \end{aligned} \qquad (6)$$

In matrix terms, one can write (6) as:

$$\boldsymbol{X} = \boldsymbol{A}^d \boldsymbol{X} + \boldsymbol{Y}^d \qquad (7)$$

with:

$$\boldsymbol{A}^d = \begin{bmatrix} a_{11}^d & a_{12}^d & \cdots & a_{1n}^d \\ a_{21}^d & a_{22}^d & \cdots & a_{2n}^d \\ \vdots & \vdots & \ddots & \vdots \\ a_{n1}^d & a_{n2}^d & \cdots & a_{nn}^d \end{bmatrix} \qquad \boldsymbol{X} = \begin{bmatrix} x_1 \\ x_2 \\ \vdots \\ x_n \end{bmatrix}$$

Where $\boldsymbol{A}^d$ is the domestic intermediate input coefficient matrix, $\boldsymbol{X}$ is a vector matrix of the output and $\boldsymbol{Y}^d$ is a vector matrix for the final demand of each of the n sectors in the economy. Solving (7) for $\boldsymbol{X}$ gives:

$$\boldsymbol{X} = (\boldsymbol{I} - \boldsymbol{A}^d)^{-1} \boldsymbol{Y}^d \qquad (8)$$

The Leontief inverse matrix is then given by $\boldsymbol{B} = (\boldsymbol{I} - \boldsymbol{A}^d)^{-1}$ where a typical cell gives the ratio of sector i's input absorbed by j to sector j's output. In other words, it captures the output generated in all different sectors in response to a change in output in a particular sector.

The total backward linkage for sector j is the sum of the elements in the jth column of the Leontief inverse matrix, which measures the total output from all sectors generated from a one-unit change in the final demand of sector j (Rasmussen, 1956), that is:

$$b_{\bullet j} = \sum_{i=1}^{n} b_{ij} \qquad (9)$$

Considering that we are primarily interested in the degree of backward dependence to the rest of the economy, it is appropriate that we omit the on-diagonal elements in the column sum of sector *j*, $b_{\bullet j}$, to consider the output multiplier effect that is created beyond our sector of interest (Blair & Miller, 2009).

We will refer to the total backward linkage as the direct backward linkage (DBL), and to the latter measure, where on-diagonal elements are netted out of the summation, as the indirect backward linkage (IBL).

In this way, the DBL coefficient measures the additional output that will be generated across all sectors, including mining, in response to a one-unit monetary increase in mining demand. Likewise, the IBL coefficient would show the additional output generated across other sectors, excluding mining, in response to a one-unit monetary increase in mining demand.

2.2.2 Forward Linkages

While the Leontief model relates sectoral gross outputs to the demand of a given sector, the Ghosh model relates sectoral gross production to inputs (Miller & Blair, 2009). One then can consider the supply-side perspective:

$$x_j = z_{1j}^d + z_{2j}^d + \dots + z_{nj}^d + w_j \qquad (10)$$

where w_j includes imports used by sector *j* as well as value-added items. We then obtain a set of n equations for each of the n sectors:

$$\begin{aligned} x_1 &= z_{11}^d + z_{21}^d + \dots + z_{n1}^d + w_1 \\ x_2 &= z_{12}^d + z_{22}^d + \dots + z_{n2}^d + w_2 \\ &\vdots \\ x_n &= z_{1n}^d + z_{2n}^d + \dots + z_{nn}^d + w_n \end{aligned} \qquad (11)$$

We define the domestic direct output coefficient, a_{ij}^{*d}, which gives the ratio of sector's *i* domestic production absorbed by sector *j* to sector *i*'s output, as:

$$a_{ij}^{*d} = \frac{z_{ij}^d}{x_i} \qquad (12)$$

The domestic direct output coefficient (12) can then be substituted into the system of equations in (11) to give:

$$\begin{aligned} x_1 &= a_{11}^{*d}x_1 + a_{21}^{*d}x_1 + \dots + a_{n1}^{*d}x_1 + w_1 \\ x_2 &= a_{12}^{*d}x_2 + a_{22}^{*d}x_2 + \dots + a_{n2}^{*d}x_2 + w_2 \\ &\vdots \\ x_n &= a_{1n}^{*d}x_n + a_{2n}^{*d}x_n + \dots + a_{nn}^{*d}x_n + w_n \end{aligned} \qquad (13)$$

We rewrite (13) in matrix form:

$$\boldsymbol{X'} = \boldsymbol{X'A^{*d}} + \boldsymbol{W'} \qquad (14)$$

with:

$$\boldsymbol{A^{*d}} = \begin{bmatrix} a_{11}^{*d} & a_{21}^{*d} & \cdots & a_{n1}^{*d} \\ a_{12}^{*d} & a_{22}^{*d} & \cdots & a_{n2}^{*d} \\ \vdots & \vdots & \ddots & \vdots \\ a_{1n}^{*d} & a_{2n}^{*d} & \cdots & a_{nn}^{*d} \end{bmatrix} \qquad \boldsymbol{X} = \begin{bmatrix} x_1 \\ x_2 \\ \vdots \\ x_n \end{bmatrix} \qquad \boldsymbol{W'} = \begin{bmatrix} w_1 \\ w_2 \\ \vdots \\ w_n \end{bmatrix}$$

where $\boldsymbol{W'}$ is the vector of imports and value-added items used by sectors and $\boldsymbol{A^{*d}}$ is the matrix of domestic direct output coefficients. Solving (14) for $\boldsymbol{X'}$ yields:

$$\boldsymbol{X'} = \boldsymbol{W'}(\boldsymbol{I} - \boldsymbol{A^{*d}})^{-1} \qquad (15)$$

where $(\boldsymbol{I} - \boldsymbol{A^{*d}})^{-1}$ is the output inverse matrix.

The total forward linkage is the sum of the elements in the *i*th row of the output inverse matrix which gives the effect on total output throughout all sectors of a unit change in primary inputs for sector *i*, that is:

$$b_{i\bullet}^{*} = \sum_{j=1}^{n} b^{*}{}_{ij} \qquad (16)$$

Similarly, to consider the forward dependency to the rest the economy, we will omit the on-diagonal elements in the row sum of sector *j*, $b^*_{i\bullet}$, and refer to this measure as the indirect forward linkage (IFL). The total forward measure, with all on-diagonal elements included, will be referred to as the direct forward linkage (DFL).

In this way, the DFL measures the additional input availability of each sector, including mining, resulting from a one-unit monetary increase in mining output. Likewise, the indirect backward linkage measures the additional input availability for all sectors, excluding mining, resulting from a one-unit monetary increase in mining output.

2.2.3 Backward Leakages

Akin to the technical coefficients in (5), we can define the imports direct input coefficient, $\boldsymbol{a^m_{ij}}$, as:

$$a^m_{ij} = \frac{z^m_{ij}}{x_j} \qquad (16)$$

which captures the imports of product *i* absorbed by sector *j* per unit of output of sector *j*. We can then define $\boldsymbol{A}^m$ as the matrix of imports direct input coefficients which allows us to construct the backward leakage matrix:

$$\boldsymbol{A}^m(\boldsymbol{I} - \boldsymbol{A}^d)^{-1} \qquad (17)$$

where the sum of the elements in the *j*th column provides the total leakage, i.e. value of all imports, which result from a one-unit increase in the final demand for sector *j* (Dietzenbacher et al., 2005). Thus, the backward leakage in our analysis measures the strength with which imports demand increases resulting from a one-monetary unit increase in mining demand.

2.2.4 Forward Leakages

Whereas the calculation of the previous measures relies on national input-output tables, to obtain the forward leakage is necessary to employ an inter-country input-output table; this is because it requires measuring changes in input availability in all foreign sectors as a given domestic sector increases its output.

We define an inter-country matrix of direct output coefficients with *n* products and *k* countries, $\boldsymbol{A^{IC}}$. In this inter-country matrix, the on-diagonal matrices represent the domestic output coefficient matrix, $\boldsymbol{A^{*d}_k}$, of *k* countries, and the off-diagonal matrices represent the foreign output coefficient matrix, $\boldsymbol{A^{*m}_k}$, of *k* countries. The global matrix $\boldsymbol{A^{IC}}$ can be written as:

$$\boldsymbol{A}^{IC} = \begin{bmatrix} \boldsymbol{A}^{*d}_{AA} & \cdots & \boldsymbol{A}^{*m}_{AK} \\ \boldsymbol{A}^{*m}_{BA} & \cdots & \boldsymbol{A}^{*m}_{BK} \\ \vdots & \ddots & \vdots \\ \boldsymbol{A}^{*m}_{KA} & \cdots & \boldsymbol{A}^{*d}_{KK} \end{bmatrix}$$

with:

$$\boldsymbol{A}^{*d}_k = \begin{bmatrix} a^{*d}_{11} & a^{*d}_{21} & \cdots & a^{*d}_{n1} \\ a^{*d}_{12} & a^{*d}_{22} & \cdots & a^{*d}_{n2} \\ \vdots & \vdots & \ddots & \vdots \\ a^{*d}_{1n} & a^{*d}_{2n} & \cdots & a^{*d}_{nn} \end{bmatrix} \qquad \boldsymbol{A}^{*m}_k = \begin{bmatrix} a^{*m}_{11} & a^{*m}_{12} & \cdots & a^{*m}_{n1} \\ a^{*m}_{12} & a^{*m}_{22} & \cdots & a^{*m}_{n2} \\ \vdots & \vdots & \ddots & \vdots \\ a^{*m}_{1n} & a^{*m}_{2n} & \cdots & a^{*m}_{nn} \end{bmatrix}$$

where the typical cell in $\boldsymbol{A^{*d}_k}$, gives the domestic direct output coefficient, $\boldsymbol{a^{*d}_{ij}}$, as previously defined in (12). The typical cell in $\boldsymbol{A^{*m}_k}$, gives the foreign output coefficient which, in turn, is defined as:

$$a^{*m}_{ij} = \frac{z^{*m}_{ij}}{x_i} \qquad (18)$$

The foreign output coefficient, $\boldsymbol{a^{*m}_{ij}}$, captures the ratio of domestic sector *i* production absorbed by non-domestic sector *j* per unit of output of domestic sector *i*.
Akin to the forward linkage, the total forward leakage is the sum of the elements in the *i*th row of the inter-country output matrix $\boldsymbol{A^{IC}}$, however, we exclude the cells which correspond to the domestic matrix of direct output coefficient $\boldsymbol{A^{*d}_k}$. Thus, the forward leakage[8] gives the effect on total output throughout all sectors outside of country *A* of a unit change in primary inputs for sector *i* of country *A*.

This measure, thus, allows us to measure the increase in the availability of mining inputs in all foreign sectors as the result of a one-unit monetary increment in the domestic production of mining.

8 Our measure of forward leakages differs to the one put forward by (Dietzenbacher et al., 2005), in which the forward leakage resulting from one unit change in the primary inputs for sector *i* is given by the sum of the elements in the *i*th row of the leakage matrix. $\widehat{(I - A^d)^{-1}A^{*m}}$ure describes how imports affect the availability of primary inputs for a domestic sector. Our definition, in contrast, measures how the output of a domestic sector affects the availability of primary inputs in all sectors outside that country.

2.3 Data

To obtain the previous measures, we utilize a sample of middle and high-income countries using OECD Input-Output data from 1995 to 2011 (2015 edition). The sample covers 20 countries with an active mining industry across different regions – including Latin America. This period allows us to capture some of the changes in inter-industrial relations that took place as trade liberalization, stronger integration into global value chains and the emergence of China and other Asian economies materialized. More importantly, it coincides with the commodity boom of the 2000s, in which energy and metal prices in some cases tripled from historically low levels after 2003 (Adler & Sosa, 2011). The period of this study also covers the peak of commodity prices in 2011.

National input-output tables (NIOTs) describe supply and demand relationships between producers and consumers within a country. They can either show flows of final and intermediate goods and services defined according to industry outputs (industry × industry tables) or according to product outputs (product × product tables).

The OECD database of harmonized NIOTs takes the industry × industry approach. This reflects the collection mechanisms for data sources according to industrial activity, such as R&D expenditure, employment, foreign direct investment, and energy consumption. The utilized version of NIOTs consists of matrices of inter-industrial flows of goods and services (produced domestically and imported) in current prices (USD million) (OECD, n.d.)

The inter-country input-output (ICIO) tables also cover inter-industrial relationships across countries. In an ICIO table, the diagonal blocks represent domestic transaction flows of intermediate goods and services across industries (NIOTs), while the off-diagonal blocks represent the inter-country flows of intermediates via exports and imports.

OECD input-output datasets are based on an ample array of sources, such as National Accounts (SNA 1993 format) statistics from the OECD and UNSD, and merchandise trade statistics from UN Comtrade. The tables employ a 34-sector classification based on the UN International Standard Industrial Classification of All Economic Activities, Revision 3 (ISIC Rev.3).

Table 2.1. OECD, Inter-Country Input-Output (ICIO) Tables, 2015 edition

	Intermediates use	Final Demand (FD)							Output (X)
	ctry 1 x indy 1 […] ctry 71 x indy 71	Households Final Consumption Expenditure	Non-Profit Institutions Serving Households	General Government Final Consumption	Gross Fixed Capital Formatio n	Change in Inventories and Valuables	Direct purchases by non-residents	Discrepancy	
country 1 x industry 1									
country 1 x industry 2									
[…]									
[…]									
country 71 x industry 1									
[…]	(Z)	(FD)							(X)
country 71 x industry 34									
Value added + taxes - subsidies on intermediate products (VA)	(VA)	***Note*: FD = Total final expenditures + *discrepancy* (i.e. exports to unspecified partners)**							
Output (X)	(X)								

Z	Intermediate transactions	(2414 rows/sectors x 2414 columns/countries)
VA	Value-added at basic prices + taxes - subsidies on intermediate products	(1 row x 2414 columns/countries)
X	Output at basic prices	(1 row x 2414 columns/countries)

Note: 2414 = 34 industry sectors x 71 countries (i.e., 63 countries + rest of the world + split tables for China and Mexico).
Source: OECD

According to the sector classification, the mining sector ("Mining and quarrying") includes the extraction of minerals occurring naturally as solids (coal and ores), liquids (petroleum), or gases (natural gas). It also includes supplementary activities aimed at preparing the crude materials for marketing, for example, crushing, grinding, cleaning, drying, sorting, concentrating ores, liquefaction of natural gas, and agglomeration of solid fuels[9] (UNSD, n.d.).

9 This follows the default level of aggregation in the OECD IOT 2015.edition.

For the comparative purpose of this analysis, we divide the sample between high- and middle-income groups; yet, since Latin American countries (which would fall in either category) are the main focus of the analysis, a separate group was created for this region. Likewise, a separate group was formed for high-income countries heavily reliant on oil. As a result, countries were grouped as follows[10],[11]:

- Latin America: Argentina (ARG), Brazil (BRA), Chile (CHL), Colombia (COL), Mexico (MEX), and Peru (PER).
- Middle-income countries (excludes Latin American countries): Indonesia (IDN), Philippines (PHL), Malaysia (MYS), Thailand (THA), Russian Federation (RUS), and South Africa (ZAF).
- High-income countries (excludes Latin American countries): Australia (AUS), Canada (CAN), Netherlands (NLD), Norway (NOR), United Kingdom (GBR), and the United States (USA).
- Oil-specialized, high-income countries: Brunei Darussalam (BRN) and Saudi Arabia (SAU).

2.4 Mining's Importance

In the period covered, 1995 to 2011, most countries in the sample experienced an important expansion of the mining sector (i.e., the share of GDP and exports) – unsurprisingly so, considering the 2000s commodities boom[12]. Furthermore, mining activities constituted the largest share of the overall extractive industries' contribution to GDP and exports[13]. However, as pointed out by Sinnott et al., (2010), while higher production did contribute to the growth of the mining sector during the boom, the expansion was largely fueled by higher commodity prices. Considering this, and that the data we utilize are based on current prices, the expansion of mining here described reflects both commodity price and output increments.

10 The middle-income and high-income category was based on the World Bank Atlas method for income classification which assigns countries to income groups according to their 2016 gross national income (GNI) per capita.

11 Note that the classification of groups is meant to facilitate comparisons, and naturally, some level of heterogeneity is expected in each group. For this, relevant country-specific differences are discussed in each of the empirical results sub-sections.

12 For country-level details see Table 2.3 in Annex.

13 This contribution would comprise the output of the extractive commodity sector, i.e., mining (C10 to C14 according to ISIC Rev. 3), and that of the extractive manufacturing industries, i.e., refinery and processing of mineral and metals (C23, C26, C27, C28 according to ISIC Rev. 3).

Figure 2.1 shows the substantial expansion of mining in Latin America, with Peru being the most mining-dependent country in the region. As a share in GDP, the mining sector grew from 1% to 4% in Brazil, 3% to 8% in Colombia, 5% to 12% in Peru, 5% to 7% in Mexico, 3% to 5% in Chile and 3% to 4% in Argentina. The share of mining in total exports in Mexico went from 8% to 14%, in Colombia from 24% to 46%, in Peru from 22% to 49%, in Brazil from 5% to 20%, and in Chile from 12% to 16%. Only Argentina had a decline from 6% to 5%. Other extractive industries, i.e., refinery, also grew but marginally when compared to mining. Only in Chile was the importance of the processing of metals comparable to mining: in 2011, processed metals represented 4% of GDP and 12% of exports.

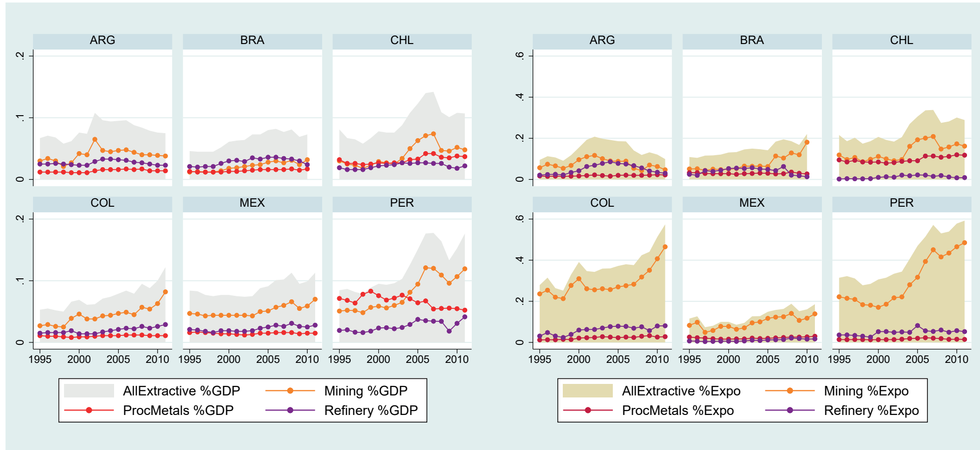


Figure 2.1. Extractive sectors contribution to GDP and exports in Latin America
Source: Author's elaboration with OECD data.

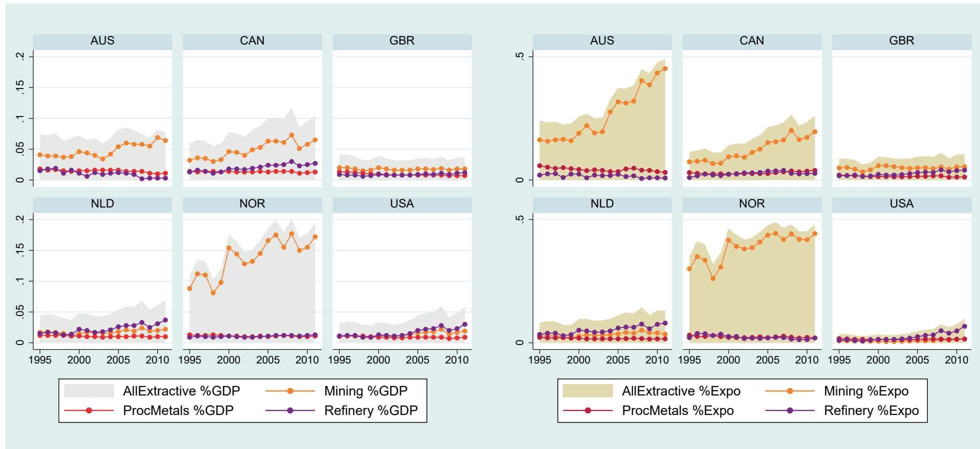


Figure 2.2. Extractive sectors contribution to GDP and exports in high-income countries
Source: Authors' elaboration with OECD data.

Figure 2.3 shows that the importance of mining in high-income countries is quite heterogenous: While in Australia and Norway, it is substantially high, in other countries like the US, it is relatively small.

The share of mining in GDP moved from 9% to 17% in Norway, 4% to 6% in Australia, and 3% to 7% in Canada. There were no significant changes in the US, the Netherlands, or Great Britain. Mining exports went from 30 to 44% in Norway, 16% to 45% in Australia, and 7% to 20% in Canada. It remained virtually the same in the US (1% to 2%), the Netherlands (3% to 4%), and Great Britain (5%).

It is noteworthy that in the US and the Netherlands, the refinery sector became much more important than mining: the share of refinery activities in GDP grew from 1% to 3% in the US and from 1% to 4% in the Netherlands while refinery exports went from 1% to 7% and from 3% to 8% respectively.

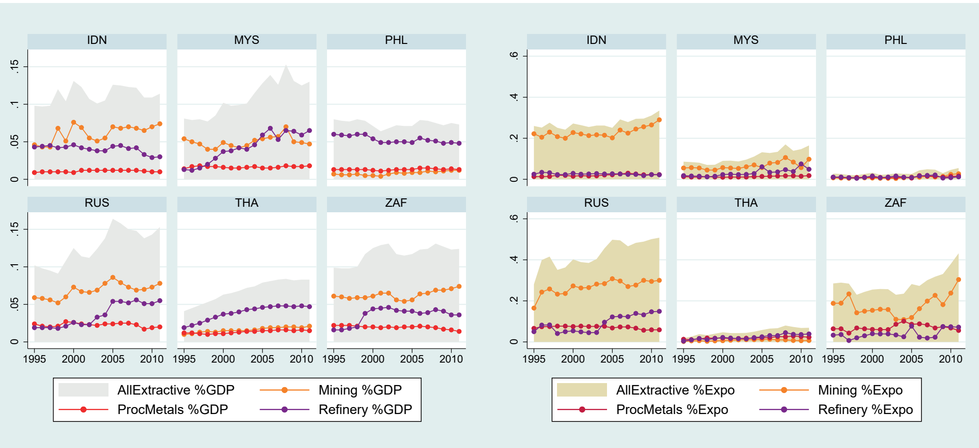


Figure 2.3. Extractive sectors contribution to GDP and exports in middle-income countries
Source: Authors' elaboration with OECD data.

The share of mining in GDP in middle-income countries was similar to that of Latin America, as shown in Figure 2.4. The mining sector expanded from 6% to 7% in South Africa, from 6% to 8% in Russia, and 6% to 7% in Indonesia and remained at 5% in Malaysia. In the Philippines and Thailand, the share of mining in GDP remained quite low. Overall, mining exports grew substantially more in this group than in Latin America. The expansion of mining exports was particularly high for South Africa (from 19% to 30%), Russia (16% to 30%), and Indonesia (22% to 29%).

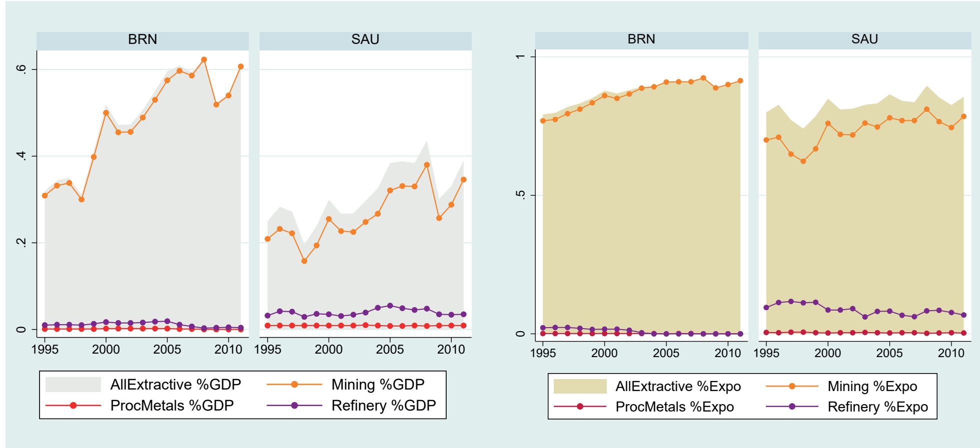


Figure 2.4. Extractive sectors contribution to GDP and exports in high-income oil-specialized countries
Source: Author's elaboration with OECD data.

It is worth mentioning that the refinery sector grew substantially in this group, except for Indonesia. The refinery sector stood as the most important type of extractive industry in the Philippines, Malaysia, and Thailand in 2011.

Lastly, Saudi Arabia and Brunei became even more specialized in this sector, as seen in Figure 2.5: Mining's contribution to GDP went from 21% to 35% in Saudi Arabia and from 31% to 61% in Brunei. Exports increased from 70% to 78% in Saudi Arabia and from 77% to 91% in Brunei. Saudi Arabia had a relatively important refinery sector, which also declined slightly between 1995 and 2011.

2.5 Empirical Results

2.5.1 Backward Linkages in Mining

In this subsection, we discuss changes in direct backward linkages (DBL) – which measure demand changes in all sectors as mining demand grows – and indirect backward linkages (IBLs) – which measure demand changes only outside the mining sector[14]. These measures – especially the latter - allow us to understand whether the mining sector has moved towards a lesser or higher degree of enclaveness.

Results indicate that mining backward linkages have consistently declined across our sample: on average, DBL and IBL values were reduced by 18% and 26%, respectively, between 1995

14 Due to our interest in the mining sector's connectivity in this subsection we will focus primary on IBL values but when appropriate we will report both measures.

and 2011[15]. Possibly the steep decline in mining backward linkages reflected an overall reduction of linkages across domestic sectors. However, this does not seem to be the case as the average DBL and IBL values across sectors remained relatively constant over time[16].

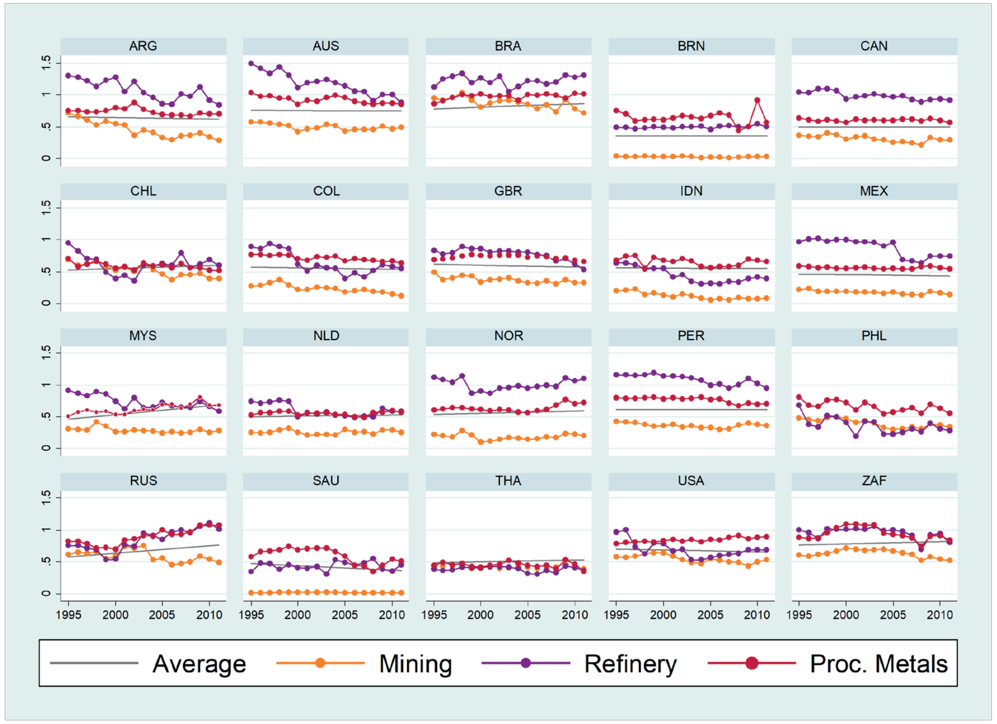


Figure 2.5. IBLs in extractive industries and fitted values for unweighted average IBLs
Source: Author's elaboration with OECD data.

Although results suggest that, on average, the mining sector became more enclave over time, there are significant differences across regions and countries (as seen in Figure 2.5); these are as follows:

- Latin America: This group, on average, had the biggest drop in DBL and IBL values (28% and 40%, respectively). DBLs and IBLs dropped substantially in Chile (by 39% and 43%, respectively), in Mexico (by 36% and 36%), in Colombia (by 18% and 56%), and in Argentina (by 50% and 61%). Brazil – which had the highest values of DBLs and IBLs across the sample – DBLs and IBLs were reduced by 18% and 25%, respectively. The smallest reductions were observed in Peru (4% and 16%, respectively).
- High-income countries: In contrast to Latin America, high-income countries experienced the smallest reductions in the sample, with DBLs falling by 10% and IBLs by 13%. The largest reduction was in Great Britain where DBL and IBL values dropped by 29% and 33% respectively. The second steepest reduction was seen in Canada (17% and 20%), and in Australia (20% and 14%). The Netherlands is the only country in the sample that experienced an increase in the DBL and IBL coefficients (9% and 3%, respectively). It is worth noticing that, after Brazil and Russia, the USA and Australia had the highest IBL and DBL values.
- Middle-income countries: The average drop in DBL and IBL values in this group was 23% and 22%, respectively – higher than in high-income countries but not as high as in Latin America. In Russia DBL and IBL values were reduced by 30% and 19%, respectively, and in South Africa by 13% (both cases). Mining IBL values in Indonesia dropped substantially, i.e., 57% - the second steepest fall after Argentina. Contrariwise, backward linkage values in Thailand and Malaysia remained virtually unchanged.
- Oil-specialized, high-income countries: DBLs and IBLs in Saudi Arabia were reduced by 27% and 40%, while in Brunei DBLs increased by 4% and IBLs fell by 26%. These two countries had by far the highest degree of enclaveness in the mining sector across our sample (as measured by initial levels of the period)[17].

15 Results at the aggregate level, by group and country are reported in Table 2.4 in Annex.
16 Average DBL and IBL values across all domestic sectors grew by 1%. Details are reported in Table 2.4 in Annex.

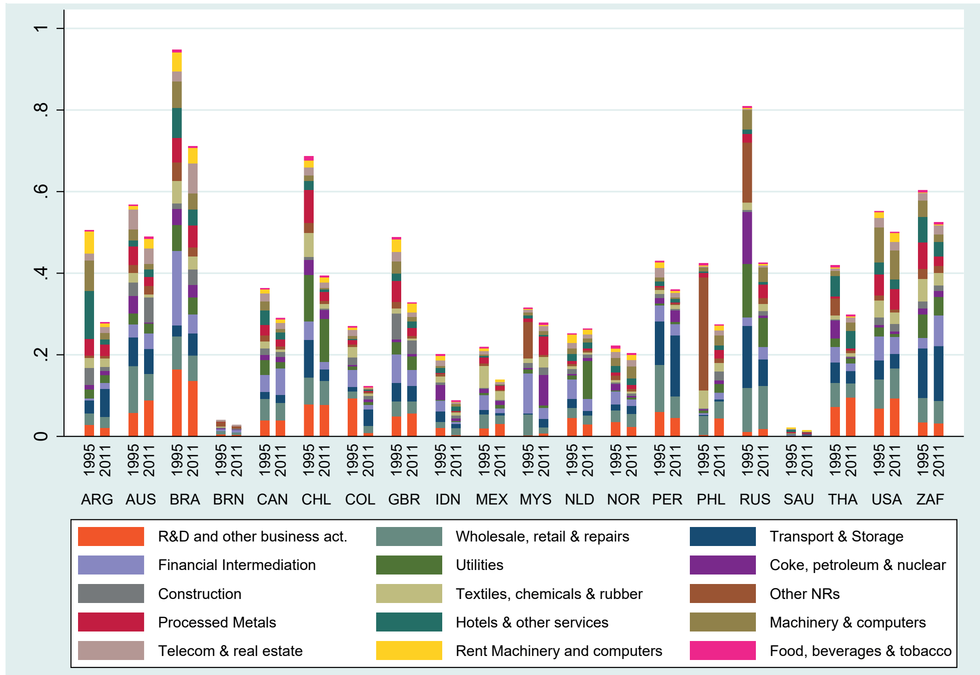


Figure 2.6. Distribution of backward linkages across sectors (1995 and 2011)
Source: Authors' elaboration with OECD data.

17 For instance, in 2011 the mining IBL value was 0.02 USD whereas the average IBL was 0.37 USD in Saudi Arabia – meaning that an increase in demand for mining has practically no impact on the demand for other sectors' output.

2.5.2 Breakdown of Backward Linkages by Sector

In this subsection, we discuss the sectors that are most important in supplying domestic mining – in terms of backward linkages - and how these changed from 1995 to 2011. This is relevant as backward linkages are considered to be strategic when they are established with sectors of higher technological sophistication.

Results indicate that across the sample, services – albeit of different levels of technological sophistication (proxied by productivity) – were the main supplying sectors of the mining industry. Mining backward linkages were more strongly allocated to the wholesale and retail trade and repairs sector (C50T52), R&D and other business activities (C73T74)[18],[19], transport and storage (C60T63), and financial intermediation (C65T67)[20]. Whereas the wholesale and retail trade sector is considered low productivity, or *non-modern*[21], the rest of the sectors are considered to be high-productivity, or *modern*, sectors.

Although the above describes an overall picture of the mining backward linkage allocation, the strength of mining backward linkages to other sectors did vary across groups and countries – as seen in Figure 2.6. Other group- and country-specific considerations are as follows:

- Latin America: In this region, the most important sectors were the services mentioned above. In 2011, R&D and other business services were the most important mining supply sector in Brazil and Mexico. In Chile, this was the second most important backward linkage for mining after the utilities sector (C40T41). In Peru, Argentina, and Colombia, backward linkages to the transport and storage sector were the highest.
- High-income countries: The mining sector in high-income countries had linkages to service sectors which were rather similar to Latin America. Interestingly, in Norway and the US, there was a strong linkage between mining and the manufacturing sector – i.e., machinery and computers. On average, financial intermediation played a bigger role as a mining supplier in these countries.
- Middle-income countries: For middle-income countries, backward linkages to the coke, petroleum, nuclear energy, and transport and storage sectors were stronger than for R&D and other business services (except for Thailand – where there was a strong mining backward linkage with the latter sector).
- Oil-specialized high-income countries: Brunei and Saudi Arabia's supplier linkages were allocated to the wholesale, retail, and repair sectors and financial services.

18 This C74T74 sector aggregates sectors 73 and 74 in the ISIC Rev. 3 classification. Sector 73 covers: research and experimental development on natural sciences and engineering (731) and on social sciences and humanities (732). Sector 74 covers: Legal, accounting, book-keeping, and auditing activities; tax consultancy; market research and public opinion polling; business and management consultancy (741); architectural, engineering, and other technical activities (742); advertising (743). It also includes other business activities, such as labor recruitment and provision of personnel (7491); investigation and security activities (7492); building-cleaning (7493); photography (7494), packaging (7495) and other activities (7499) from bill collecting and business brokerage to translation and secretarial services.

19 Table 2.5 in Annex reports the backward linkage by sector for the average across countries and by region.

20 This is according to the ISIC Rev.3 sector classification used in OECD IOTs.

21 The modern/non-modern sector classification is based on Lavopa & Szirmai (2014) which considers the aggregate level of labor productivity in these sectors.

2.5.3 Backward Leakages

While backward linkages measure the strength with which mining demand incentivizes demand across domestic sectors, backward leakages measure the same but for foreign sources. In this subsection, we discuss the latter with respect to direct backward linkages (DBLs). Namely, we use the ratio of backward leakages to direct backward linkages to describe changes in domestically sourced inputs demand relative to imported inputs demand[22].

Results indicate that, overall, the ratio of backward leakages to linkages in the mining sector remained quite stable: on average, it increased by 9% across the sample over the 1995-2011 period[23]. There are, however, some group- and country-level differences to be considered:

- Latin America: The ratio of backward leakages to linkages in mining increased the most in Latin America (14%). This increment was substantial in Argentina and Chile - where the ratio grew by 36% and 25%, respectively. It is worth noting that in 2011, Brazil had the lowest ratio of backward leakage in mining, followed by the USA and Russia.
- High-income countries: The backward leakage ratio in the mining sector grew on average 6% in this group. This ratio increased in Great Britain (by 20%) and in Australia by (12%). Other high-income countries had no significant increases or, as in the case of the USA and the Netherlands, the ratio even dropped slightly.
- Middle-income countries: The backward leakage ratio in the mining sector remained quite stable in most middle-income countries - with the Philippines having the biggest increase (24%).
- Oil-specialized high-income countries: In this group, this ratio remained virtually unchanged, as seen in Figure 2.7.

22 If the mining leakage value itself is considered, changes were marginal: the average increment was 1% across the sample.

23 Results at the country-level, group, and aggregate level are reported in detail in Table 2.4 in Annex.

Figure 2.7. Ratio of backward leakages to backward linkages in the mining sector and (unweighted) average leakages ratio
Source: Authors' elaboration with OECD data.

2.5.4 Breakdown of Backward Leakages by Sector

This subsection discusses leakages by sector and how these changed between 1995 and 2011 to obtain an overview of the type of mining inputs absorbed by foreign sectors. Results in figure 2.8 show that, across countries, backward leakages include services - i.e., transport and storage and wholesale, retail, and repairs – but also manufactures – i.e., machinery and equipment, chemicals, and the refinery sector[24]. The aggregate overview did not vary much across regions, however, some considerations in this regard are:

- Latin America: Backward leakages from the coke, petroleum, and nuclear energy sector increased in the region. Only Brazil had a relatively strong backward linkage to R&D and other business activities in foreign sectors.
- High-income countries: Backward leakages were mainly accounted for by machinery and equipment, processed metals, and chemicals – as they did in Latin America. However, this group had higher leakages to the R&D and other business activities sector.
- Middle-income countries: Backward leakages to the transport, and storage; machinery and equipment; and wholesale, retail and repairs were the highest in these countries. An increase in backward leakages to the refinery sector was also observed.
- Oil-specialized high-income countries: Backward leakages – which were extremely low – were focused on transport and storage; processed metals and minerals; and the machinery and equipment sector.

24 Table 2.6 in Annex reports the backward linkage values by sector for the average across countries and by region.

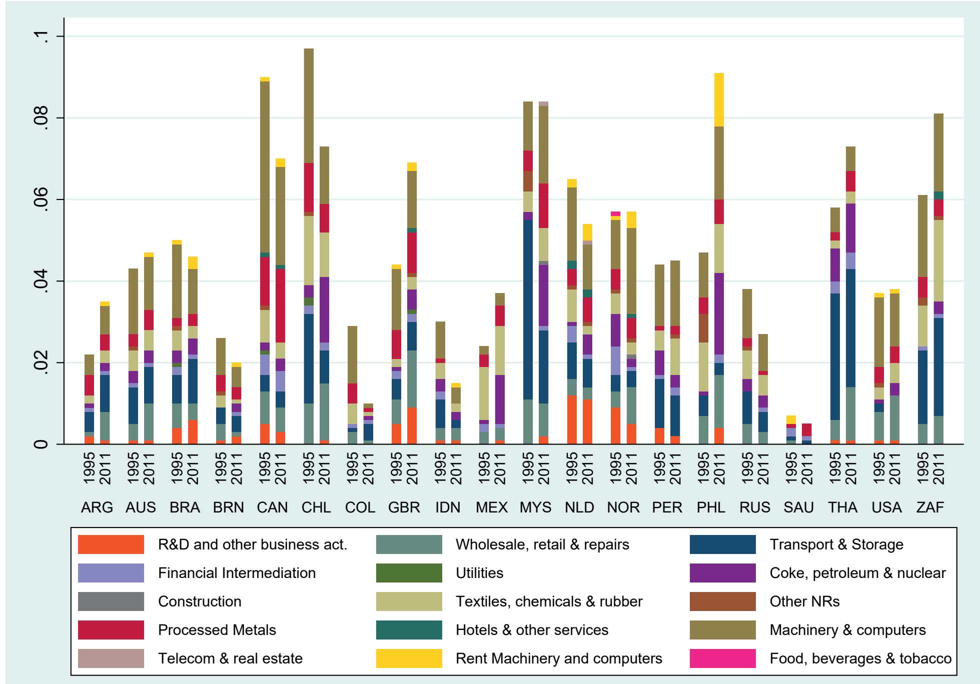


Figure 2.8. Distribution of backward leakages of the mining sector (1995 and 2011)
Source: Authors' elaboration with OECD data.

2.5.5 Forward Linkages

Forward linkages in the case of mining are also a proxy for inter-industrial connections but from a supply perspective. A higher indirect forward linkage (IFL) coefficient for mining would indicate a higher utilization of mining's output as input in other sectors – indicating a lower degree of enclaveness.

However, we find the opposite: results indicate that, across countries, mining forward linkages (ILFs) declined by one-fourth (26%) over the 1995-2011 period[25]. As with IBLs, this reduction in mining IFL values is much higher than the reduction for the average sector IFL value (3%) across the sample. This reduction, strikingly similar to the one observed in

25 Results at aggregate level, and for each group and country, and are reported in detail in Table 2.4 in Annex.

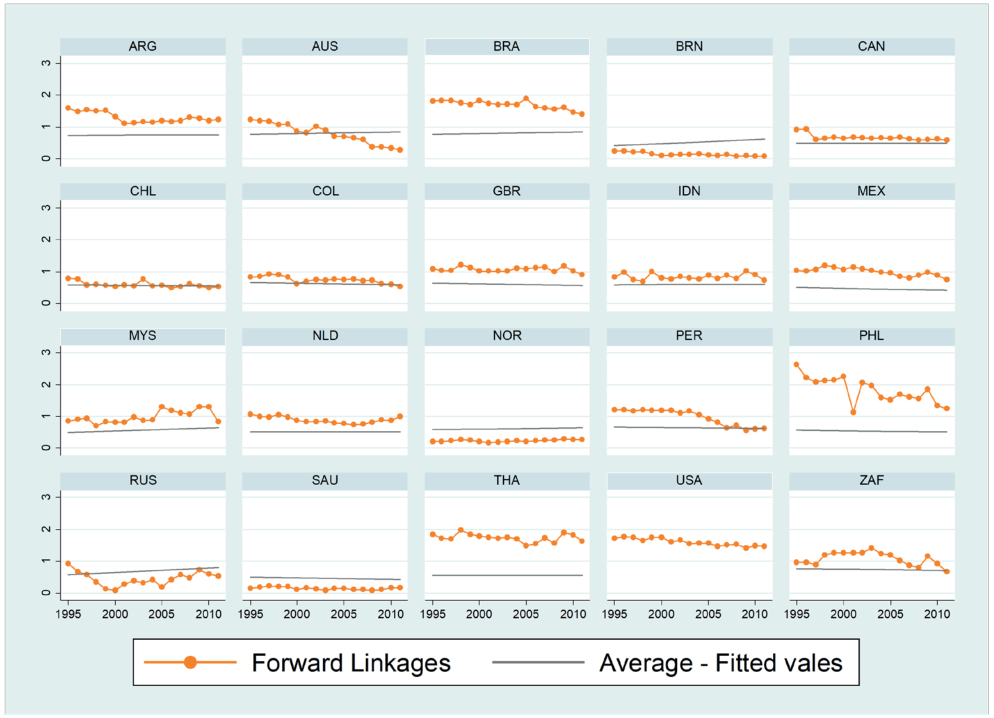


Figure 2.9. Forward linkages of the mining sector and forward linkages of the unweighted average sector
Source: Authors' elaboration with OECD data.

backward linkages, further suggests that the mining sector became more, not less, enclave. Yet, there were important differences across countries in this regard, as seen in Figure 2.9. Further considerations across regions and countries are as follows:

- Latin America: This group had the steepest fall in mining IFL values, with an average reduction of 32%. Peru had a substantial reduction in IFL values of 48%; followed by Colombia (36%) and Chile (35%). In Argentina and Brazil, IFL coefficients dropped by 23% (in both countries). Despite these reductions, in 2011 Brazil, along with Thailand and the USA, had the highest forward linkage values in the sample.
- High-income countries: Although on average IFLs in this group had the smallest reductions (21%) this varied substantially across countries. Australia's mining IFLs were reduced by 77% – the largest reduction in the sample - and Canada's were reduced by 38%. In contrast, the US, Great Britain, and the Netherlands had minor reductions in mining IFL values. Norway's IFL values had an increase of 29% during the period.
- Middle-income countries: On average, mining IFL values were reduced by 25% in these countries – with the steepest reductions taking place in the Philippines (55%), Russia (41%), and South Africa (31%). In contrast, IFL values in Thailand, Indonesia, and Malaysia were reduced only marginally or not at all.

- Oil-specialized high-income countries: This group, on average, had a decline of 30% in mining IFL values. This change does not mean much as the initial levels were close to zero.

2.5.6 Breakdown of Forward Linkages by Sector

This subsection discusses which sectors are more strongly connected to the mining sector as consumers of mining inputs and changes in this regard between 1995 and 2011. Under a natural resource industrialization strategy, it is expected, that mining inputs are also used to develop forward linkages to downstream industries, such as metal processing or refinery activities.

In line with this expectation, results across countries indicate that forward linkages in mining are concentrated in refinery sectors, i.e., coke, petroleum, and nuclear energy, processed metals, and minerals (C27), utilities (C40T41), and construction (C45)[26]. Expectedly, there are some differences across groups and countries – as seen in Figure 2.10. Some of these differences are:

- Latin America: Forward linkages to the refinery sector noticeably declined in this region – especially in Chile and Brazil. In Mexico, the most important reduction of forward linkages took place in the chemical sector, in Argentina in the utilities sector, and in Peru in the processed metals and minerals sector.
- High-income countries: Forward linkages developed heterogeneously among these countries: in Australia and Canada, these declined substantially – with Australia having the steepest decline across the sample. In the US and the Netherlands, forward linkages remained quite stable. In Norway, forward linkage coefficients increased especially in the transport and storage sector.
- Middle-income countries: In these countries, forward linkages also developed quite differently among countries. Whereas forward linkages to the refinery sector increased in Malaysia and Thailand, in Indonesia and the Philippines, these were reduced by more than half.
- Oil-specialized high-income countries: As with backward linkages, forward linkages values were extremely low in these countries. In Brunei, forward linkages were highly concentrated in the construction sector whereas in Saudi Arabia these concentrated in refinery, chemicals, and processed metals and minerals sectors.

26 Table 2.7 in Annex reports the forward linkage values by sector for the average across countries and by region.

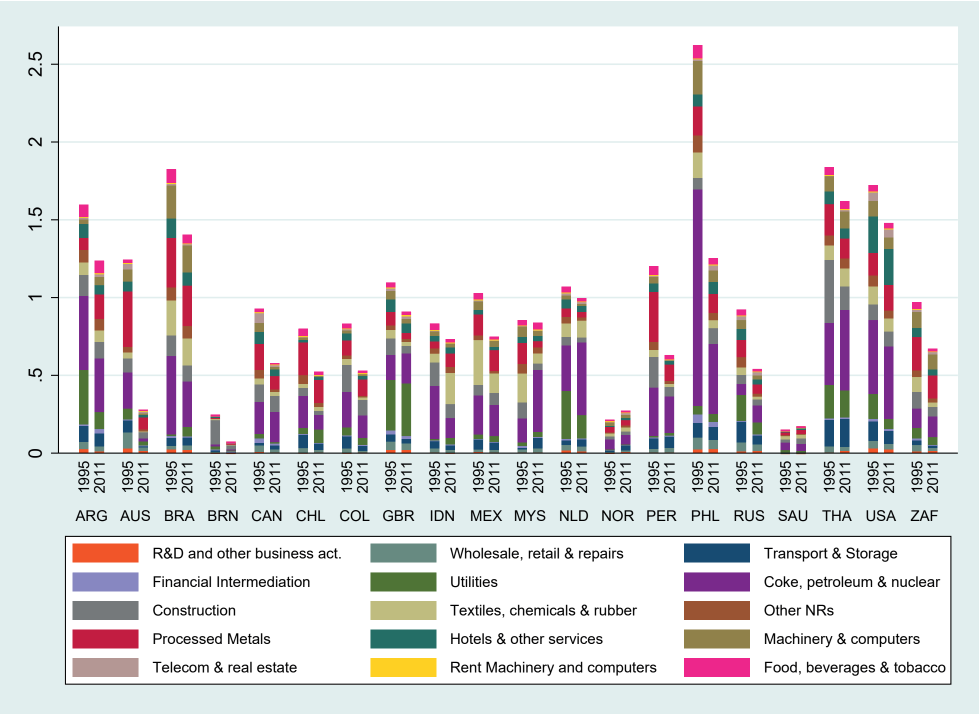


Figure 2.10. Distribution of forward linkages across sectors (1995 and 2011)
Source: Authors' elaboration with OECD data

2.5.7 Forward Leakages

This subsection discusses changes in forward leakages which measure by how much the input availability for foreign sectors increases as the domestic mining output increases. If the latter measure increases, it would indicate a higher integration to global value chains as a commodity producer. Across countries, forward leakage values in mining increased, on average, by 53% whereas the leakage ratio, i.e., forward leakages to forward linkages, on average, increased by 81%[27] - suggesting that countries in our sample, on average, strengthened their position in the early stages of mining global value chains. However, there were substantial differences in the evolution of forward leakages across countries, as shown in Figure 2.11. Further considerations by group and country are as follows:

- Latin America: This group with the steepest increase in the forward leakage ratio in the mining sector was Latin America (94%). The largest increment in leakage ratio took place in Peru (164%) and the smallest in Mexico (38%). Forward leakages (in levels) were particularly high in Peru and Chile, next to Australia, Saudi Arabia, and Brunei.

27 Results at aggregate level, and for each group and country, and are reported in detail in Table 2.4 in Annex.

- High-income countries: The forward leakage ratio increase in this group was small in relation to other groups: on average, it increased by 69%. Yet, the forward leakage ratio in Australia grew by 212% whereas in Canada it grew only by 17%. Norway was the only country in the sample in which this ratio fell (by 8%).
- Middle-income countries: On average, the ratio of forward leakages to forward linkages increased by 76% in these countries. The biggest increases in this ratio took place in the Philippines (112%) and the lowest in Indonesia (19%).
- Oil-specialized high-income countries: Increases in the forward leakage ratio were somewhat low for Brunei (30%) and rather high for Saudi Arabia (156%).

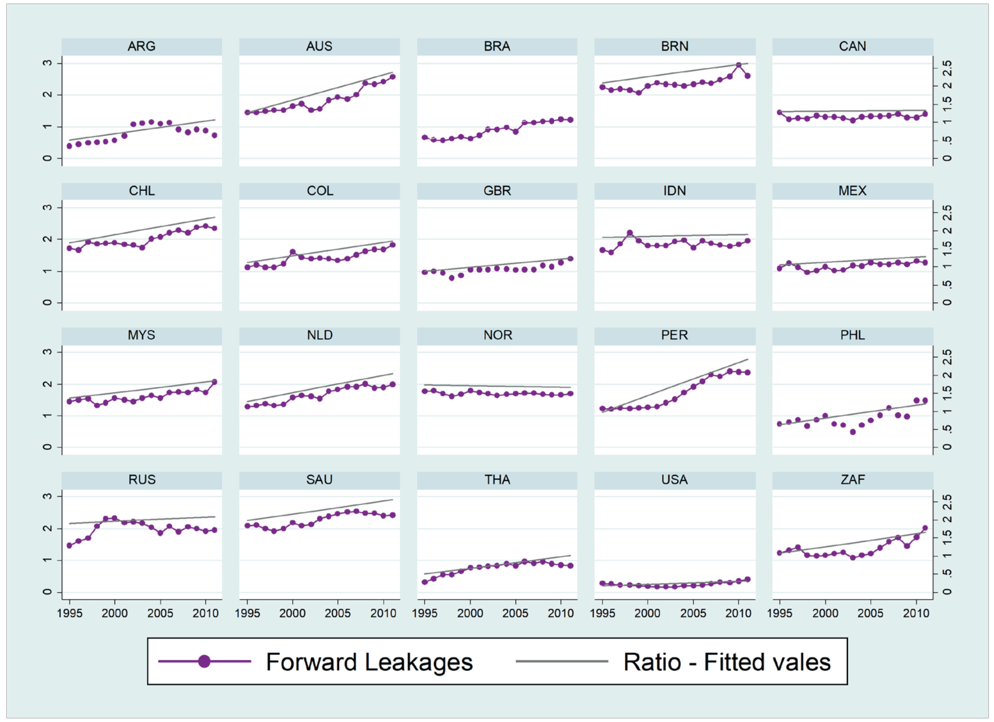


Figure 2.11. Forward leakages (left axis) and the forward leakages to forward linkages ratio (right axis) in the mining sector
Source: Authors' elaboration with OECD data.

2.5.8 Summary and discussion of descriptive results

The key empirical results emerging from this analysis can be summarized as follows. Linkage development suggests that the mining sector had a strong tendency toward increased enclaveness – at least during the 1995-2011 period. This result is consistent with other papers which have employed a similar methodology and timeframe, e.g., Castaño et al., (2019) in Chile. Our results show that, on average, backward and forward linkages were reduced by about one-fourth. Latin America, on average, was the worst-performing group concerning linkage development. Oil-specialized countries – which had the most enclave mining sector in the sample – also performed poorly in this regard.

Backward linkages had a steep fall in Latin America (except for Peru), Indonesia, Great Britain, and Saudi Arabia. Yet, other countries with a long-standing mining sector still failed to expand or even maintain linkages. This includes middle-income countries, i.e., South Africa, as well as high-income countries, i.e., Australia and Canada. The exceptions to this trend were the Netherlands, Thailand, and Malaysia - where backward linkages either increased or remained stable. It is also important to consider the levels of inter-industrial connectivity. In 2011, Australia, Brazil, South Africa, and the USA had the highest indirect backward linkages values. This suggests that in these countries there is, indeed, a strong pool of domestic mining suppliers as described in previous studies (Farooki, 2012; Kaplan, 2012; Scott-Kemmis, 2013). Moreover, this could also reflect the impact of policy interventions aimed at developing higher linkages, such as strong local-content policies in Brazil (McKinsey Global Institute, 2013).

Results show that the strongest mining backward linkages were established with service sectors of various levels of technological complexity/productivity. This is in line with recent studies that highlight the central role of services for the mining sector. Korinek (2020) shows that services are the main contributor to the domestic added-value of the mining sector in high- and middle-income countries. Moreover, services play a central role in local linkage formation – especially in developing countries – as domestic suppliers can offer mining services adapted to local specificities. These specificities are rarely exploited by large multinational companies – which have traditionally dominated the mining value chain –, and therefore constitute an important window of opportunity for domestic suppliers (Calzada Olvera, 2021; Pietrobelli et al., 2018; Perez et al., 2009).

In high-income countries, and most of Latin America, there were relatively strong mining backward linkages to R&D and other business services. However, an important distinction is that this sector aggregates services with different degrees of knowledge intensity[28]. In high-income countries, supplier linkages to this sector possibly reflect the demand for knowledge inputs required by the high level of sophistication of mining services and stronger regulations that require the use of highly specialized services (Korinek, 2020). The same cannot be assumed in the case of Latin America, as several case studies have indicated that while there is an incipient knowledge-intensive mining service sector it remains largely underdeveloped (Molina, 2018; Pietrobelli et al., 2018). Therefore, it can only be concluded that the role that services play in this region is indeed important, but the knowledge components are likely to differ in high-income countries. Finally, mining backward linkages to the machinery and other equipment were relatively high only in Norway and the USA.

28 The R&D and business services sector in the OECD 2015 edition includes knowledge-intensive services, such as scientific services, and legal and management consultancies; but also, services that are not, such as labor recruitment and provision of personnel, cleaning of buildings, and surveillance activities.

Backward leakages, which show how much the domestic mining sector depends on foreign inputs, were relatively stable across countries between 1995 and 2011. The ratio of backward leakages to backward linkages was particularly high in Latin America and low in high-income countries. On average, domestic leakages included services, such as transport and storage, as well as inputs, such as chemicals and refinery products, and machinery and equipment. An important distinction is that high-income countries and Brazil had stronger linkages to the foreign R&D and other business activities sector – suggesting that in these countries the mining sector has a higher demand for knowledge inputs.

Forward linkages shrunk across the sample indicating an overall trend of shrinking connectivity with downstream sectors. However, Norway, the Netherlands, Malaysia, Thailand, and the USA did not experience this substantial drop – which coincides with the expansion of refinery activities in most of these countries, as discussed in section 2.4. In terms of levels, the countries with the highest values of forward linkages were Brazil, Thailand, and the USA.

As expected, mining forward linkages in our sample were developed with downstream industries, like refinery activities and metal processing, but also with the utilities and construction sectors.

Finally, the forward leakage to forward linkage ratio indicates that, on average, countries strengthened their position as commodity producers in global mining value chains. There were several exceptions to the trend, such as the Netherlands, Norway, Malaysia, Thailand, and the USA. In Australia, Chile, Peru, Saudi Arabia, and the Philippines forward leakages show that the mining sector in these countries substantially reduced its connection with domestic downstream sectors.

2.5.9 The Size of Mining and Inter-Industrial Linkages

Mining activities have long been associated with an enclave mode of production with no linkages to local economies, and therefore no contribution to the expansion of local industries (Singer, 1950), as well as to lower industrialization prospects due to the Dutch disease (Sachs & Warner, 1999).

Thus, according to the perspective, the expansion of mining activities is associated with lower levels of linkage development. The descriptive analysis presented in earlier sections suggests that the expansion of mining activities indeed failed to foster higher linkage development. In this subsection, we then test whether the expansion of the mining activities has a statistically negative association with forward and backward linkages (proxied by IBL and IFL coefficients). Pearson correlation coefficients indicate a negative relation between linkage development (i.e., IBLs and IFLs) and mining's contribution to GDP and/or exports across much of the sample (significant at the 5% level). Scatterplots in Figures 2.12-2.15 depict these correlations by country. Nonetheless, a few exceptions stand out: The Netherlands and Thailand showed no negative correlation in either measure[29]. Likewise, Indonesia and Russia did not show a negative relation between IFLs and mining's contribution to GDP and/or exports[30]. Norway and Malaysia had a positive correlation between IFLs and the mining share of GDP and exports (yet, only Malaysia's positive correlation between mining's share of GDP and IFLs was statistically significant at the 5% level).

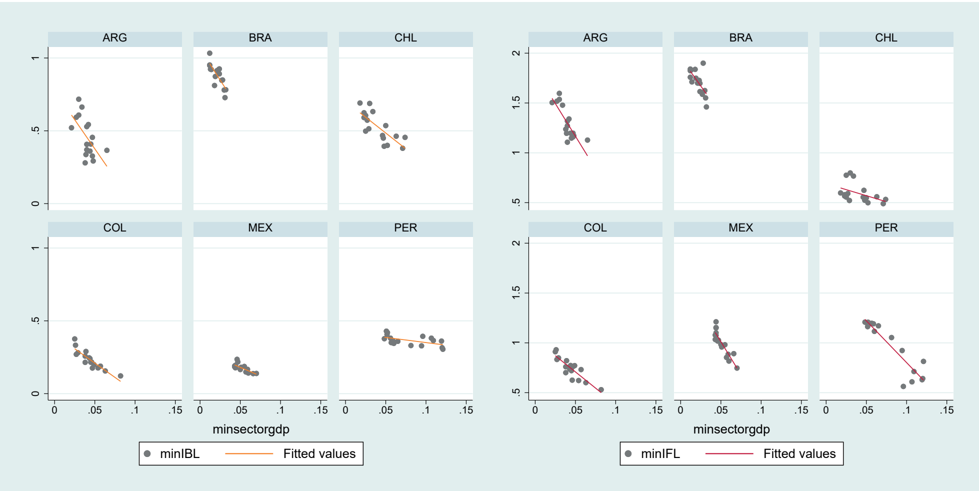


Figure 2.12. Correlation between the contribution of mining to GDP and IBLs (left) and IFLs (right) in Latin America

29 Argentina, Peru, Indonesia, Malaysia, Russia, and the USA showed a statistically significant negative correlation between IBLs and the mining share in the GDP but not with exports. Great Britain had a statistically significant negative correlation between IBLs and the share of mining exports but not with the GDP.

30 Chile, The Netherlands, Great Britain, the Philippines and Thailand had a statistically significant negative correlation between IBLs and the share of mining exports but not of GDP.

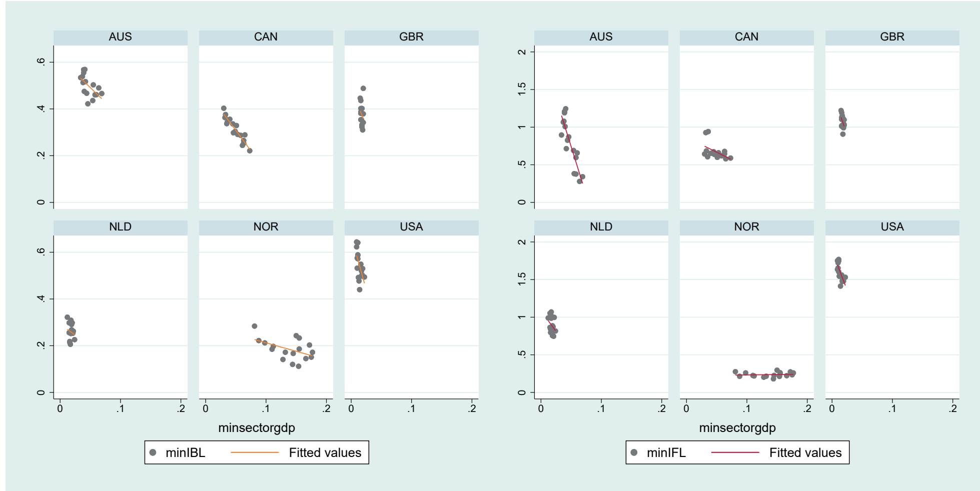


Figure 2.13. Correlation between the contribution of mining to GDP and IBLs (left) and IFLs (right) in high-income countries

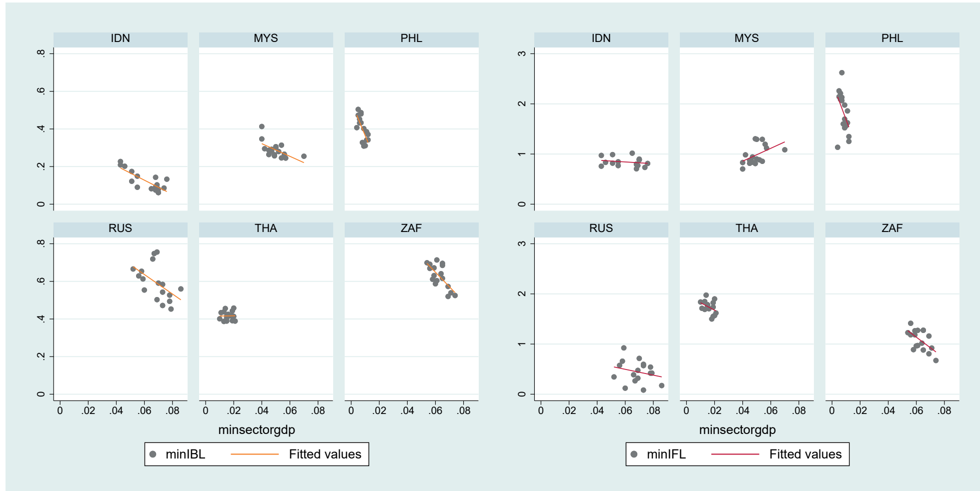


Figure 2.14. Correlation between the contribution of mining to GDP and IBLs (left) and IFLs (right) in middle income countries

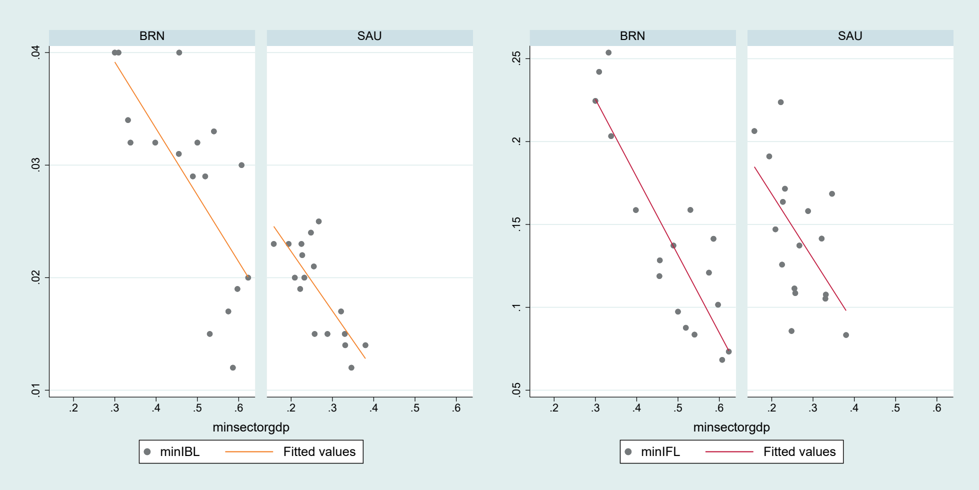


Figure 2.15. Correlation between the contribution of mining to GDP and IBLs (left) and IFLs (right) in oil-specialized high-income countries (OS-HIC)

Finally, to examine the relationship between IBLs and mining's share in GDP we undertake a panel regression exercise using fixed effects and observations for all 20 countries in the sample across 17 years. Results in Table 2.2 show that, on average, an increase of 1% in the share of mining GDP is associated with a change of -0.000655 in the value of backward linkages (IBLs) (significant at the 1% level) and of -0.00208 in the value of forward linkages (IFLs) (significant at the 5% level). Likewise, an expansion of mining exports is also negatively correlated to both backward and forward linkages. However, results are only statistically significant for the latter: A 1% increase in mining exports corresponds to a change of -0.00310 in the value of forward linkages (IFLs) (significant at the 1% level).

Table 2.2. Regression Results

	(1)	(2)	(3)	(4)
VARIABLES	IBLs	IBLs	IFLs	IFLs
Mining share GDP (log)	-0.0655*** (0.0226)		-0.208** (0.0940)	
Mining share exports (log)		-0.0116 (0.0249)		-0.310*** (0.0693)
Constant	0.202** (0.0808)	0.392*** (0.0717)	0.405 (0.329)	0.323* (0.168)
Observations	340	340	340	340
R-squared	0.436	0.411	0.276	0.411
Number of countries	20	20	20	20

*** p<0.01, ** p<0.05, * p<0.1. Robust standard errors in parentheses.
Note: Models include country- and year-specific fixed effects.

While this regression exercise controls for year trends, controlling for commodity prices by considering the actual composition of each country's mining sector could provide more accurate results. Having said this, an expansion of the mining sector seems to be correlated to lower inter-industrial linkages in our sample; although, as also shown above, there is some heterogeneity in effects (i.e., Norway and Malaysia).

2.6 Conclusion

Following the commodity bonanza which began in the early 21st century, the promotion of productive linkages from and to the extractive sectors became one of the main policy objectives of resource-based economy development strategies (Castaño et al., 2019; Dietsche, 2014).

We find that despite these efforts, the development of inter-industrial linkages for the mining sector has stagnated for most countries in our sample during the period studied (1995-2011). On average, there is a negative correlation between backward and forward linkages and changes in the importance of the mining sector (both in terms of share of exports and GDP). However, changes in such measures diverge across country groups. Backward and forward linkages in mining have been reduced more steeply in Latin American and oil-specialized countries. In contrast, the group of high-income countries, and some middle-income countries, had the smallest reductions, and in some cases increases, in those measures.

There is a tendency across countries, but especially in Latin America and high-income countries to employ service sectors of higher technological sophistication, e.g., R&D and other business services, and transport and storage. However, due to the level of aggregation it is hard to establish the true nature of these services.

While the dependence on inputs from other regions remained quite stable on average, processing of mining output by non-domestic sectors is on the rise for most countries in our sample – especially in Latin America. Certainly, the expansion of emerging markets, i.e., China, drove the global demand for mining commodities which ultimately strengthened the position of many of the countries to position themselves as commodity exporters in the mining value chain.

Certainly, there were significant differences among regions and countries. Latin American and oil-specialized countries showed a stronger tendency toward the reduction of inter-industrial linkages. Countries that were successful in avoiding such a trend were typically high-income countries, i.e., Norway, the USA, the Netherlands, and other middle-income countries, i.e., Thailand and Malaysia. This is consistent with a body of literature that refers to these countries as prime examples of how natural resources can be turned into a blessing instead of a curse[31].

Results show that countries with a long-standing mining tradition, including Australia, Brazil, Chile, South Africa, or Russia, did not develop inter-industrial connectivity as expected during the 2000s commodities boom. Furthermore, long-run economic performance in these countries has been suboptimal – except for Australia and, to some extent, Chile.

Moreover, even when developing countries successfully develop linkages, sustained growth is not guaranteed: Malaysia and Thailand, which performed quite well in this sense, are still to escape the so-called 'middle-income trap' (Jitsuchon, 2012; Rasiah, 2011). Future research then must address how industrial connectivity and other aspects related to structural change, i.e., productivity, play out – especially in the face of commodity price booms and busts to explain differences in long-term growth.

To conclude, Latin America is still characterized by its high, and ever-growing, commodity dependence (Adler & Sosa, 2011), and the outlining of its inter-industrial connectivity in the mining sector shows – at best – a mixed scenario. Its performance vis-à-vis other groups of countries calls for stronger active policies that stimulate linkages to key sectors for innovation and technological upgrading necessary for the development of knowledge-based economies and broad-based growth.

31 For example Wright & Czelusta, (2004) in the case of the USA, Larsen (2006) and Ville & Wicken (2012) in the case of Norway, Gylfason (2001), Sovacool (2010) and Noh (2013) in the case of Thailand and Malaysia.

Bibliography

Adler, G., & Sosa, S. (2011). Commodity Price Cycles: The Perils of Mismanaging the Boom. In *IMF Working Papers* (WP/11/283; Vol. 11, Issue 283). https://doi.org/10.5089/9781463926649.001

Andersen, A. D., Johnson, B. H., Marín, A., Kaplan, D., Stubrin, L., Lundvall, B.-Å., & Kaplinsky, R. (2015). *Natural resources, innovation, and development*. https://doi.org/10.5278/VBN/MISC/NRID

Aroca, P. (2001). Impacts and development in local economics based on mining: The case of the Chilean II region. *Resources Policy*, *27*(2), 119–134. https://doi.org/10.1016/S0301-4207(01)00013-7

Auty, R. (1993). *Sustaining development in mineral economies : the resource curse thesis*. Routledge. https://books.google.nl/books/about/Sustaining_Development_in_Mineral_Econom.html?id=_PTl9b-ZSDcC&redir_esc=y

Benavente, J. M. (2006). Wine Production in Chile. In V. Chandra (Ed.), *Technology, Adaptation, and Exports - How some developing countries got it right* (pp. 225–242). The World Bank.

Calzada Olvera, B. (2021). Innovation in mining: what are the challenges and opportunities along the value chain for Latin American suppliers? *Mineral Economics*. https://doi.org/10.1007/s13563-021-00251-w

Castaño, A., Lufin, M., & Atienza, M. (2019). A structural path analysis of Chilean mining linkages between 1995 and 2011. What are the channels through which extractive activity affects the economy? *Resources Policy*. https://doi.org/10.1016/j.resourpol.2018.12.007

Davar, E. (2005). Input-Output System Models: Leontief versus Ghosh. *15th International Input-Output Conference Beijing, China P.R. 27 June – 1 July*. https://www.iioa.org/conferences/15th/pdf/ezra_davar.pdf

De Mesnard, L. (2001). *About the reinterpretation of the Ghosh model as a price model*. https://hal.archives-ouvertes.fr/hal-01527259

Dietsche, E. (2014). Diversifying mineral economies: conceptualizing the debate on building linkages. *Mineral Economics*, *27*(2–3), 89–102. https://doi.org/10.1007/s13563-014-0058-4

Dietzenbacher, E. (1997). In Vindication of the Ghosh Model: A Reinterpretation as a Price Model. *Journal of Regional Science*, *37*(4), 629–651. https://doi.org/10.1111/0022-4146.00073

Dietzenbacher, E., Albino, V., Kühtz, S., & Kuehtz, S. (2005). The Fallacy of Using US-Type Input-Output Tables. *15th International Conference on Input-Output Techniques, Renmin Univ. of China, Beijing June 27 to July 1 2005*, 1–15. http://iioa.org/conferences/15th/pdf/dietzenbacher_albino_kunz.pdf

Farinelli, F. (2012). *Natural Resources, Innovation and Export Growth: The Wine Industry in Chile and Argentina*. University of Maastricht.

Farooki, M. (2012). The diversification of the global mining equipment industry – Going new places? *Resources Policy*, *37*(4), 417–424. https://doi.org/10.1016/J.RESOURPOL.2012.06.006

Farooki, M., & Kaplinsky, R. (2014). Promoting diversification in resource-rich economies. *Mineral Economics*, *27*(2–3), 103–113. https://doi.org/10.1007/s13563-014-0050-z

Giovannucci, D., Leibovich, J., Pizano, D., Paredes, G., Montenegro, S., Arévalo, H., & Varangis, P. (2002). *Colombia coffee sector study*. http://papers.ssrn.com/sol3/papers.cfm?abstract_id=996138

Giuliani, E. (2011). Role of Technological Gatekeepers in the Growth of Industrial Clusters: Evidence from Chile. *Regional Studies*, *45*(10), 1329–1348. https://doi.org/10.1080/00343404.2011.619973

Gylfason, T. (2001). *Natural Resource and Economic Growth: What is the connection?* (No. 530; CESifo Working Papers).

Jitsuchon, S. (2012). *Thailand in a Middle-income Trap: Vol. 27 No. 2* (TDRI Quarterly Review). https://tdri.or.th/wp-content/uploads/2012/12/t5j2012-somchai.pdf

Kaplan, D. (2012). South African mining equipment and specialist services: Technological capacity, export performance and policy. *Resources Policy*, *37*(4), 425–433. https://doi.org/10.1016/j.resourpol.2012.06.001

Kaplinsky, R. (2011). *Commodities for Industrial Development: Making Linkages Work* (01/2011).

Katz, J. (2006). Salmon Farming in Chile. In C. Vandana (Ed.), *Technology, Adaptation, and Exports - How some developing countries got it right* (pp. 193–224). The World Bank.

Korinek, J. (2020). The mining global value chain. In *OECD Trade Policy Papers* (Issue 235). https://doi.org/10.1787/2827283e-en

Larsen, E. R. (2006). Escaping the Resource Curse and the Dutch Disease? *American Journal of Economics and Sociology*, *65*(3), 605–640. https://doi.org/10.1111/j.1536-7150.2006.00476.x

Lavopa, A., & Szirmai, A. (2014). *Structural Modernization and Development Traps. An Empirical Approach* (UNU-MERIT Working Papers, Issues 2014–076).

Lin, J., & Treichel, V. (2012). *Learning from China's rise to escape the middle-income trap - A new structural economics approach to Latin America* (No. 6165; Policy Research Working Paper). https://openknowledge.worldbank.com/handle/10986/12013

Maggi, C. (2003). *El cluster del cultivo y procesamiento del salmon en la region sur-austral de Chile* (C. Pietrobelli & R. Rabellotti (eds.)). Inter-American Development Bank.

McKinsey Global Institute. (2013). *Reverse the curse: Maximizing the potential of resource-driven economies McKinsey Global Institute*. www.mckinsey.com/mgi.

McMahon, G., & Remy, F. (2002). *Global Mining Large Mines and Local Communities: Forging Partnerships, Building Sustainability* (G. McMahon & F. Remy (eds.)).

Miller, R. E., & Blair, P. D. (2009). Input-output analysis: Foundations and extensions, second edition. In *Input-Output Analysis: Foundations and Extensions, Second Edition*.

Molina, O. (2018). Innovation in an unfavorable context: Local mining suppliers in Peru. *Resources Policy*, *58*(2018), 34–48. https://doi.org/10.1016/j.resourpol.2017.10.011

Morris, M., & Fessehaie, J. (2014). The industrialisation challenge for Africa: Towards a commodities based industrialisation path. *Journal of African Trade*, *1*(1–2), 25. https://doi.org/10.1016/j.joat.2014.10.001

Morris, M., Kaplinsky, R., & Kaplan, D. (2012). "One thing leads to another"—Commodities, linkages and industrial development. *Resources Policy*, *37*(4), 408–416. https://doi.org/10.1016/J.RESOURPOL.2012.06.008

Mytelka, L. K., & Bortagaray, I. (2006). Strengthening the Agricultural Innovation System in Colombia: An Analysis of the Cassava and Flower Sectors. In *Enhancing Agricultural Innovation: How to go beyond the strengthening of research systems*. https://doi.org/10.1596/978-0-8213-6741-4

Nchor, D., & Konderla, T. (2016). Economic multipliers and sectoral linkages: Ghana and the new oil sector. *Acta Universitatis Agriculturae et Silviculturae Mendelianae Brunensis*, *64*(2), 635–642. https://doi.org/10.11118/actaun201664020635

Noh, A. (2013). *Natural Resources and Economic Diversification: A Case of Malaysia* (2013/12). http://www.unirazak.edu.my/tpl/upload/files/TARSOG Research/TARSOGWP.2013.02.pdf

OECD. (n.d.). *OECD Input-Output Tables (IOTs)*. Retrieved June 1, 2017, from http://www.oecd.org/trade/input-outputtables.htm

Perez, C. (2010). A Vision for Latin America : A resource-based strategy for technological dynamism and social inclusion. *Globelics. The Global Network for Economics of Learning, Innovation, and Competence Building System*, 1–32.

Perez, C., Marin, A., & Navas-Aleman, L. (2009). *The possible dynamic role of natural resource-based networks in Latin American development strategies*. https://doi.org/10.4337/9781782548683.00018

Pietrobelli, C., Marin, A., & Olivari, J. (2018). Innovation in mining value chains: New evidence from Latin America. *Resources Policy*, *58*. https://doi.org/10.1016/J.RESOURPOL.2018.05.010

Rasiah, R. (2011). Is Malaysia facing negative deindustrialization? *Pacific Affairs*. https://doi.org/10.5509/2011844715

Rasmussen, P. N. (1956). *Studies in inter-sectoral relations*. E. Harcks.

Reis, H., & Rua, A. (2006). *An input-output analysis: Linkages vs leakages* (No. 17; Estudos e Documentos de Trabalho).

Sachs, J., & Warner, A. (1995). Natural Resource Abundance and Economic Growth. In *National Bureau of Economic Research* (No. 5398; Vol. 3). https://doi.org/10.3386/w5398

Sachs, J., & Warner, A. (1999). The big push, natural resource booms and growth. *Journal of Development Economics*, *59*(1), 43–76. https://doi.org/10.1016/S0304-3878(99)00005-X

Scott-Kemmis, D. (2013). *How about those METS? Leveraging Australia's mining equipment, technology and services sector*. http://www.minerals.org.au/file_upload/files/publications/mca_how_about_those_METS_FINAL.pdf

Singer, H. W. (1950). The Distribution of Gains Between Investing and Borrowing Countries. *American Economic Review, Papers and Proceedings*, *44*, 473–485.

Sinnott, E., Nash, J., & Torre, A. de la. (2010). *Natural Resources in Latin America and the Caribbean: Beyond Boom and Busts?* The World Bank. https://doi.org/10.1596/978-0-8213-8482-4

Sovacool, B. K. (2010). The political economy of oil and gas in Southeast Asia: heading towards the natural resource curse? *The Pacific Review*, *23*(2), 225–259. https://doi.org/10.1080/09512741003624484

Stilwell, L. C., Minnitt, R. C. A., Monson, T. D., & Kuhn, G. (2000). An input-output analysis of the impact of mining on the South African economy. *Resources Policy*, *26*(1), 17–30. https://doi.org/10.1016/S0301-4207(00)00013-1

UNIDO. (2012). *Promoting Industrial Diversification in Resource Intensive Economies The Experiences of Sub-Saharan Africa and Central Asia Regions*.

UNSD. (n.d.). *United Nations Statistics Division ISIC Rev.3.1 code C*. Retrieved July 1, 2017, from https://unstats.un.org/unsd/cr/registry/regcs.asp?Cl=17&Lg=1&Co=C

Ville, S., & Wicken, O. (2012). The Dynamics of Resource-Based Economic Development : Evidence from Australia and Norway. *Department of Economics, University of Wollongong, Working Paper 04-12*, 55. http://ro.uow.edu.au/commwkpapers/241

Wright, G., & Czelusta, J. (2004). The Myth of the Resource Curse. *Challenge*, *47*(2), 6–38. https://web.stanford.edu/~write/papers/Wright Res Curse.pdf

Annex

Table 2.3. Extractive Industries: Mining, Refinery and Processed Metals and Minerals

Country	ARG	ARG	AUS	AUS	BRA	BRA	BRN	BRN	CAN	CAN
Year	1995	2011	1995	2011	1995	2011	1995	2011	1995	2011
Mining %GDP	0.03	0.04	0.04	0.06	0.01	0.04	0.31	0.61	0.03	0.07
Mining %Exports	0.06	0.05	0.16	0.45	0.05	0.20	0.77	0.91	0.07	0.20
Refinery %GDP	0.03	0.02	0.02	0.00	0.02	0.02	0.01	0.00	0.01	0.03
Refinery %Exports	0.02	0.03	0.02	0.01	0.02	0.01	0.02	0.00	0.01	0.03
Proc. Metals %GDP	0.01	0.01	0.02	0.01	0.01	0.02	0.00	0.00	0.01	0.01
Proc. Metals %Exports	0.02	0.02	0.06	0.03	0.03	0.03	0.00	0.00	0.03	0.04

Country	CHL	CHL	COL	COL	GBR	GBR	IDN	IDN	MEX	MEX
Year	1995	2011	1995	2011	1995	2011	1995	2011	1995	2011
Mining %GDP	0.03	0.05	0.03	0.08	0.02	0.02	0.05	0.07	0.05	0.07
Mining %Exports	0.12	0.16	0.24	0.46	0.05	0.05	0.22	0.29	0.08	0.14
Refinery %GDP	0.02	0.02	0.01	0.03	0.01	0.01	0.04	0.03	0.02	0.03
Refinery %Exports	0.00	0.01	0.03	0.08	0.02	0.04	0.02	0.02	0.01	0.02
Proc. Metals %GDP	0.03	0.04	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02
Proc. Metals %Exports	0.09	0.12	0.01	0.03	0.02	0.01	0.01	0.02	0.03	0.03

Country	MYS	MYS	NLD	NLD	NOR	NOR	PER	PER	PHL	PHL
Year	1995	2011	1995	2011	1995	2011	1995	2011	1995	2011
Mining %GDP	0.05	0.05	0.02	0.02	0.09	0.17	0.05	0.12	0.01	0.01
Mining %Exports	0.05	0.10	0.03	0.04	0.30	0.44	0.22	0.49	0.01	0.03
Refinery %GDP	0.01	0.06	0.01	0.04	0.01	0.01	0.02	0.04	0.06	0.05
Refinery %Exports	0.02	0.05	0.03	0.08	0.02	0.02	0.04	0.05	0.01	0.01
Proc. Metals %GDP	0.01	0.02	0.01	0.01	0.01	0.01	0.01	0.02	0.01	0.01
Proc. Metals %Exports	0.01	0.02	0.02	0.02	0.03	0.02	0.43	0.40	0.01	0.02
Average Backward Leakage	1.24	1.28	1.21	1.24	1.18	1.16	1.08	1.13	1.17	1.16

Country	RUS	RUS	SAU	SAU	THA	THA	USA	USA	ZAF	ZAF
Year	1995	2011	1995	2011	1995	2011	1995	2011	1995	2011
Mining %GDP	0.06	0.08	0.21	0.35	0.01	0.02	0.01	0.02	0.06	0.07
Mining %Exports	0.16	0.30	0.70	0.78	0.00	0.01	0.01	0.02	0.19	0.30
Refinery %GDP	0.02	0.05	0.03	0.03	0.02	0.05	0.01	0.03	0.02	0.04
Refinery %Exports	0.05	0.15	0.10	0.07	0.00	0.04	0.01	0.07	0.03	0.07
Proc. Metals %GDP	0.02	0.02	0.01	0.01	0.01	0.02	0.01	0.01	0.02	0.01
Proc. Metals %Exports	0.07	0.06	0.00	0.00	0.01	0.02	0.02	0.01	0.06	0.06
Average Backward Leakage	1.09	1.12	1.17	1.16	1.21	1.30	1.06	1.08	1.08	1.13

Table 2.4. Mining Direct backward linkages (DBL), Mining

Group	LCN	LCN	LCN	LCN	LCN	LCN	LCN	LCN	LCN
Country	ARG	ARG		BRA	BRA		CHL	CHL	
Year	1995	2011	Δ	1995	2011	Δ	1995	2011	Δ
Mining DBL	1.84	1.42	-23%	2.05	1.86	-9%	1.74	1.45	-17%
Mining DBL (-1USD)	0.84	0.42	-50%	1.05	0.86	-18%	0.74	0.45	-39%
Mining IBL	0.72	0.28	-61%	0.95	0.71	-25%	0.69	0.39	-43%
Mining Backward Leakage	1.03	1.08	5%	1.07	1.06	-1%	1.12	1.16	4%
Mining Backward Leakage Ratio	0.56	0.76	36%	0.52	0.57	10%	0.64	0.8	25%
Mining IFL	1.6	1.24	-23%	1.82	1.4	-23%	0.8	0.52	-35%
Mining Forward Leakage	0.39	0.72	85%	0.66	1.22	85%	1.73	2.34	35%
Mining Forward Leakage Ratio	0.15	0.30	110%	0.23	0.48	113%	0.93	1.48	59%
Average sector IFL	0.76	0.74	-3%	0.77	0.81	5%	0.67	0.55	-18%
Average sector DBL	1.73	1.69	-2%	1.9	1.94	2%	1.68	1.67	-1%
Average sector IBL	0.65	0.6	-8%	0.77	0.83	8%	0.59	0.58	-2%
Average sector Backward Leakage	1.04	1.09	5%	1.04	1.06	2%	1.09	1.13	4%

Group	LCN	LCN	LCN	LCN	LCN	LCN	LCN	LCN	LCN	LCN
Country	COL	COL		MEX	MEX		PER	PER		Av.
Year	1995	2011	Δ	1995	2011	Δ	1995	2011	Δ	Δ
Mining DBL	1.28	1.23	-4%	1.25	1.16	-7%	1.46	1.44	-1%	-10%
Mining DBL (-1USD)	0.28	0.23	-18%	0.25	0.16	-36%	0.46	0.44	-4%	-28%
Mining IBL	0.27	0.12	-56%	0.22	0.14	-36%	0.43	0.36	-16%	-40%
Mining Backward Leakage	1.03	1.01	-2%	1.02	1.04	2%	1.05	1.05	0%	1%
Mining Backward Leakage Ratio	0.8	0.82	2%	0.82	0.9	10%	0.72	0.73	1%	14%
Mining IFL	0.83	0.53	-36%	1.03	0.75	-27%	1.2	0.63	-48%	-32%
Mining Forward Leakage	1.13	1.83	62%	1.09	1.28	17%	1.23	2.38	93%	63%
Mining Forward Leakage Ratio	0.611	1.113	82%	0.53	0.73	38%	0.33	0.87	164%	94%
Average sector IFL	0.67	0.61	-9%	0.47	0.41	-13%	0.66	0.63	-5%	-7%
Average sector DBL	1.66	1.66	0%	1.53	1.48	-3%	1.69	1.69	0%	-1%
Average sector IBL	0.58	0.54	-7%	0.46	0.42	-9%	0.61	0.6	-2%	-3%
Average sector Backward Leakage	1.09	1.11	2%	1.12	1.17	4%	1.08	1.13	5%	4%

Group	HIC	HIC	HIC	HIC	HIC	HIC	HIC	HIC	HIC
Country	AUS	AUS		CAN	CAN		GBR	GBR	
Year	1995	2011	Δ	1995	2011	Δ	1995	2011	Δ
Mining DBL	1.72	1.58	-8%	1.41	1.34	-5%	1.55	1.39	-10%
Mining DBL (-1USD)	0.72	0.58	-19%	0.41	0.34	-17%	0.55	0.39	-29%
Mining IBL	0.57	0.49	-14%	0.36	0.29	-19%	0.49	0.33	-33%
Mining Backward Leakage	1.05	1.09	4%	1.1	1.09	-1%	1.07	1.15	7%
Mining Backward Leakage Ratio	0.61	0.69	13%	0.78	0.81	4%	0.69	0.83	20%
Mining IFL	1.24	0.28	-77%	0.93	0.58	-38%	1.1	0.91	-17%
Mining Forward Leakage	1.44	2.56	78%	1.45	1.4	-3%	0.96	1.39	45%
Mining Forward Leakage Ratio	0.60	1.87	212%	0.73	0.86	17%	0.44	0.71	59%
Average sector IFL	0.77	0.81	5%	0.52	0.5	-4%	0.63	0.54	-14%
Average sector DBL	1.9	1.84	-3%	1.56	1.55	-1%	1.71	1.65	-4%
Average sector IBL	0.78	0.73	-6%	0.49	0.48	-2%	0.6	0.54	-10%
Average sector Backward Leakage	1.08	1.12	4%	1.14	1.18	4%	1.11	1.2	8%

Group	HIC	HIC	HIC	HIC	HIC	HIC	HIC	HIC	HIC	HIC
Country	NLD	NLD		NOR	NOR		USA	USA		Av.
Year	1995	2011	Δ	1995	2011	Δ	1995	2011	Δ	Δ
Mining DBL	1.27	1.29	2%	1.26	1.23	-2%	1.66	1.71	3%	-4%
Mining DBL (-1USD)	0.27	0.29	7%	0.26	0.23	-12%	0.66	0.71	8%	-10%
Mining IBL	0.25	0.26	4%	0.22	0.2	-9%	0.57	0.53	-7%	-13%
Mining Backward Leakage	1.07	1.07	0%	1.06	1.06	0%	1.07	1.05	-2%	1%
Mining Backward Leakage Ratio	0.85	0.83	-2%	0.84	0.86	2%	0.64	0.62	-3%	6%
Mining IFL	1.07	1	-7%	0.21	0.27	29%	1.72	1.48	-14%	-21%
Mining Forward Leakage	1.28	1.99	55%	1.77	1.7	-4%	0.27	0.41	52%	37%
Mining Forward Leakage Ratio	0.62	0.98	60%	1.42	1.30	-8%	0.44	0.76	73%	69%
Average sector IFL	0.51	0.52	2%	0.62	0.67	8%	0.75	0.7	-7%	-2%
Average sector DBL	1.58	1.65	4%	1.61	1.69	5%	1.8	1.75	-3%	0%
Average sector IBL	0.5	0.54	8%	0.53	0.61	15%	0.68	0.65	-4%	0%
Average sector Backward Leakage	1.21	1.24	2%	1.18	1.16	-2%	1.06	1.08	2%	3%

Note: Groups refer to Latin America (LCN); high-income countries (HIC); middle-income countries (MIC); and oil-specialized high-income countries (OSHIC).

Table 2.4. (Cont.)

Region	MIC	MIC	MIC	MIC	MIC	MIC	MIC	MIC	MIC
Country	**IDN**	**IDN**		**MYS**	**MYS**		**PHL**	**PHL**	
Year	1995	2011	Δ	1995	2011	Δ	1995	2011	Δ
Mining DBL	1.24	1.19	-4%	1.65	1.3	-21%	1.49	1.36	-9%
Mining DBL (-1USD)	0.24	0.19	-21%	0.65	0.3	-54%	0.49	0.36	-27%
Mining IBL	0.2	0.09	-55%	0.31	0.28	-10%	0.48	0.34	-29%
Mining Backward Leakage	1.03	1.04	1%	1.1	1.09	-1%	1.05	1.14	9%
Mining Backward Leakage Ratio	0.83	0.87	5%	0.67	0.83	24%	0.71	0.84	18%
Mining IFL	0.83	0.73	-12%	0.86	0.84	-2%	2.62	1.25	-52%
Mining Forward Leakage	1.67	1.95	17%	1.45	2.08	43%	0.73	1.48	103%
Mining Forward Leakage Ratio	0.89	1.06	19%	0.66	1.12	69%	0.41	0.86	112%
Average sector IFL	0.58	0.63	9%	0.45	0.61	36%	0.56	0.49	-13%
Average sector DBL	1.63	1.64	1%	1.57	1.81	15%	1.69	1.63	-4%
Average sector IBL	0.55	0.56	2%	0.47	0.65	38%	0.55	0.53	-4%
Average sector Backward Leakage	1.12	1.11	-1%	1.24	1.28	3%	1.17	1.16	-1%

Region	MIC	MIC	MIC	MIC	MIC	MIC	MIC	MIC	MIC	MIC
Country	**RUS**	**RUS**		**THA**	**THA**		**ZAF**	**ZAF**		**Av.**
Year	1995	2011	Δ	1995	2011	Δ	1995	2011	Δ	Δ
Mining DBL	1.81	1.56	-14%	1.42	1.43	1%	1.64	1.55	-5%	-9%
Mining DBL (-1USD)	0.81	0.56	-31%	0.42	0.43	2%	0.64	0.55	-14%	-24%
Mining IBL	0.61	0.49	-20%	0.4	0.39	-3%	0.6	0.52	-13%	-22%
Mining Backward Leakage	1.04	1.03	-1%	1.06	1.1	4%	1.06	1.09	3%	2%
Mining Backward Leakage Ratio	0.58	0.66	14%	0.75	0.77	3%	0.65	0.7	8%	12%
Mining IFL	0.92	0.54	-41%	1.84	1.62	-12%	0.97	0.67	-31%	-25%
Mining Forward Leakage	1.48	1.97	33%	0.32	0.84	163%	1.24	2.02	63%	70%
Mining Forward Leakage Ratio	0.98	1.51	0.53	0.09	0.15	63%	0.37	0.61	68%	64%
Average sector IFL	0.56	0.79	41%	0.53	0.5	-6%	0.72	0.68	-6%	10%
Average sector DBL	1.71	1.83	7%	1.58	1.61	2%	1.8	1.86	3%	4%
Average sector IBL	0.64	0.76	19%	0.47	0.48	2%	0.7	0.77	10%	11%
Average sector Backward Leakage	1.09	1.12	3%	1.21	1.3	7%	1.08	1.13	5%	3%

Region	OSHIC	OSHIC	OSHIC	OSHIC	OSHIC	OSHIC	OSHIC	ALL COUNTRIES
Country	**BRN**	**BRN**	**BRN**	**SAU**	**SAU**	**SAU**	**Average**	**Average**
Year	1995	2011	Cha Δ	1995	2011	Δ	Δ	Δ
Mining DBL	1.23	1.24	1%	1.02	1.02	0%	0%	**-7%**
Mining DBL (-1USD)	0.23	0.24	4%	0.02	0.02	0%	2%	**-18%**
Mining IBL	0.04	0.03	-25%	0.02	0.01	-50%	-38%	**-26%**
Mining Backward Leakage	1.03	1.02	-1%	1.01	1.01	0%	0%	**1%**
Mining Backward Leakage Ratio	0.84	0.83	-1%	0.99	0.99	0%	-1%	**9%**
Mining IFL	0.24	0.07	-71%	0.15	0.17	13%	-29%	**-26%**
Mining Forward Leakage	2.25	2.61	16%	2.08	2.43	17%	16%	**53%**
Mining Forward Leakage Ratio	1.57	2.04974	30%	0.27995	0.72	156%	93%	**81%**
Average sector IFL	0.93	0.49	-47%	0.48	0.41	-15%	-31%	**-3%**
Average sector DBL	1.44	1.37	-5%	1.51	1.45	-4%	-4%	**1%**
Average sector IBL	0.39	0.31	-21%	0.42	0.37	-12%	-16%	**1%**
Average sector Backward Leakage	1.18	1.23	4%	1.17	1.16	-1%	2%	**3%**

Table 2.5. Backward linkages by sector

Sector	LCN		HIC		MIC		OSHIC		ALL COUNTRIES	
Year	1995	2011	1995	2011	1995	2011	1995	2011	1995	2011
C01T05: Agriculture, hunting, forestry and fishing	0.003	0.002	0.003	0.002	0.062	0.003	0.006	0.004	0.021	0.002
C10T14: Mining and quarrying	1.053	1.091	1.066	1.073	1.105	1.048	1.095	1.105	1.077	1.074
C15T16: Food products, beverages and tobacco	0.004	0.002	0.004	0.003	0.004	0.003	0.000	0.000	0.004	0.002
C17T19: Textiles, textile products, leather and footwear	0.003	0.002	0.001	0.000	0.003	0.002	0.000	0.000	0.002	0.001
C20: Wood and products of wood and cork	0.003	0.001	0.003	0.001	0.002	0.001	0.000	0.000	0.002	0.001
C21T22: Pulp, paper, paper products, printing and publishing	0.010	0.005	0.010	0.006	0.006	0.003	0.000	0.000	0.008	0.004
C23: Coke, refined petroleum products and nuclear fuel	0.019	0.018	0.016	0.010	0.040	0.058	0.001	0.001	0.023	0.026
C24: Chemicals and chemical products	0.025	0.010	0.012	0.007	0.017	0.013	0.000	0.000	0.017	0.009
C25: Rubber and plastics products	0.009	0.004	0.005	0.002	0.005	0.004	0.000	0.000	0.006	0.003
C26: Other non-metallic mineral products	0.007	0.004	0.004	0.003	0.004	0.003	0.000	0.000	0.005	0.003
C27: Basic metals	0.013	0.009	0.012	0.008	0.006	0.007	0.001	0.001	0.010	0.007
C28: Fabricated metal products	0.014	0.007	0.015	0.010	0.009	0.012	0.000	0.000	0.012	0.009
C29: Machinery and equipment, n.e.c.	0.012	0.005	0.018	0.015	0.008	0.007	0.000	0.000	0.011	0.008
C30T33X: Computer, Electronic and optical equipment	0.003	0.001	0.003	0.002	0.002	0.002	0.000	0.000	0.002	0.002
C31: Electrical machinery and apparatus, n.e.c.	0.003	0.002	0.002	0.001	0.002	0.002	0.000	0.000	0.002	0.002
C34: Motor vehicles, trailers and semi-trailers	0.001	0.001	0.004	0.002	0.003	0.002	0.000	0.000	0.003	0.002
C35: Other transport equipment	0.005	0.001	0.004	0.002	0.002	0.001	0.000	0.000	0.004	0.001
C36T37: Manufacturing n.e.c.; recycling	0.005	0.002	0.001	0.002	0.004	0.003	0.000	0.000	0.003	0.002
C40T41: Electricity, gas and water supply	0.037	0.031	0.021	0.030	0.038	0.027	0.001	0.001	0.029	0.026
C45: Construction	0.016	0.011	0.024	0.023	0.007	0.012	0.002	0.001	0.014	0.014
C50T52: Wholesale and retail trade; repairs	0.057	0.040	0.055	0.044	0.056	0.045	0.005	0.004	0.051	0.039
C55: Hotels and restaurants	0.007	0.002	0.003	0.003	0.005	0.003	0.000	0.000	0.005	0.003
C60T63: Transport and storage	0.047	0.058	0.036	0.031	0.059	0.044	0.000	0.000	0.043	0.040
C64: Post and telecommunications	0.007	0.010	0.012	0.008	0.004	0.006	0.001	0.001	0.007	0.007
C65T67: Financial intermediation	0.058	0.021	0.047	0.038	0.036	0.029	0.004	0.004	0.043	0.027
C70: Real estate activities	0.011	0.010	0.012	0.010	0.005	0.006	0.001	0.000	0.008	0.008
C71: Renting of machinery and equipment	0.010	0.005	0.011	0.010	0.002	0.001	0.001	0.001	0.007	0.005
C72: Computer and related activities	0.015	0.007	0.005	0.008	0.001	0.003	0.000	0.000	0.006	0.005
C73T74: R&D and other business activities	0.074	0.053	0.049	0.055	0.024	0.033	0.003	0.002	0.045	0.043
C75: Public administration and defense; compulsory social security	0.023	0.006	0.008	0.005	0.000	0.000	0.001	0.001	0.009	0.003
C80: Education	0.003	0.001	0.002	0.002	0.000	0.000	0.001	0.000	0.002	0.001
C85: Health and social work	0.000	0.000	0.001	0.001	0.000	0.001	0.000	0.000	0.001	0.001
C90T93: Other community, social and personal services	0.004	0.003	0.007	0.006	0.018	0.014	0.000	0.000	0.009	0.007
C95: Private households with employed persons	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.000

Note: Groups refer to Latin America (LCN); high-income countries (HIC); middle-income countries (MIC); and oil-specialized high-income countries (OSHIC).

Table 2.6. Backward leakages by sector

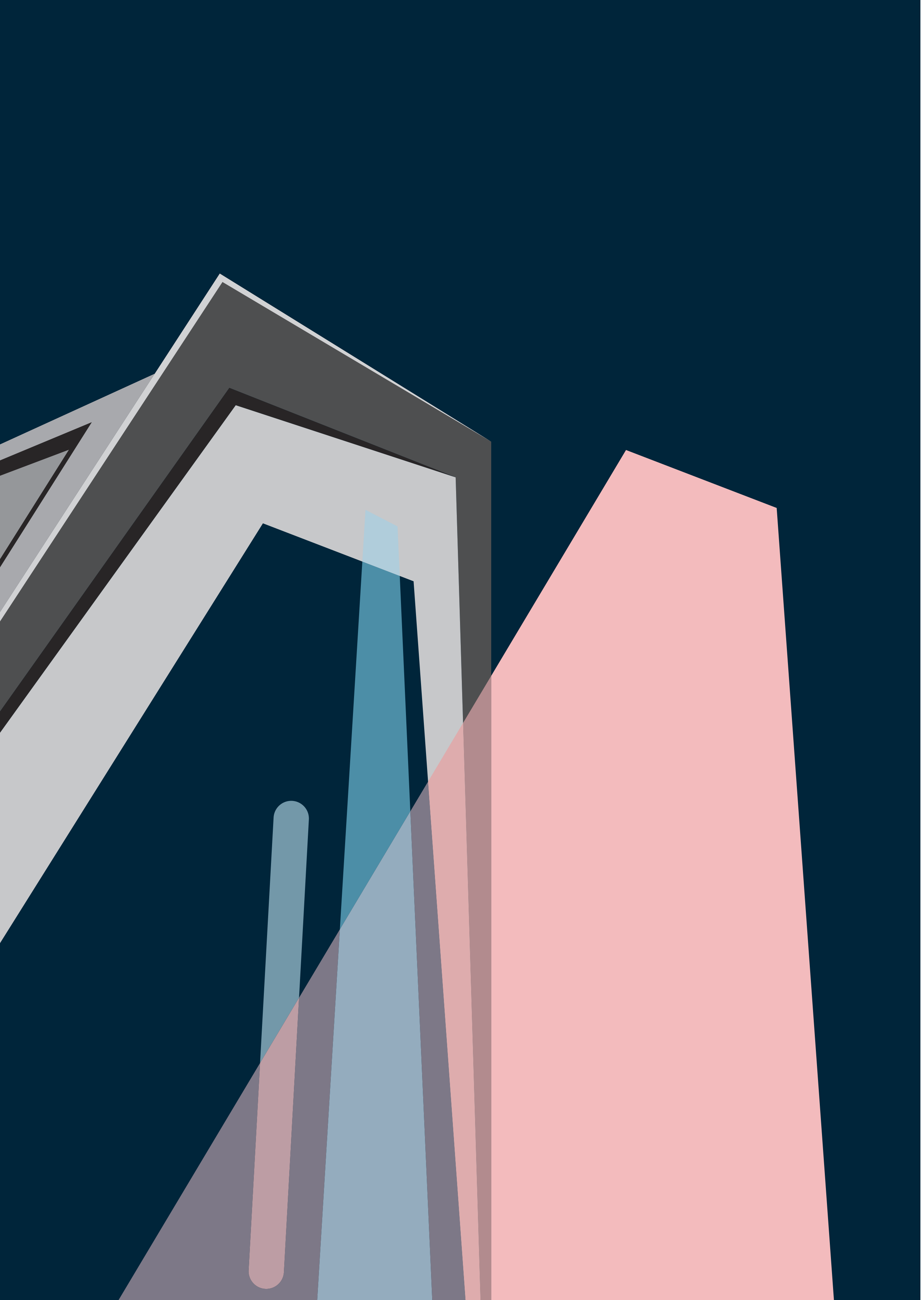
Sector	LCN		HIC		MIC		OSHIC		AVERAGE	
Year	1995	2011	1995	2011	1995	2011	1995	2011	1995	2011
C01T05: Agriculture, hunting, forestry and fishing	0.000	0.000	0.000	0.000	0.002	0.000	0.000	0.000	0.001	0.000
C10T14: Mining and quarrying	1.007	1.025	1.013	1.028	1.005	1.020	1.002	1.001	1.008	1.022
C15T16: Food products, beverages and tobacco	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
C17T19: Textiles, textile products, leather and footwear	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
C20: Wood and products of wood and cork	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
C21T22: Pulp, paper, paper products, printing and publishing	0.000	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000
C23: Coke, refined petroleum products and nuclear fuel	0.002	0.006	0.002	0.004	0.003	0.009	0.000	0.001	0.002	0.006
C24: Chemicals and chemical products	0.007	0.006	0.004	0.002	0.006	0.007	0.001	0.000	0.005	0.005
C25: Rubber and plastics products	0.001	0.001	0.001	0.001	0.001	0.001	0.000	0.000	0.001	0.001
C26: Other non-metallic mineral products	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
C27: Basic metals	0.002	0.002	0.003	0.006	0.001	0.002	0.002	0.002	0.002	0.003
C28: Fabricated metal products	0.002	0.002	0.003	0.002	0.002	0.002	0.000	0.000	0.002	0.002
C29: Machinery and equipment, n.e.c.	0.011	0.007	0.013	0.009	0.008	0.008	0.001	0.001	0.010	0.007
C30T33X: Computer, Electronic and optical equipment	0.001	0.000	0.002	0.002	0.001	0.001	0.001	0.000	0.001	0.001
C31: Electrical machinery and apparatus, n.e.c.	0.001	0.000	0.001	0.001	0.001	0.001	0.000	0.000	0.001	0.001
C34: Motor vehicles, trailers and semi-trailers	0.001	0.001	0.002	0.001	0.001	0.001	0.000	0.000	0.001	0.001
C35: Other transport equipment	0.000	0.000	0.002	0.000	0.001	0.000	0.000	0.001	0.001	0.000
C36T37: Manufacturing n.e.c.; recycling	0.000	0.000	0.000	0.002	0.000	0.000	0.002	0.000	0.000	0.001
C40T41: Electricity, gas and water supply	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
C45: Construction	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
C50T52: Wholesale and retail trade; repairs	0.004	0.005	0.006	0.009	0.006	0.008	0.002	0.001	0.005	0.007
C55: Hotels and restaurants	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
C60T63: Transport and storage	0.008	0.007	0.006	0.005	0.019	0.014	0.002	0.003	0.010	0.008
C64: Post and telecommunications	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
C65T67: Financial intermediation	0.002	0.001	0.003	0.001	0.001	0.002	0.001	0.001	0.002	0.001
C70: Real estate activities	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
C71: Renting of machinery and equipment	0.000	0.000	0.001	0.002	0.000	0.000	0.001	0.001	0.000	0.001
C72: Computer and related activities	0.000	0.000	0.000	0.001	0.000	0.002	0.000	0.000	0.000	0.001
C73T74: R&D and other business activities	0.002	0.002	0.006	0.005	0.000	0.001	0.001	0.001	0.002	0.003
C75: Public administration and defense; compulsory social security	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
C80: Education	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
C85: Health and social work	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
C90T93: Other community, social and personal services	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
C95: Private households with employed persons	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Note: Groups refer to Latin America (LCN); high-income countries (HIC); middle-income countries (MIC); and oil-specialized high-income countries (OSHIC).

Table 2.7. Forward linkages by sector

Sector	LCN		HIC		MIC		OSHIC		AVERAGE	
Year	1995	2011	1995	2011	1995	2011	1995	2011	1995	2011
C01T05: Agriculture, hunting, forestry and fishing	0.037	0.028	0.020	0.011	0.044	0.028	0.005	0.003	0.031	0.020
C10T14: Mining and quarrying	1.059	1.091	1.066	1.073	1.105	1.048	1.095	1.105	1.078	1.074
C15T16: Food products, beverages and tobacco	0.056	0.036	0.027	0.016	0.048	0.031	0.001	0.001	0.039	0.025
C17T19: Textiles, textile products, leather and footwear	0.016	0.007	0.005	0.001	0.022	0.013	0.001	0.001	0.013	0.007
C20: Wood and products of wood and cork	0.005	0.002	0.004	0.002	0.007	0.004	0.000	0.000	0.005	0.002
C21T22: Pulp, paper, paper products, printing and publishing	0.012	0.007	0.016	0.009	0.013	0.008	0.001	0.001	0.012	0.007
C23: Coke, refined petroleum products and nuclear fuel	0.330	0.219	0.239	0.233	0.413	0.289	0.031	0.024	0.298	0.225
C24: Chemicals and chemical products	0.083	0.053	0.046	0.042	0.070	0.056	0.011	0.013	0.061	0.047
C25: Rubber and plastics products	0.018	0.012	0.007	0.004	0.014	0.010	0.000	0.000	0.012	0.008
C26: Other non-metallic mineral products	0.053	0.025	0.025	0.015	0.057	0.034	0.006	0.006	0.041	0.023
C27: Basic metals	0.120	0.111	0.099	0.049	0.074	0.049	0.002	0.007	0.088	0.063
C28: Fabricated metal products	0.021	0.014	0.017	0.009	0.017	0.014	0.000	0.001	0.017	0.011
C29: Machinery and equipment, n.e.c.	0.014	0.013	0.013	0.007	0.017	0.011	0.000	0.000	0.013	0.009
C30T33X: Computer, Electronic and optical equipment	0.010	0.004	0.008	0.002	0.029	0.014	0.000	0.000	0.014	0.006
C31: Electrical machinery and apparatus, n.e.c.	0.007	0.006	0.006	0.003	0.010	0.009	0.000	0.001	0.007	0.005
C34: Motor vehicles, trailers and semi-trailers	0.018	0.017	0.015	0.007	0.015	0.013	0.000	0.000	0.014	0.011
C35: Other transport equipment	0.003	0.003	0.006	0.004	0.005	0.004	0.000	0.000	0.005	0.004
C36T37: Manufacturing n.e.c.; recycling	0.010	0.005	0.008	0.003	0.019	0.010	0.000	0.000	0.011	0.005
C40T41: Electricity, gas and water supply	0.081	0.059	0.148	0.098	0.090	0.071	0.017	0.010	0.097	0.070
C45: Construction	0.126	0.078	0.081	0.056	0.150	0.080	0.091	0.033	0.116	0.068
C50T52: Wholesale and retail trade; repairs	0.028	0.023	0.047	0.026	0.043	0.033	0.004	0.003	0.036	0.025
C55: Hotels and restaurants	0.014	0.008	0.012	0.007	0.014	0.011	0.001	0.001	0.012	0.008
C60T63: Transport and storage	0.077	0.056	0.052	0.038	0.082	0.073	0.009	0.004	0.064	0.051
C64: Post and telecommunications	0.006	0.004	0.007	0.005	0.005	0.007	0.001	0.001	0.005	0.005
C65T67: Financial intermediation	0.006	0.008	0.014	0.009	0.016	0.010	0.001	0.000	0.011	0.008
C70: Real estate activities	0.005	0.004	0.025	0.015	0.008	0.009	0.000	0.000	0.011	0.008
C71: Renting of machinery and equipment	0.001	0.001	0.002	0.002	0.001	0.001	0.000	0.000	0.001	0.001
C72: Computer and related activities	0.002	0.001	0.002	0.003	0.001	0.001	0.000	0.000	0.002	0.002
C73T74: R&D and other business activities	0.011	0.009	0.019	0.015	0.010	0.012	0.001	0.001	0.012	0.011
C75: Public administration and defense; compulsory social security	0.017	0.014	0.040	0.035	0.018	0.012	0.006	0.005	0.023	0.019
C80: Education	0.007	0.005	0.008	0.006	0.007	0.008	0.001	0.001	0.007	0.006
C85: Health and social work	0.011	0.007	0.012	0.011	0.008	0.007	0.002	0.001	0.009	0.008
C90T93: Other community, social and personal services	0.011	0.006	0.015	0.009	0.013	0.010	0.001	0.001	0.012	0.008
C95: Private households with employed persons	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Note: Groups refer to Latin America (LCN); high-income countries (HIC); middle-income countries (MIC); and oil-specialized high-income countries (OSHIC).



CHAPTER 3

Commodity Prices, Linkages and Economic Growth

Abstract

Several scholars have observed a negative association between natural resource abundance and per capita GDP growth. Among the main arguments offered to explain this association, is the Dutch Disease hypothesis (Corden & Neary, 1982), which predicts the loss of competitiveness in (non-commodity) tradeable sectors as the result of macroeconomic imbalances induced by high-value commodity exports, as well as the tendency of natural resource sectors, i.e., extractive, to operate in enclaves (Singer, 1950). More recently, several academics have suggested that extractive sectors no longer operate in isolation and, instead, can catalyze the emergence of win-win linkages with local industries - ultimately leading to economy-wide benefits in resource-rich countries. Nonetheless, empirical evidence to support the latter remains limited; moreover, as discussed in Chapter 2, in most cases there seems to have been a contraction of such linkages in recent years. In this paper, thus, we investigate how the inter-industrial connectivity of extractive sectors (mining) affect economic growth prospects as commodity prices change. In particular, we test whether stronger linkages to the mining sector led to higher growth as the result of industrial synergies, or to lower growth as these linkages amplify negative shocks in a domino-like way. Similarly, we investigate if higher commodity prices provide an impetus for the formation of mining linkages. We follow closely the framework of Collier and Goderis (2012) who use panel error correction models which allows for an examination of the short- and long-run effects of international commodity prices on output per capita and mining linkage formation. We cover a period from 1980 to 2015 for 154 countries. We find that linkages - much like higher commodity prices - affect growth positively only in the short run with no significant effects in the long run. Moreover, contrary to expectations, higher commodity prices have a significant negative effect on the formation of mining linkages.

3.1 Introduction

Since the first half of the 20th century, several arguments have been put forth to explain the corrosive effects of extractive commodity exploitation on growth, also referred to as the resource curse**.** Among the primary arguments to explain this negative association we find, on the one hand, the macroeconomic imbalances triggered by high-value commodities exports as predicted by the Dutch Disease (Corden & Neary, 1982), and on the other, the natural tendency of extractive sectors to operate in enclaves (Singer, 1950).

Countless empirical works have focused on exploring the link between natural resource exploitation and growth using a wide variety of natural resource-related measures, methods, and periods of study. Yet, despite the high number of cross-country empirical investigations, evidence remains inconclusive (e.g., Alexeev & Conrad, 2009; Bravo-Ortega & Gregorio, 2007; Brunnschweiler, 2008; Cavalcanti et al., 2011; Collier & Goderis, 2012; James, 2015; Lederman & Maloney, 2007; Manzano & Rigobón, 2007; Sachs & Warner, 1995, 2001; Stijns, 2005). While a consensus is far from being reached, the recent academic debate has shifted away from the nearly-universal 'resource curse' notion toward a more nuanced perspective (Badeeb et al., 2017). Many scholars now agree that the way in which countries manage their extractive resources is what ultimately determines economic outcomes (e.g., Lederman & Maloney, 2007a). Along these lines, the role of institutions has been particularly emphasized – as institutions are responsible for handling natural resources and, thus, are decisive for (avoiding) the resource curse (Mehlum et al., 2006; Sarmidi et al., 2014).

Furthermore, in recent decades studies have provided new evidence on the enclave nature of oil, energy, and other mining operations. Largely motivated by the rising commodity prices post 2002, several authors have put forth that extractive sectors no longer operate in isolation from the rest of the economy and, instead, offer great potential for developing win-win linkages. Those linkages constitute a basis for technological progress, diversification, and industrialization in resource-rich countries (Andersen et al., 2015; Farooki & Kaplinsky, 2014; Morris et al., 2012; Perez, 2010). In this view, a favorable commodity price environment facilitates the development of said linkages; for instance, high prices allow for investments in technologies and human capital surrounding the extraction of commodities (Morris et al., 2012; Perez, 2010).

Other scholars have focused on the degree of 'enclaveness' of the extractive sector: by measuring inter-industry connectivity at national and subnational scales, several authors have found that mining operations continue to resemble an enclave – despite the increased production and output seen during the 2000s boom (Atienza et al., 2018; Castaño et al., 2019; Nchor & Konderla, 2016; Sadik-Zada et al., 2021).

Despite these contributions to the linkage literature, few studies investigate if indeed moving away from a mining enclave towards strong mining linkages leads to economy-wide benefits and if higher prices – as seen in the recent 2000s commodity boom – would facilitate the formation of said linkages.

In this paper, we contribute to empirical research on the resource curse firstly by investigating the long- and short-term growth effects of higher prices of natural resource commodities – specifically of mining commodities (including minerals, oil, and energy). We do this by utilizing a time-series framework, i.e., a panel error-correction model as in Collier and Goderis (2012), to capture long- and short-run effects of country-specific commodity prices, as calculated by Deaton and Miller (1995), and of mining linkages, based on input-output measures (i.e., backward linkages). Secondly, we expand our econometric analysis to explore the relationship between linkage development with the mining sector and country-specific commodity prices. Our analysis covers more than 140 countries and a relatively recent period, i.e., 1980-2015.

The paper is structured as follows: Section 3.2 discusses background literature, hypothesis, and research questions. Section 3.3 presents and discusses our empirical results. Section 3.4 concludes.

3.2 Background and Hypotheses

Sachs and Warner (Sachs & Warner, 1995) among others have observed a negative association between natural resource abundance and per capita GDP growth. A number of arguments why such a relationship arises have been given. Sachs and Warner (Sachs & Warner, 1995) concluded that Dutch disease was the major driver of this observed relationship, with the high rents earned through commodities exports raising the exchange rate, in turn creating difficulties for other tradeable sectors (including manufacturing) by making their output less competitive on both domestic and international markets. Other arguments include the enclave nature of commodities production, the declining terms of trade of commodities, the relatively high volatility of commodity prices, as well as political economy aspects related to commodities production (e.g., war, corruption, and rent distribution).

Concerning some of these other arguments, Singer (1950) and Hirschman (1958) argued that the extraction of hard commodities (e.g. minerals and metals) occurs in isolation from the local economies in which the mines are based. As a consequence of their high capital intensity, few jobs are created, and there are weak linkages to local suppliers[32]. What is more, benefits from mining commodities extraction are largely repatriated, conferring very limited benefits to the host economy. Auty (2006) expands on this idea and explains that not only are the upstream industries of mining specialized inputs located in mining districts of developed countries but also that downstream industry – where the higher added value is conferred – are also located abroad. Thus, the economic benefit that stems from mining is skewed toward the return on capital and its taxation. Moreover, mining revenues in developing countries end up feeding patronage and graft and ultimately corroding the quality of institutions.

Moreover, Prebisch(1950) and Singer (1950) also observed that the long-run trend for commodities prices relative to manufactures prices was declining. The main explanation suggested by Singer and Prebisch was that the declining terms of trade of commodities were driven by labor market differences. Full employment in high-income manufacturing economies implied that cost-push pricing would result from the higher wages being demanded by powerful trade unions and that the prices of exports of these economies would consequently increase. In low-income countries, by contrast, surplus labor and the weakness of trade unions would not lead to the same cost-plus pricing, and the prices of their exports would either remain stable or decrease (Kaplinsky, 2011).

In addition, Prebisch and Singer asserted that the nature of demand for different products and the development of synthetic substitutes for natural resources would further depress commodity prices. However, recent evidence on this matter is at best mixed: some authors confirm that there is a long-run secular trend in relative commodity prices (Harvey et al., 2010), others find a trendless series or even a positive trend (Cuddington et al., 2007; Svedberg & Tilton, 2006); or, that there is shifting trend over time (Kellard & Wohar, 2006). Finally, other authors have also found mixed evidence where a declining trend only appears if a given currency, i.e. British pounds, or deflator, i.e., UK pound, is employed (Fernandez, 2012).

Another important literature stream has focused on political economy to explain the resource curse. As identified by Badeeb et al. (2017), there is a point of divergence in the resource curse literature. While many authors concentrate on the corrosive effects of resource rents on institutional quality to explain poor outcomes, others explore the mediating role of institutions in the resource curse hypothesis. Few authors, such as Sachs and Warner (1995, 1997) and Brunnschweiler (2008), do not find that institutions play a significant causal role in the resource curse outcome. Yet others, such as Mehlum et al., (2006), Torvik (2009),

32 In the view of Singer (1950), the mining sector *does* generate multiplier effects via linkages but not in the countries where the mining operations are located. The lack of linkages to local suppliers arises because the – usually sophisticated – inputs and capital goods supplied to mine sites are produced abroad (typically in industrialized countries).

Mavrotas et al.(2011), and Sarmidi et al. (2014), argue that the quality of institutions *does* determine whether natural resources are a curse or a blessing.

The discussion on the relationship between commodities and economic growth is often predicated on the idea that commodities production is an enclave, with few links to other sectors. Kaplinsky (2011) notes that there are numerous examples to suggest that the mining industry is not necessarily an enclave. He refers to the case of Canada – and the associated Staples theory – where the development of manufacturing in Canada arose in part due to linkages to the export-oriented commodities sector, which included fish, fur, timber, and minerals (Innis, 1930; Watkins, 1963). Other examples include the development of manufacturing in the U.S. in the 19th and 20th centuries, Sweden's industrialization in the nineteenth century being driven by export booms in cereals and sawn wood, and later in pulp, paper, and iron ore, as well as the recent development of industry in Australia and Norway being linked to the synergies arising between commodities production and industry (Wright & Czelusta, 2004). Kaplinsky (2011) argues further that in these examples the capabilities developed in industry fed back into commodities production by reducing costs and enabling the exploitation of less well-endowed mineral seams, oil deposits, and agricultural land.

Morris et al., (2012) build on the latter and present a general model of linkage development for the mining sector – largely drawing from a number of Sub-Saharan African case studies. They explain that the lead mining firms are increasingly relying on local outsourcing for non-core business activities and on local suppliers as sources of innovative services and other inputs. Moreover, they suggest that high prices in the 2000s – which would likely remain relatively high – provide an added impetus for linkage expansion. Other studies which look at the relationship between economic growth and natural resources have focused on linkages between industries. For example, Lederman and Maloney (2007b) find that it is not natural resource abundance but rather low domestic inter-industrial linkages that explain poor economic performance. These studies look at the benefits of higher industrial connectivity (across the economy or specifically linked to extractive sectors), yet they do not provide any theoretical underpinnings to explain why linkages may (or may not) develop in the presence of higher commodity prices.

According to Hirschman (1958), the linkages from commodities to the industry can take three general forms. The first are *fiscal* linkages, the resource rents which the government can harvest from the commodities sectors in the form of corporate taxes, royalties, and taxes on the incomes of employees. These rents can be used to promote industrial development in sectors unrelated to commodities. The second major category of linkages are *consumption* linkages, that is, the demand for the output of other sectors arising from the incomes earned in the commodities sector. The third form of linkages are *production* linkages, both forward

(processing commodities) and backward (producing inputs into the commodities sector) linkages. It is the latter type of linkages that we consider in this paper.

Namely, we explore whether increased linkages between the commodities sector and other sectors of the economy can – through technological progress – enhance aggregate growth. Contrary to this, however, is the argument that increased linkages with the rest of the economy make it easier for shocks within the commodities sector to be spread throughout the economy, exacerbating the effect of the initial shock. Commodities prices tend to be more volatile than prices within other sectors – most notably manufacturing. To the extent that the commodities sector is an enclave, the effect of any shock to commodities prices will be largely confined to the commodities sector. Given the large share of GDP accounted for by commodities in some countries, the effects of such shocks on aggregate growth can be substantial. In the case where linkages to other sectors are strong, however, then the effect of a shock to commodities prices can have knock-on effects on other sectors of the economy, multiplying the overall negative effect on the economy. Effects may well differ by type of linkage, however. A negative demand shock to the commodities sector would be likely to have significantly negative effects on the demand for upstream suppliers for example, but the effect on downstream buyers may be more nuanced (with a potentially positive effect due to the lower commodities prices lowering input costs and output prices, and potentially increasing demand).

Likewise, we explore whether the expansion of backward linkages is incentivized (or not) by higher mining commodity prices. On the one hand, higher prices could indeed facilitate the expansion of linkages by allowing local firms to invest in the development of innovative products and services necessary for the extraction of natural resources, as suggested by Perez (2010); higher prices could also allow mining firms to invest in acquiring inputs and services from local suppliers as they have more resources to experiment with. On the other hand, a surge in prices could de-incentivize further backward linkage development: if higher commodity prices affect adversely manufacturing (as predicted by the Dutch disease argument), local providers are less likely to be able to produce inputs, machinery, and other equipment necessary for the mining industry. Additionally, a surge in prices could reduce the necessity of extractive firms to look out for new services or inputs – even if locally supplied; high prices normally allow high-cost, low-productivity mines to remain operating (Tilton, 2014), further reducing the window for supplier linkage expansion.

Finally, we consider the different effects in the short- and long-run of mining booming prices. Empirical work which focuses on country-specific prices to find the effect of commodity booming prices, i.e., Deaton and Miller (1995), find a strong positive effect of prices on income in the short-run. However, initial effects could be more than offset by other effects (such as the ones discussed above) in the long run as pointed out by Collier and Goderis (2012); and, therefore, it is important to disentangle long- from short-run effects. Likewise, prices may have different long- and short-run impacts on linkages. In the short run, a positive price environment could translate into an immediate increment in linkages, for instance, due to the expansion of mining sites which requires construction equipment, maintenance services, etc. But in the long run, according to the Dutch disease, high commodity prices could result in the loss of competitiveness of manufacturing and other sectors - consequently reducing ability to supply equipment, machinery, and other inputs to the mining sector and, thus, the ability to expand linkages.

Ultimately, the hypotheses/questions that we would like to address are:

(i) Is there a negative impact of mining commodity prices on long-run (and short-run) growth?

(ii) Do greater linkages between the mining commodities sector and other sectors impact long-run (and short-run) growth?

(iii) Do higher mining commodity prices impact linkages between the mining sector and other sectors?

(iv) Can institutional quality mediate the economic outcomes of linkages and commodity prices on growth as well as on the formation of linkages?

3.3 Methodology

We follow closely the work of Collier and Goderis (2012) who use panel error correction models to examine the short- and long-run effects of international commodity prices on output per capita.

The initial estimating equation of Collier and Goderis (2012) is written as follows[33]:

$$\Delta y_{i,t} = \lambda y_{i,t-1} + \beta_1' x_{i,t-1} + \alpha_i + \delta t + \varepsilon_{i,t} \quad (1)$$

with $y_{i,t}$ being the log of real per capita GDP, $\Delta y_{i,t}$ the growth rate of real per capita GDP, $x_{i,t-1}$ is an $m \times 1$ vector of m variables that are expected to affect the long-run steady-state level of GDP per capita, α_i is a country-specific fixed effect (controlling for country-specific, time-invariant unobservables), t is a time trend (that allows for a non-zero steady-state growth in output per capita), and ε is a well-behaved error term.

33 The discussion and the description of the method that follows are based largely on the discussion in Collier and Goderis (2012).

Collier and Goderis (2012) note that the model above allows for a study of the potential determinants of the steady-state level of output, but that it does not allow the transition to the steady-state to be affected by short-run business cycle fluctuations due to shocks to the economic environment. As a result, they augment the model with contemporaneous and lagged changes in $x_{i,t}$ and a lagged dependent variable (to account for persistence in growth rates). The resulting model is then written as:

$$\Delta y_{i,t} = \lambda y_{i,t-1} + \beta_1' x_{i,t-1} + \beta_2 \Delta y_{i,t-1} + \sum_{j=0}^{k} \beta_{3j}' \Delta x_{i,t-j} + \alpha_i + \delta t + \varepsilon_{i,t} \quad (2)$$

which can be written as an error correction model:

$$\Delta y_{i,t} = a_1 \big(y_{i,t-1} - \theta' x_{i,t-1} - \mu_i - gt\big) + a_2 \Delta y_{i,t-1} + \sum_{j=0}^{k} a_{3j}' \Delta x_{i,t-j} + a_i + a_4 t + \varepsilon_{i,t} \quad (3)$$

with $\lambda = a_1, \beta_1 = -a_1\theta, \beta_2 = a_2, \beta_{3j} = a_{3j}$, for $j = 0, \dots, k$, $\alpha_i = a_i - a_1\mu_i$, and $\delta = a_4 - a_1 g$. In this latter model, output responds to deviations from long-run equilibrium (captured by the term in brackets) that will eventually bring the economy back to its steady-state. The coefficient a_1 is expected to be negative and its size represents the speed of convergence to steady-state. The steady-state is realized when the terms in brackets is zero so that $y_{i,t-1} = \theta' x_{i,t-1} + \mu_i + gt$. Should we assume a constant value for x_i, the steady-state then will be given by g so that $y_{i,t} = y_{i,t-1} + g$ and so the long-run is written as:

$$y_{i,t} = \theta' x_{i,t-1} + \mu_i + g + gt \quad (4)$$

Short-run effects are captured in equation (2), with λ being the speed of convergence, β_2 the short-run effect of growth of the previous year and β_{3j}' the short-run effects of changes in the variables of the x-vector. Long-run effects of the vector $x_{i,t-1}$ in equation (2) are captured by the vector θ' in equations (3) and (4). Given that $\theta' = -(\beta_1'/\lambda)$, these are computed based on the coefficients in the equation (2).

The fixed effect a_1 controls for any country-specific and time-invariant unobservables (captured by μ_i in equation (4)). We also include a time trend t that allows the growth rate g in equations (3) and (4) to be different from zero. To control for regional macroeconomic shocks, we include also an rT x 1 vector of regional time dummies where r represents the region.

In total we consider a period from 1980 to 2015, using annual data for 154 countries (or 148 countries – depending on the data availability of the variables included in our estimations) across six regions[34].

For answering, our last research question, we employ a modified version of equation (2) where we change the dependent variable to mining linkages (defined in section 3.2.2).

3.3.1 Mining Commodities Price Index

Dehn (2000) points out that most of the analyses surrounding the effects of commodity price movements focus on prices of individual commodities (e.g., oil), terms-of-trade, or aggregate commodity price indices (not country-specific). These may not be the best approaches to capture the impacts of commodity price movements. Relatively few countries' exports are concentrated in one commodity, such as oil, suggesting that the information conveyed by the price of an individual commodity is limited. Terms-of-trade indices, on the other hand, capture too much information which is not related to commodity prices. Lastly, aggregate commodity price indices capture less accurately how commodity price movements affect growth than a country-specific index, simply because they do not take into account differences in the export basket composition of each country – especially in countries specialized in a narrow range of commodities.

To overcome these limitations, we construct a country-specific commodity price index ($p_{i,t}$) based on the geometric weighted index initially developed by Deaton and Miller (1995) and later employed by Dehn (2000) and Collier and Goderis (2012). This has the advantage over other natural resource proxies, as it is a relatively exogenous approach as countries, as well as mining and oil firms, have no influence (or very limited at best) on international prices. We use the world price of mining commodities and net exports to allow for a country-specific commodity price index, with the resulting variable being deflated by the manufacturing unit value index and included in logs.

34 These are: (i) East Asia & Pacific; (ii) Europe and Central Asia; (iii) Latin America and the Caribbean; (iv) Middle East and North Africa; (v) North America; (vi) South Asia; (vii) Sub-Saharan Africa. Regions include all income levels. For details on data and sources, please see Annex.

First, we calculated net exports for the main mining commodities: energy, metals, and precious metals (see Table 3.1 for details) for each country in our sample. To assign the weights, net exports of each mining commodity, $(x-m)_{c,i}$, were divided by the total of mining commodities. We calculated this for four years: 1995, 2000, 2005, and 2010 and took the average as our weight[35]. This resulting weight, $W_{c,i}$, is therefore country-specific and fixed over time.

$$W_{c,i} = \frac{(x-m)_{c,i}}{\sum_{c=1}^{l}(x-m)_{c,i}} \quad \text{for all} \quad (x-m)_{c,i} > 0 \tag{5}$$

After this, we use the weights, $W_{c,i}$, to build our geometric weighted average mean in logs:

$$P_{i,t} = log\frac{\prod_{c=1}^{l} P_{c,t}^{Wc,i}}{MUV_t} \tag{6}$$

Where $P_{c,i}$ is the USD international commodity price for the commodity c in time t, $W_{c,i}$ the weight for commodity c in country i and MUV_t our deflator, i.e., manufacturing unit value index in time t. We further rescaled the international commodity prices such that they equal 100 in the year.

To account for the relative importance that mining commodities exports have in the overall economy, we weighted our price index, $P_{i,t}$, by the share of net mining commodities in GDP (of the year 2000), S_i, which is defined as:

$$S_i = \frac{\sum_{c=1}^{l}(x-m)_{c,i}}{GDP_{2000}} \quad \text{for all} \quad (x-m)_{c,i} > 0 \tag{7}$$

The resulting index, $S_i\, P_{c,i}$, is used in our regression analysis.

Data to calculate our mining commodity price index is from Thibault Fally's dataset on Commodity Trade from 1995-2014[36] and 2000 GDP data from the World Development Indicators.

35 Holding a fixed weight over time is important in order to exclude endogenous responses as put forth by Dean (1999). However, Goderis and Collier (2012) also indicate that a changing composition of primary exports is rather limited. In our sample, for instance, the average weight of crude oil has a pairwise correlation of 0.76 with the 1995 weight, and of, 0.78 0.80 and 0.78 with the years 2000, 2005 and 2010, respectively. It is important to mention that we opted for weights based on an average to obtain as many observations as possible as many countries do not have any trade data reports before the 2000s.

36 Trade data comes from the BACI database, constructed by CEPII and based on UN-Comtrade data, and provided at the 6-digit level of the Harmonized Commodity Description and Coding System (HS). It employs the HS 1992 nomenclature, as it provides the longest series, covering the years 1995 to 2014 (Fally & Sayre, 2018).

Figure 3.1 presents how the commodity price index evolved for all the countries in the sample as well as the log of GDP per capita (in constant 2005 USD). The evolution of the mining commodity price index reflects major price developments since 1980 – including the peaks that occurred at the end of the 1970s and the recent price upswings which characterized the 2000s commodities boom. Moreover, the trend also outlines the low prices observed during the 1980s and the first half of the 1990s. After 1995, however, the commodity price index began to pick up – largely due to the growing demand coming from China – and around this time, GDP per capita growth also began to accelerate. Figure 3.2 depicts the evolution of the same variables as in Figure 3.1 but for top mining exporters[37] (i.e., countries where the net exports of mining commodities were equivalent to 10% or more of total GDP in 2000). Much like in the previous figure, GDP per capita growth and the mining price index grew noticeably after 1995. A couple of (expected) differences stand out in relation to Figure 3.1: after the mid-1980s both plotted lines began moving more closely to each other while GDP per capita (log) is somewhat higher – which is in line with the high growth rates seen for many resource-rich countries in the 2000s and 2010s.

Table 3.1. HS Codes Used in the Construction of Country Specific Mining Commodity Price Indices

Commodity Name	HS Code	HS Description
Energy		
Coal	2701	Coal; briquettes, ovoids, and similar solid fuels manufactured from coal
Crude Oil	2709	Crude oil from petroleum and bituminous minerals
Natural Gas	2711	Petroleum gases & other gaseous hydrocarbons
Metals and Minerals		
Aluminum	2606	Aluminum ores and concentrates
Copper	2603	Copper ores and concentrates
Iron Ore	2601	Iron ores & concentrates, including roast pyrites
Lead	2607	Lead ores and concentrates
Nickel	2604	Nickel ores and concentrates
Tin	2609	Tin ores and concentrates
Zinc	2608	Zinc ores and concentrates
Precious Metals		
Gold	7108	Gold (including gold plated with platinum), unwrought, semi-manufactured, or powder
Silver	7106	Silver (including silver plated with gold or platinum), unwrought, semi-manufactured, or powder
Platinum	7110	Platinum, unwrought, unwrought, semi-manufactured, or powder

37 These countries are Algeria, Angola, Azerbaijan, Bahrain, Brunei Darussalam, Rep. Congo, Gabon, Iraq, Kuwait, Libya, Nigeria, Oman, Papua New Guinea, Qatar, United Arab Emirates, and Yemen. These countries are also present in our estimations.

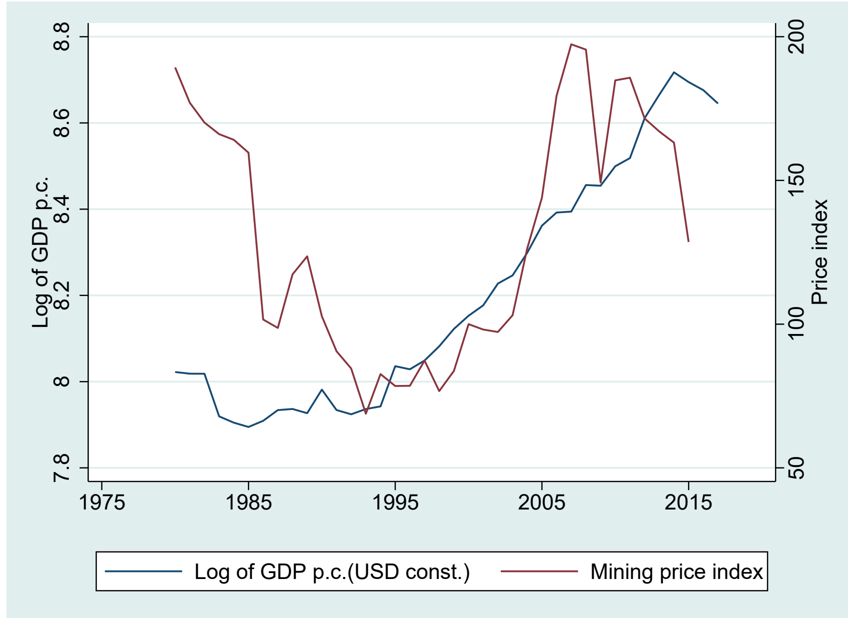


Figure 3.1. Median values of log of GDP per capita growth and mining commodities price index
Source: Authors' elaboration with data from World Bank's Pink Sheet, Thibault Fally's Commodity Trade, and World Development Indicators.

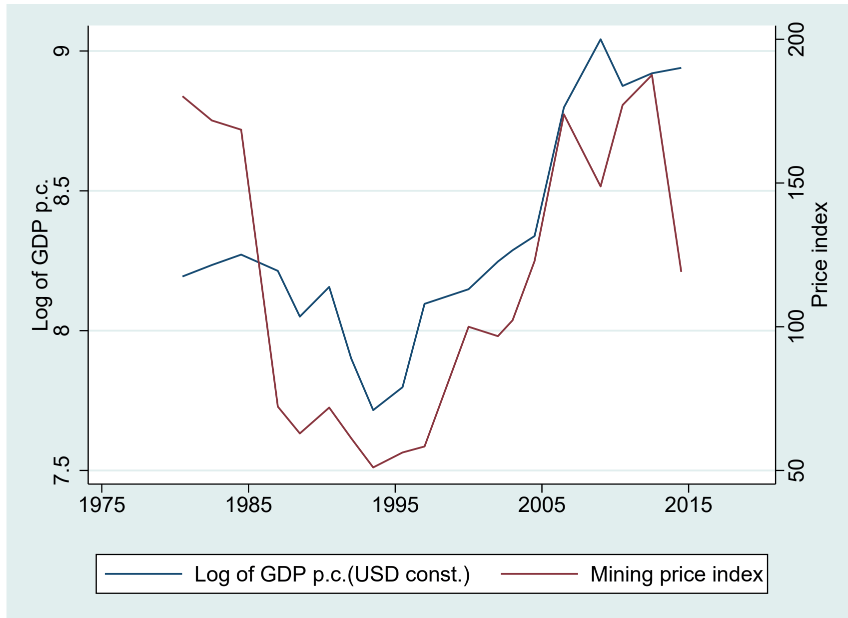


Figure 3.2. Median values of log of GDP per capita growth and mining commodities price index in countries with a high level of dependency on mining commodities
Source: Authors' elaboration with data from World Bank's Pink Sheet, Thibault Fally's Commodity Trade, and World Development Indicators.

3.3.2 Mining Linkages and Control Variables

Referring back to Collier and Goderis (2012), we include a series of control variables that proxy for the elements in the augmented Solow model, i.e., investment, initial output per capita, population growth, and human capital[38]. For this, we include in our specifications the following long-run variables: (i) gross fixed capital investment; (ii) population growth; (iii) the share of population aged 0-14; (iv) the ratio of trade to GDP; (v) the log of the inflation rate; (vi) and the log of population. All these indicators are from the World Development Indicators (WDI) database.

To account for institutional quality, we use (vii) the government effectiveness index from the WDI. We chose this proxy to capture perceptions of the quality of public services, the quality of the civil service and the degree of its independence from political pressures, the quality of policy formulation and implementation, and the credibility of the government's commitment to such policies.

We further include the following short-run controls: (viii) major disasters in a given year (as defined by the IMF[39]; (ix) interstate wars in a given year; (x) civil wars in a given year; and (xi) number of coups d'états in a given year. These indicators are from the Centre for Research on the Epidemiology of Disaster (CRED), 1946–2008 UCDP/PRIO Armed Conflict dataset, and Thyne-Powell's 'Coups in the World' database. For more details on our control variables, see Annex 1.

The above describes the basic setup of the model and allows us to address the first hypothesis. In order to address the second and third hypotheses, we construct for each country in our dataset an indicator of the extent of mining linkages to other sectors of the economy using standard methods in input-output analysis – namely, backward linkages[40]. For this purpose, we use data from EORA[41]. We then interact this with our measure of commodity prices to examine whether the effect of commodity prices varies with the extent of linkages. Summary statistics of our sample are reported in Table 3.2.

38 We also included Barro-Lee's Educational Attainment data for secondary and tertiary education to account for human capital. However, these are not included in the estimations reported since they were not statistically significant and reduced our sample to 128 countries.

39 The IMF criteria of what constitutes a major disaster is: 0.5% or more of population affected, or damage equivalent to 0.5% of GDP or one or more deaths per 10,000 habitants. For more details on data and sources, see Annex 1.

40 We utilize the standard Leontief model for backward linkages as described in Miller and Blair (2009, p. 555): " If sector *j* increases its output, this means there will be increased demands from sector *j* (as a purchaser) on the sectors whose goods are used as inputs to production in *j*. This is the direction of causation in the usual demand-side model, and the term backward linkage is used to indicate this kind of interconnection of a particular sector with those ("upstream") sectors from which it purchases inputs".

41 The construction of the backward measure here employed follows the method for calculating backward linkages (IBLs) described in the previous chapter (i.e., Subchapter 2.2.1 Backward Linkages).

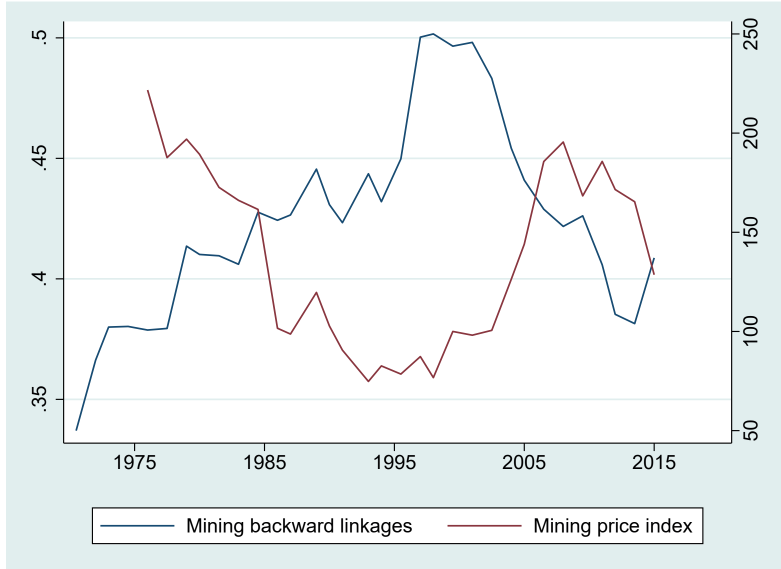


Figure 3.3. Median values for mining backward linkages and mining commodities price index
Source: Authors' elaboration with data from World Bank's Pink Sheet, Thibault Fally's Commodity Trade, World Development Indicators, and EORA.

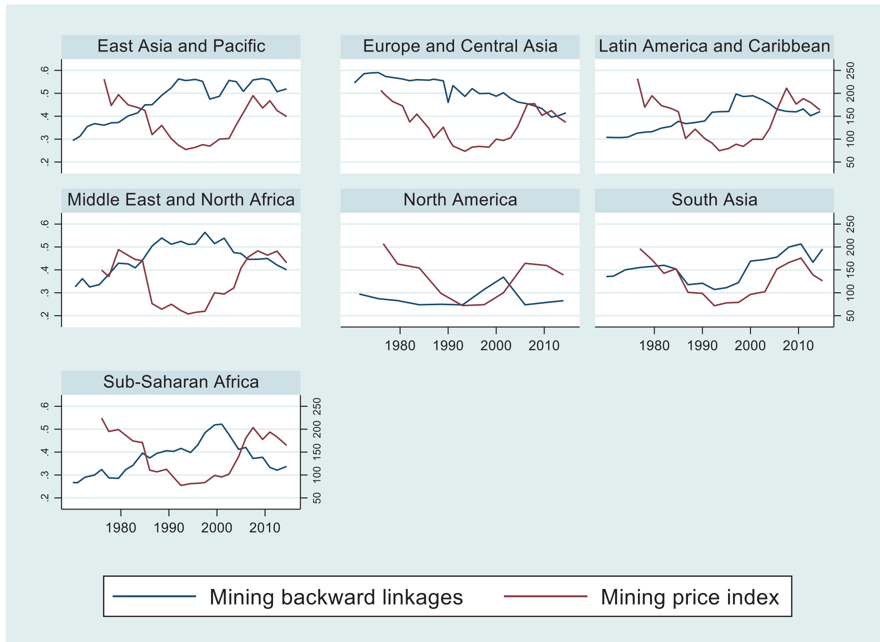


Figure 3.4. Median values for mining backward linkages and mining commodities price index by region
Source: Authors' elaboration with data from World Bank's Pink Sheet, Thibault Fally's Commodity Trade, World Development Indicators, and EORA.

Having explained the main variables of interest, we can briefly discuss their evolution. Figure 3.3 shows median values for the mining price index and backward linkages. While linkages increased during the 1980s, after the mid-1990s there was strong increment – which could be reflective of higher outsourcing practices in mining firms (which largely began in the 1990s). However, in the early 2000s – coinciding with the sharp increments in the mining price index – the linkages contracted noticeably. Shortly before 2015, however, linkages showed a bit of an upswing. Figure 3.4 depicts the same variables but across regions. The development of the mining price index shows some variation but is, expectedly, more or less the same across all regions. In terms of backward linkages, most regions showed a downward trend after the 2000s – except for South Asia and East Asia and Pacific regions where linkages grew in a fairly steady manner since the 1990s.

Table 3.2. Summary Statistics

	N	Mean	SD	Min	Max
Gross fixed capital investment (% of GDP)	4,090	0.22	0.07	0.00	0.71
Population ages 0-14 (% of total)	4,128	0.31	0.11	0.11	0.51
Mining backward linkages (DBL)	4,128	0.49	0.31	0.00	2.12
Log of mining backward linkages (DBL)	4,128	-0.99	0.87	-7.17	0.75
Exports of goods and services (% of GDP)	4,119	0.39	0.27	0.00	2.31
Log of Inflation	4,125	-0.89	2.34	-30.82	1.25
Inflation	4,125	0.67	0.36	0.00	3.48
Non-logged Price Index, 2000 = 100	4,128	131.68	52.68	43.39	428.31
Log of Weighted Mining Commodity Price Index (MCP index)	4,128	0.11	0.25	0.00	1.47
Net exports of mining commodities (% of GDP) in 2000 (*Weights*)	4,128	0.02	0.05	0.00	0.28
Government efficiency index	4,115	0.15	0.98	-1.96	2.30
Log of Population	4,128	16.03	1.74	11.06	21.04
Log of GDP per capita (constant 2005 USD)	4,128	8.41	1.53	5.32	11.43
No. of coups d'état in a given year	4,128	0.02	0.18	0.00	4.00
No. of interstate wars in a given year	4,128	0.00	0.06	0.00	1.00
No. civil of wars in a given year	4,128	0.04	0.19	0.00	1.00
No. of major disasters in a given year	4,128	0.05	0.23	0.00	3.00
Observations	4,128				

3.4 Results

3.4.1 Effects of mining commodity prices and linkages on growth

The effects of mining commodity prices and linkages on growth, based on Equation (2), are reported in Table 3.3. The results show that there is no evidence of a negative long-run effect of mining commodity prices on economic growth, i.e., log of GDP per capita (constant USD). The signs are positive but not significant. This is in contrast to the results of Collier and Goderis (2012) where a negative effect is found for mineral commodities prices during the 1963-2008 period. A possible explanation for this difference is that their results are driven by older decades covered in their study. As highlighted in the study of Gerelmaa and Kotani (2016), there is no empirical evidence for the Dutch disease in the decades following 1990[42]. Moreover, Cavalcanti et al., (2011) who also employ a panel error correction model for oil abundance measures and cover a similar period to ours (1980-2006), find no evidence of long-term negative effects on growth[43].

We do find that an increase in the mining price index is consistently associated with short-run growth across all the models (at the 1% level in Columns (1) and (5); and at the 5% level in the rest). Our results indicate that this significant effect is mainly found in the contemporary difference, and, in some specifications, i.e., Columns (1) and (5), one year after there was an increment in the index. To illustrate the short-run effects, we must consider first the importance of the mining sector in a given country question[44]. As shown in Table 3.2, on average, the share of net exports of mining commodities in GDP in our sample was 2% and the maximum value was 28%. Thus, based on the short-run coefficients in Column (4) in Table 3.3, for a country whose net mining exports are 2%, a 10% increment in the mining price index would be associated with an increment of 0.054% in GDP per capita growth (2.7% multiplied by 0.02), holding other factors constant. In a country whose net mining exports are 28%, this would cumulate to an increment of 0.76% in GDP per capita growth (2.7 multiplied by 0.28). The positive short-term effect of our findings is consistent with Goderis and Collier (2012), Cavalcanti et al., (2011), and Deaton and Miller (1995). The positive impact on growth is, however, short-lived: the coefficients are not significant for the second and third lagged differences, with the positive coefficient becoming smaller and even turning negative as we move to higher-order lags.

42 The empirical results of this study showed that in the period from 1970 to 1990, slower growth is indeed associated with natural resource abundance but not in the years after (1991-2010).

43 Badeeb et al., (2017) in an extensive review of empirical studies, indicate the negative effects associated to natural resources on economic growth may disappear as studies start to include recent periods, i.e. more years after 2000.

44 Recall that the mining commodity price index is weighted by the share of net commodity exports in GDP (of 2000) as defined in Equation (5).

Regarding the long-run effects of mining backward linkages, coefficients have a positive sign but are not significant in any of the models – akin to the mining price index long-run coefficients. Our results, then, suggest that developing stronger interindustry connectivity with the mining sector is not necessarily a factor that, on its own, will lead to long-term growth – unlike what has been hypothesized by several scholars, such as Morris et al. (2012). Nevertheless, these results also indicate that higher linkages to the mining sector, on average, are not associated with long-term detrimental effects on growth; thus, we find no evidence that higher mining backward linkages would lead to a domino-like transmission negative effect across the economy.

Regarding short-run effects of mining backward linkages, we find that contemporaneous changes, as well as those in the first and third lag, are insignificant. Nevertheless, models shown in Columns (2) and (6) suggest a significant positive effect for the second lagged difference (at the 5% level); in other words, after two years of an increment in mining backward linkages, on average, there is a positive impact on growth: namely, a 10% increment in mining backward linkages will to a 0.10% increment in GDP per capita growth, holding other factors constant. However, as with the effect of mining prices, the positive effect of an increment in mining linkages is not sustained – as higher-order lags do not result to be significant. A possible explanation for this short-lived effect is that a couple of years after local industries increased connectivity with the mining sector, these heightened industrial synergies translate into higher economic activity. Yet, because supply linkages vary substantially over the life cycle of an oil or mine project, these supply linkages (and their economy-wide benefits) cannot be sustained over time: Backward linkages typically peak at the early stages of an extractive project when engineering, procurement, and construction activities are carried out but plateau thereafter (Sen, 2020). All in all, these results underscore the temporary nature of an economic boost brought about by mining prices and/or developing backward linkages. We also introduce an interaction effect between the mining price index and backward linkages to investigate whether the effect of prices on growth depends on the extent of linkages. As earlier discussed, we hypothesize that in the presence of a negative (positive) price shock, linkages may amplify negative (positive) effects in a domino-like way. Results show that in the long run there is a negative but insignificant effect on growth. In the short run, there is some positive effect on growth in the second lag; however, these coefficients are only significant at the 10% level (additionally, they seem to absorb the effect of the second lagged change in mining backward linkage as seen in Columns (2) to (4)). Overall, these results highlight that – in contrast to our expectations – the effects of commodity prices on economic growth are not necessarily amplified by linkages.

Other regressors behave in our estimations as expected. The GDP per capita coefficient (*Log of GDP per capita t-1*), significant at the 1% level, captures the speed of conditional convergence, with poorer countries expected to grow more rapidly than developed nations[45]. Moreover, long-run growth is also negatively correlated to a young population, (*Population ages 0-14*), and is positively correlated to the ratio of trade to GDP, (*Exports of goods and services)*. Likewise, negative and significant short-run effects on economic growth are associated with the presence of contemporary major natural disasters, wars (civil and interstate), and coups d'état. The negative effect of war and coup d'état – much more related to political stability – are larger than that of natural disasters[46].

Table 3.3. Estimation Results

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Growth of GDP per capita							
Long-run effects								
Gross fixed capital investment	0.076**	0.025	0.024	0.014	0.070**	0.016	0.014	0.002
	(0.033)	(0.021)	(0.020)	(0.020)	(0.036)	(0.022)	(0.022)	(0.021)
Log of population growth	0.086	0.017	0.042	0.059	0.127	0.079	0.107	0.138
	(0.306)	(0.306)	(0.307)	(0.298)	(0.307)	(0.304)	(0.303)	(0.295)
Population ages 0-14 (% of total)	-0.150**	-0.182***	-0.178***	-0.139**	-0.182**	-0.223***	-0.217***	-0.184***
	(0.062)	(0.053)	(0.053)	(0.059)	(0.070)	(0.058)	(0.058)	(0.060)
Mining commodity price index	0.012	0.023	0.019	0.026	0.019	0.032	0.028	0.039
	(0.049)	(0.056)	(0.064)	(0.062)	(0.050)	(0.057)	(0.065)	(0.063)
Exports of goods and services (% of GDP)	0.029***	0.025**	0.026**	0.025***	0.031***	0.026**	0.027**	0.027**
	(0.010)	(0.010)	(0.010)	(0.009)	(0.011)	(0.011)	(0.011)	(0.011)
Log of inflation	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Log of population	-0.002	-0.006	-0.006	-0.006	-0.009	-0.019*	-0.020*	-0.020*
	(0.010)	(0.009)	(0.009)	(0.009)	(0.013)	(0.010)	(0.011)	(0.011)
Log of Mining backward linkages		0.001	0.004	0.004		0.000	0.003	0.003
		(0.002)	(0.003)	(0.003)		(0.002)	(0.003)	(0.003)
Mining commodity price index * log of backward linkages			-0.017	-0.010			-0.017	-0.009
			(0.012)	(0.015)			(0.013)	(0.015)
Short-run effects								
Log of GDP per capita $_{t-1}$	-0.053***	-0.057***	-0.058***	-0.054***	-0.056***	-0.063***	-0.063***	-0.060***
	(0.010)	(0.008)	(0.008)	(0.007)	(0.011)	(0.008)	(0.008)	(0.007)
Δ Log of GDP per capita$_{t-1}$	0.254***	0.260***	0.259***	0.241***	0.255***	0.262***	0.260***	0.242***
	(0.0421)	(0.0501)	(0.0490)	(0.0482)	(0.0422)	(0.0501)	(0.0489)	(0.0481)
Δ Mining commodity price index $_{t}$	0.393***	0.319**	0.341**	0.318**	0.394***	0.315**	0.338**	0.314**
	(0.127)	(0.135)	(0.146)	(0.139)	(0.129)	(0.137)	(0.147)	(0.139)
Δ Mining commodity price index $_{t-1}$	0.299**	0.120	0.153	0.132	0.296**	0.109	0.143	0.117
	(0.140)	(0.088)	(0.097)	(0.103)	(0.144)	(0.087)	(0.096)	(0.103)

45 The coefficients that capture this convergence rate (5-6%) are within the range of those reported in Goderis and Collier (2012).

46 Other common controls utilized in growth regressions, such as Barro-Lee's years of secondary (WDI) were not included as they were not significant in any estimation and reduced our sample to 128 countries.

Δ Mining commodity price index $_{t-2}$	0.101	0.000	0.039	0.011	0.100	-0.006	0.033	0.002
	(0.105)	(0.089)	(0.093)	(0.088)	(0.108)	(0.090)	(0.092)	(0.087)
Δ Mining commodity price index $_{t-3}$	-0.032	-0.119	-0.096	-0.101	-0.033	-0.124	-0.101	-0.107
	(0.100)	(0.096)	(0.090)	(0.087)	(0.103)	(0.097)	(0.091)	(0.086)
Δ Mining backward linkages(log) $_{t}$		0.005	0.004	0.004		0.004	0.003	0.003
		(0.008)	(0.008)	(0.008)		(0.008)	(0.008)	(0.008)
Δ Mining backward linkages(log) $_{t-1}$		-0.002	-0.005	-0.005		-0.002	-0.005	-0.005
		(0.004)	(0.004)	(0.004)		(0.004)	(0.004)	(0.004)
Δ Mining backward linkages(log) $_{t-2}$		0.010**	0.004	0.004		0.010**	0.004	0.004
		(0.004)	(0.004)	(0.004)		(0.004)	(0.004)	(0.004)
Δ Mining backward linkages(log) $_{t-3}$		0.005	0.005	0.005		0.005	0.005	0.005
		(0.003)	(0.004)	(0.004)		(0.003)	(0.004)	(0.004)
Δ Mining commodity price index * log of mining backward linkages $_{t}$			0.019	0.025			0.022	0.028
			(0.046)	(0.046)			(0.045)	(0.045)
Δ Mining commodity price index * log of mining backward linkages $_{t-1}$			0.039	0.035			0.039	0.035
			(0.056)	(0.054)			(0.057)	(0.054)
Δ Mining commodity price index * log of mining backward linkages $_{t-2}$			0.047*	0.045*			0.048*	0.045*
			(0.027)	(0.024)			(0.027)	(0.024)
Δ Mining commodity price index * log of mining backward linkages $_{t-3}$			-0.009	-0.008			-0.009	-0.008
			(0.026)	(0.024)			(0.026)	(0.024)
Major disasters $_{t}$				-0.010***				-0.010***
				(0.003)				(0.003)
Coup d'état $_{t}$				-0.020***				-0.020***
				(0.007)				(0.007)
Civil wars $_{t}$				-0.025***				-0.027***
				(0.010)				(0.010)
Interstate wars $_{t}$				-0.081**				-0.089**
				(0.040)				(0.042)
Constant	0.490**	0.610***	0.602***	0.570***	0.630**	0.867***	0.877***	0.849***
	(0.221)	(0.181)	(0.182)	(0.172)	(0.270)	(0.185)	(0.199)	(0.188)
Observations	4,250	4,128	4,128	4,128	4,250	4,128	4,128	4,128
Number of Countries	154	148	148	148	154	148	148	148
Adjusted R-squared	0.163	0.131	0.132	0.156	0.164	0.135	0.136	0.163
Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time Trend	Yes	Yes	Yes	Yes	No	No	No	No
Regional time trend	No	No	No	No	Yes	Yes	Yes	Yes

*** p<0.01, ** p<0.05, * p<0.1. Robust standard errors in parentheses

In the second set of regressions presented in Table 3.4, we introduce a government effectiveness indicator to account for institutional quality, which is positive and significant at the 1% level in all our estimations. A one-unit increase in this indicator cumulates to a 1.6-1.9% growth rate of GDP per capita, holding other factors constant.

However, in contrast to the work of Collier and Goderis (2012), introducing this control does not yield significant positive coefficients on the mining price index when considering long-run effects. Short-run effects of the mining price index on growth remain positive and significant (namely in the contemporary difference). In general, the estimations shown in Table 3.4 are largely similar to those in Table 3.3 despite the introduction of a proxy for institutional quality. Moreover, in the estimations of Table 3.4, we interact the mining price index with the government effectiveness indicator, but the coefficients remain statistically insignificant.

In short, findings reported in Table 3.4 suggest that mining prices and interindustry connectivity with the mining sector are, on average, not a determinant of long-term growth, even when the quality of institutions is controlled for.

Table 3.4. Estimation Results – Governance Effectiveness

	(1)	(2)	(3)	(4)	(5)	6)	(7)	(8)
	Growth of GDP per capita							
Long-run effects								
Gross fixed capital investment	0.028	0.017	0.027	0.015	0.077**	0.071*	0.027	0.016
	(0.021)	(0.023)	(0.021)	(0.023)	(0.034)	(0.037)	(0.021)	(0.023)
Government effectiveness	0.018***	0.020***	0.017***	0.019***	0.017***	0.018***	0.017***	0.018***
	(0.006)	(0.006)	(0.006)	(0.006)	(0.005)	(0.006)	(0.005)	(0.006)
Log of population growth	0.008	0.072	0.031	0.096	0.076	0.118	0.013	0.081
	(0.299)	(0.295)	(0.300)	(0.294)	(0.301)	(0.301)	(0.299)	(0.294)
Population ages 0-14 (% of total)	-0.179***	-0.226***	-0.176***	-0.222***	-0.143**	-0.180**	-0.177***	-0.223***
	(0.056)	(0.057)	(0.056)	(0.058)	(0.065)	(0.069)	(0.057)	(0.057)
Mining commodity price index	0.022	0.032	0.021	0.032	0.011	0.018	0.026	0.037
	(0.055)	(0.055)	(0.063)	(0.063)	(0.046)	(0.047)	(0.052)	(0.054)
Exports of goods and services (% of GDP)	0.025**	0.027**	0.026**	0.028**	0.029***	0.032***	0.025**	0.028**
	(0.010)	(0.011)	(0.011)	(0.012)	(0.011)	(0.011)	(0.010)	(0.011)
Log of inflation	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Log of population	-0.003	-0.014	-0.003	-0.014	0.001	-0.003	-0.004	-0.014
	(0.010)	(0.011)	(0.010)	(0.012)	(0.010)	(0.013)	(0.010)	(0.012)
Log of mining backward linkages	0.002	0.001	0.004	0.002			0.002	0.001
	(0.003)	(0.003)	(0.003)	(0.003)			(0.003)	(0.003)
Mining commodity price index * log of mining backward linkages			-0.013	-0.012				
			(0.012)	(0.013)				
Mining commodity price index * Government effectiveness					-0.007	-0.006	0.009	0.013
					(0.028)	(0.028)	(0.036)	(0.034)
Short-run effects								
Log of GDP per capita (constant USD)	-0.061***	-0.067***	-0.061***	-0.067***	-0.055***	-0.058***	-0.061***	-0.067***
	(0.008)	(0.009)	(0.008)	(0.009)	(0.010)	(0.012)	(0.008)	(0.009)
Δ Log of GDP per capita$_{t-1}$	0.258***	0.260***	0.257***	0.258***	0.252***	0.253***	0.259***	0.260***
	(0.050)	(0.050)	(0.048)	(0.048)	(0.042)	(0.042)	(0.050)	(0.050)
Δ Mining commodity price index $_t$	0.322**	0.320**	0.340**	0.339**	0.398***	0.400***	0.324**	0.322**
	(0.135)	(0.136)	(0.146)	(0.147)	(0.128)	(0.129)	(0.136)	(0.136)
Δ Mining commodity price index $_{t-1}$	0.126	0.115	0.153	0.141	0.304**	0.302**	0.128	0.118
	(0.090)	(0.088)	(0.097)	(0.095)	(0.142)	(0.145)	(0.094)	(0.092)
Δ Mining commodity price index $_{t-2}$	0.006	0.001	0.038	0.032	0.107	0.108	0.010	0.006
	(0.088)	(0.089)	(0.091)	(0.091)	(0.105)	(0.107)	(0.090)	(0.089)
Δ Mining commodity price index $_{t-3}$	-0.117	-0.121	-0.101	-0.106	-0.029	-0.028	-0.115	-0.118
	(0.095)	(0.096)	(0.090)	(0.091)	(0.099)	(0.100)	(0.095)	(0.095)
Δ Mining backward linkages(log) $_t$	0.005	0.004	0.005	0.003			0.005	0.004
	(0.008)	(0.008)	(0.008)	(0.008)			(0.008)	(0.008)
Δ Mining backward linkages(log) $_{t-1}$	-0.002	-0.002	-0.005	-0.005			-0.002	-0.002
	(0.004)	(0.004)	(0.004)	(0.004)			(0.004)	(0.004)
Δ Mining backward linkages(log) $_{t-2}$	0.010**	0.010**	0.005	0.005			0.010**	0.010**
	(0.004)	(0.004)	(0.004)	(0.004)			(0.004)	(0.004)
Δ Mining backward linkages(log) $_{t-3}$	0.005	0.005	0.006	0.006			0.005	0.005
	(0.003)	(0.003)	(0.004)	(0.004)			(0.003)	(0.003)
Δ Mining commodity price index * log of mining backward linkages $_t$			0.020	0.023				
			(0.046)	(0.046)				
Δ Mining commodity price index * log of mining backward linkages $_{t-1}$			0.038	0.037				
			(0.055)	(0.056)				
Δ Mining commodity price index * log of mining backward linkages $_{t-2}$			0.045*	0.045				
			(0.027)	(0.027)				
Δ Mining commodity price index * log of mining backward linkages $_{t-3}$			-0.011	-0.012				
			(0.026)	(0.026)				
Constant	0.594***	0.813***	0.585***	0.820***	0.442*	0.546*	0.592***	0.822***
	(0.184)	(0.199)	(0.184)	(0.211)	(0.233)	(0.282)	(0.185)	(0.206)
Observations	4,114	4,114	4,114	4,114	4,221	4,221	4,114	4,114
Number of Countries	148	148	148	148	154	154	148	148
Adjusted R-squared	0.135	0.140	0.136	0.141	0.166	0.168	0.135	0.140
Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time Trend	Yes	No	Yes	No	Yes	No	Yes	No
Regional time trend	No	Yes	No	Yes	No	Yes	No	Yes

*** p<0.01, ** p<0.05, * p<0.1. Robust standard errors in parentheses

3.4.2 Robustness tests

To address issues related to potential endogeneity in our price index, we considered the following:

a) Deaton and Miller (1995) point out that the advantage of using international commodity prices is that countries cannot change their prices. Therefore, to exclude the possibility that results are driven by countries whose market power could influence prices – as also done in Collier and Goderis (2012). To do this, we identified the countries in our sample whose net mineral export values were equal to or bigger than 20% of the total world exports, in at least one year of observation. In total 14 countries were identified[47] and excluded from the sample; we then re-estimated the specifications in Table 3.3 (Columns 1-4). Our results remained practically unchanged (See Table 3.6 in Annex for the details).
b) Deaton and Miller (1995) also indicate that to avoid endogenous supply responses, it is important to keep the weight of each commodity constant over time. We build our mining price index using the average weight based on net exports in 1995, 2000, 2005, and 2010 to capture as many observations in our trade data as possible. The pairwise correlation values between the average weight and yearly weights were relatively high - indicating that weights do not vary substantially over time. However, we test for potential issues stemming from endogenous supply changes by re-estimating the specifications in Table 3.3 (Columns 1-4) with a commodity price index calculated using fixed commodity weights based on production data in 1995. For this, we use Thibault Fally's data on production of commodities[48]. We calculate equation (5) by plugging production values instead of net exports. The resulting coefficients are quite similar to our estimations in Table 3.3 (See Table 3.7 in Annex for details).
c) To ensure that the price index was being deflated on country-specific values, in equation (6) we deflated the index by CPI values instead of the HMUV. After running our estimations reported in Tables 3.3 and 3.4, we find very similar results for both estimations (See Table 3.8 in Annex for details).

47 These countries were Australia (coal, gold and iron), Bolivia(copper), Canada (silver, gold, nickel, and tin), Chile (copper and gold), China (lead), Guinea(iron), Guatemala(silver), Indonesia (copper, gold, iron and lead), Mexico (silver), Peru (silver), Spain(silver), Papua New Guinea(silver), Russia (nickel and tin), and South Africa (platinum and gold). There were no countries whose oil or natural gas exports reached the 20% threshold.

48 See Fally & Sayre (2018) for details regarding sources of these data.

3.4.3 Effects of mining commodity prices on linkages

Figure 3.3 suggests a negative correlation between mining commodity prices and industrial interconnectedness between mining activities and the rest of the economy. A negative relationship between mining linkages growth and prices would imply that overcoming the 'enclave' nature of the mining sector initially discussed by Singer (1950) would be difficult to overcome given the price developments since the early 2000s.

Estimations in Columns 1 and 2 in Table 3.5 test for this relationship and indicate a strong negative relation between changes in mining commodity prices and linkages. The long-run elasticity (significant at the 1% level) indicates that a 10% increment in the price index would reduce mining linkage development by 1.5-1.6%, holding other factors constant. In the short-run, coefficients are also negative and significant (at the 5% level) in the first and third lag differences; according to this a 10% price increment after one year is associated with a contraction in linkage development of 1.8%, and after three years of 2.8%. In line with our previous results, the introduction of a government effectiveness proxy does not change our results as can be seen in Columns 3 and 4 in Table 3.5.

These results are in contrast to the positive perspective put forth by several authors who consider that in light of higher commodity prices, opportunities arise that can promote the emergence of higher local outsourcing and the development of innovative local suppliers (e.g., Morris et al., 2012; Perez, 2010). Our findings suggest the contrary: higher prices reinforce the enclave nature of natural resource industries – even after controlling for institutional quality. Our results, however, are supportive of other empirical studies that show that the commodity price boom led to a reduction of linkages not only in paradigmatic examples of extractive economies, such as Chile (Atienza et al., 2018; Castaño et al., 2019), but in most countries (Chapter 2).

Table 3.5. Estimation Results: Mining Commodity Price Index and Changes in Mining Linkages

VARIABLES	(1)	(2)	(3)	(4)
		Δ Mining Backward Linkages		
Long-run effects				
Gross fixed capital investment	-0.0907 (0.0591)	-0.0916 (0.0622)	-0.0889 (0.0589)	-0.0902 (0.0624)
Log of population growth	0.382 (0.336)	0.421 (0.338)	0.382 (0.338)	0.420 (0.339)
Population ages 0-14 (% of total)	0.0125 (0.121)	0.0419 (0.160)	0.0114 (0.122)	0.0390 (0.159)
Government effectiveness			-0.00120 (0.0129)	-0.000292 (0.0134)
Mining commodity price index	-0.160*** (0.0543)	-0.150*** (0.0534)	-0.159*** (0.0541)	-0.150*** (0.0535)
Exports of goods and services (% of GDP)	-0.0241 (0.0202)	-0.0217 (0.0211)	-0.0245 (0.0202)	-0.0220 (0.0208)
Log inflation	0.00219*** (0.000778)	0.00211*** (0.000787)	0.00223*** (0.000768)	0.00213*** (0.000779)
Log of population	-0.0218 (0.0240)	-0.0209 (0.0298)	-0.0226 (0.0245)	-0.0220 (0.0297)
Log of GDP per capita (constant USD)	0.0247 (0.0196)	0.0203 (0.0227)	0.0250 (0.0190)	0.0207 (0.0220)
Short-run effects				
Δ Log of GDP per capita$_{t-1}$	0.00433 (0.0608)	0.00776 (0.0618)	0.00169 (0.0614)	0.00476 (0.0624)
Δ Mining commodity price index $_{t}$	-0.0233 (0.249)	-0.0196 (0.249)	-0.0224 (0.249)	-0.0188 (0.249)
Δ Mining commodity price index $_{t-1}$	-0.186** (0.0899)	-0.190** (0.0909)	-0.185** (0.0903)	-0.188** (0.0910)
Δ Mining commodity price index $_{t-2}$	-0.133 (0.105)	-0.134 (0.104)	-0.133 (0.106)	-0.133 (0.105)
Δ Mining commodity price index $_{t-3}$	-0.284** (0.111)	-0.283** (0.110)	-0.284** (0.112)	-0.283** (0.111)
Constant	0.204 (0.482)	0.209 (0.519)	0.216 (0.485)	0.224 (0.521)
Observations	4,129	4,129	4,115	4,115
R-squared	0.008	0.008	0.008	0.008
Number of countries	148	148	148	148
Fixed Effects	Yes	Yes	Yes	Yes
Time Trend	Yes	No	Yes	No
Regional time trend	No	Yes	No	Yes

*** p<0.01, ** p<0.05, * p<0.1. Robust standard errors in parentheses

A plausible explanation for the strong negative relation between mining linkages and mining prices could be due to Dutch disease effects. The latter hypothesis predicts that in a country with a booming sector the manufacturing industry will contract as the result of a number of macroeconomic imbalances driven by exports of high-value extractive commodities. Having a weaker manufacturing sector implies a reduced ability to supply equipment, machinery, and other inputs necessary for fostering mining supplier linkages. Thus, it is not unreasonable to assume that Dutch disease effects translate into lower prospects of developing strong industrial linkages with the mining sector.

Yet, as summarized by Castaño et al. (Castaño et al., 2019) other – perhaps complementary – explanations are found in the mining business behavior and output maximization strategies: Higher prices lead to investments in capital investments, higher energy, and direct employment levels to achieve marginal increments of production, despite higher costs and declining productivity (Comisión Chilena de Productividad, 2017). Investments in innovation and productivity enhancement technologies that are intensive in linkages with other sectors are limited to certain tasks. Thus, as prices rise linkages decrease. In times of downturns in prices, in contrast, mining firms survive through the incorporation of innovation and better practices, and, thus, linkages rise (Castaño et al., 2019).

A caveat to consider is that our results do not exclude the possibility of important country differences. For instance, Figure 3.4 shows that during the 2000s in South Asia both linkages and mining prices followed a positive trend. Other countries where linkages have been maintained or even become stronger in the face of higher prices include Norway and the Netherlands (Chapter 2). Thus, we cannot conclude that industrial policies, especially those aimed at linkage development, are not important. As pointed out by Atienza et al. (2018), linkage formation goes beyond horizontal policies, such as infrastructure and R&D, and requires rather specific policies which may not be captured by the good governance indices here utilized. In this regard, the lack of cross-country data indicators that adequately capture the implementation of policies specifically targeted at supplier development constitutes a limitation of the analysis.

3.5 Conclusion

Using a country-specific index for mining commodities based on Deaton and Miller (1995), we find that higher commodity prices allow countries to experience a short-run boost in growth which dissipates over time. We do not find any evidence that higher prices produce a negative effect on growth in the long run. Our results differ from Collier and Goderis (2012) who find a strong negative long-run association between higher extractive commodity prices and long-run performance – as suggested in the seminal work of Sachs and Warner (1995). Yet, our findings do align with other scholarly works which find no evidence of negative long-run effects associated with extractive resource exploitation (Brunnschweiler, 2008; Brunnschweiler & Bulte, 2008; Cavalcanti et al., 2011; Deaton & Miller, 1995; James, 2015; Stijns, 2005).

Furthermore, we find that backward linkages to the mining industry on their own do not play a role in long-term growth. Nonetheless, there is a positive lagged effect on growth associated with increased supplier linkages; this seems supportive of the proposition that a higher level of industrial interconnectedness can provide economy-wide benefits. However, much like higher prices, these effects are short-lived. This may be attributed to the fact that backward linkages vary substantially over the life cycle of a mine or oil project, which involves strong domestic sourcing in the beginning (i.e., during construction and procurement phases) but plateaus thereafter. Therefore, the positive economic spillovers triggered by an initial increment in supplier linkages might be difficult to sustain over time.

An important thing to be mentioned is that linkages to the mining sector, as measured in this study, cannot account for their qualitative nature, i.e., the technological sophistication of the inputs acquired by the mining industry. The effects of mining linkages on growth may have a stronger positive effect – especially in the long run – when these reflect services and inputs of higher technological complexity.

Our results show that in any case, the formation of higher linkages is particularly difficult in booming times: higher linkages to the mining sector are negatively associated with higher commodity prices. These results, thus, do not support the positive view of several authors (e.g., Morris et al., 2012, Perez, 2010) who consider that the mining sector's tendency to act as a productive enclave no longer holds. This difficulty in forming linkages during booming times confirms other empirical works (Aroca, 2001; Castaño et al., 2019), and some of its possible causes are linked to the industrial behavior of extractive sectors as well as to the contracted industrial capacity predicted by the Dutch disease.

Finally, we do not find that institutional quality plays a mediating role in the economic outcomes discussed above (nor in the formation of linkages). These results are consistent with a small vein of empirical studies, such as Brunnschweiler (2008) and Sachs and Warner (Sachs & Warner, 1995), which show that institutions play a negligible role in economic outcomes when it comes to natural resources.

To conclude, from a policy perspective our study supports the view that the resource curse is "neither curse nor a destiny" as put forth by several authors before. Moreover, the goal of developing linkages to the mining sector should not be abandoned altogether as it can have positive effects on growth; yet much like prices, the boost is expected to be short-lived. Policy efforts, therefore, might be better off if these focus on the technological dimension and innovative quality of supplier linkages – in such a way that these spread into less cyclical sectors of the economy which ultimately may have more potential to sustain growth over time.

Bibliography

Alexeev, M., & Conrad, R. (2009). The Elusive Curse of Oil. *Review of Economics and Statistics*, *91*(3), 586–598. https://doi.org/10.1162/rest.91.3.586

Andersen, A. D., Johnson, B. H., Marín, A., Kaplan, D., Stubrin, L., Lundvall, B.-Å., & Kaplinsky, R. (2015). *Natural resources, innovation and development*. https://doi.org/10.5278/VBN/MISC/NRID

Aroca, P. (2001). Impacts and development in local economics based on mining: The case of the Chilean II region. *Resources Policy*, *27*(2), 119–134. https://doi.org/10.1016/S0301-4207(01)00013-7

Atienza, M., Lufin, M., & Soto, J. (2018). Mining linkages in the Chilean copper supply network and regional economic development. *Resources Policy*. https://doi.org/10.1016/J.RESOURPOL.2018.02.013

Auty, R. (2006). Mining Enclave to Economic Catalyst: Large Mineral Projects in Developing Countries. *The Brown Journal of World Affairs*, *13*(1), 135–145.

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. https://doi.org/10.1016/J.RESOURPOL.2016.10.015

Bravo-Ortega, C., & Gregorio, J. de. (2007). The Relative Richness of the Poor? Natural Resources, Human Capital, and Economic Growth Cl. In W. F. Maloney & D. Lederman (Eds.), *Natural Resources Neither Curse nor Destiny* (pp. 71–99). The World Bank, Stanford University Press. https://doi.org/10.1596/978-0-8213-6545-8

Brunnschweiler, C. N. (2008). Cursing the Blessings? Natural Resource Abundance, Institutions, and Economic Growth. *World Development*, *36*(3), 399–419. https://doi.org/10.1016/J.WORLDDEV.2007.03.004

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. https://doi.org/10.1016/J.JEEM.2007.08.004

Castaño, A., Lufin, M., & Atienza, M. (2019). A structural path analysis of Chilean mining linkages between 1995 and 2011. What are the channels through which extractive activity affects the economy? *Resources Policy*. https://doi.org/10.1016/j.resourpol.2018.12.007

Cavalcanti, T., Mohaddes, K., & Raissi, M. (2011). Growth, development and natural resources: New evidence using a heterogeneous panel analysis. *Quarterly Review of Economics and Finance*, *51*(4), 305–318. https://doi.org/10.1016/j.qref.2011.07.007

Collier, P., & Goderis, B. (2012). Commodity prices and growth: An empirical investigation. *European Economic Review*, *56*(6), 1241–1260. https://doi.org/10.1016/J.EUROECOREV.2012.04.002

Corden, W. M., & Neary, J. P. (1982). Booming Sector and De-Industrialisation in a Small Open Economy. *The Economic Journal*, *92*(368), 825. https://doi.org/10.2307/2232670

Cuddington, J. T., Ludema, R., & Jayasuriya, S. A. (2007). Prebisch-Singer Redux. In D. Lederman & W. F. Maloney (Eds.), *Natural Resources Neither Curse nor Destiny* (pp. 103–141). The World Bank, Stanford University Press. https://doi.org/10.1596/978-0-8213-6545-8

Deaton, A., & Miller, R. (1995). INTERNATIONAL COMMODITY PRICES, MACROECONOMIC PERFORMANCE, AND POLITICS IN SUB-SAHARAN AFRICA. In *PRINCETON STUDIES IN INTERNATIONAL FINANCE* (Issue 79).

Dehn, J. (2000). *The Effects on Growth of Commodity Price Uncertainty and Shocks*. www.worldbank.org/research/workingpapers.

Fally, T., & Sayre, J. (2018). *Data on Commodity Trade - Thibault Fally*. https://are.berkeley.edu/~fally/data.html

Farooki, M., & Kaplinsky, R. (2014). Promoting diversification in resource-rich economies. *Mineral Economics*, *27*(2–3), 103–113. https://doi.org/10.1007/s13563-014-0050-z

Fernandez, V. (2012). Trends in real commodity prices: How real is real? *Resources Policy*, *37*(1), 30–47. https://doi.org/10.1016/j.resourpol.2011.12.007

Gerelmaa, L., & Kotani, K. (2016). Further investigation of natural resources and economic growth: Do natural resources depress economic growth? *Resources Policy*, *50*, 312–321. https://doi.org/10.1016/j.resourpol.2016.10.004

Harvey, D. I., Kellard, N. M., Madsen, J. B., & Wohar, M. E. (2010). The prebisch-singer hypothesis: Four centuries of evidence. *Review of Economics and Statistics*, *92*(2), 367–377. https://doi.org/10.1162/rest.2010.12184

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

Innis, H. (1930). *The fur trade in Canada : An introduction to Canadian economic history* . Yale University Press . https://doi.org/10.14288/1.0374758

James, A. (2015). The resource curse: A statistical mirage? *Journal of Development Economics*, *114*, 55–63. https://doi.org/10.1016/j.jdeveco.2014.10.006

Kaplinsky, R. (2011). *Commodities for Industrial Development: Making Linkages Work* (01/2011).

Kellard, N., & Wohar, M. E. (2006). On the prevalence of trends in primary commodity prices. *Journal of Development Economics*, *79*(1), 146–167. https://doi.org/10.1016/J.JDEVECO.2004.12.004

Lederman, D., & Maloney, W. F. (Eds.). (2007a). *Natural Resources Neither Curse nor Destiny*. Stanford University Press and The World Bank. http://siteresources.worldbank.org/INTTRADERESEARCH/Resources/D.Lederman_W.Maloney_Natural_Resources_book.pdf

Lederman, D., & Maloney, W. F. (2007b). Trade Structure and Growth. In D. Lederman & W. F. Manoley (Eds.), *Natural Resources Neither Curse nor Destiny* (pp. 15–40). The World Bank, Stanford University Press.

Manzano, O., & Rigobon, R. (2007). Resource Curse or Debt Overhang? In D. Lederman & W. F. Maloney (Eds.), *Natural Resources Neither Curse nor Destiny* (pp. 41–70). The World Bank, Stanford University Press. https://doi.org/10.1596/978-0-8213-6545-8

Mavrotas, G., Murshed, S. M., & Torres, S. (2011). Natural Resource Dependence and Economic Performance in the 1970-2000 Period. *Review of Development Economics*, *15*(1), 124–138. https://doi.org/10.1111/j.1467-9361.2010.00597.x

Mehlum, H., Moene, K., & Torvik, R. (2006). Institutions and the Resource Curse. *The Economic Journal*, *116*(508), 1–20. https://doi.org/10.1111/j.1468-0297.2006.01045.x

Miller, R. E., & Blair, P. D. (2009). Input-output analysis: Foundations and extensions, second edition. In *Input-Output Analysis: Foundations and Extensions, Second Edition*.

Morris, M., Kaplinsky, R., & Kaplan, D. (2012). "One thing leads to another"—Commodities, linkages and industrial development. *Resources Policy*, *37*(4), 408–416. https://doi.org/10.1016/J.RESOURPOL.2012.06.008

Nchor, D., & Konderla, T. (2016). Economic multipliers and sectoral linkages: Ghana and the new oil sector. *Acta Universitatis Agriculturae et Silviculturae Mendelianae Brunensis*, *64*(2), 635–642. https://doi.org/10.11118/actaun201664020635

Perez, C. (2010). A Vision for Latin America : A resource-based strategy for technological dynamism and social inclusion. *Globelics. The Global Network for Economics of Learning, Innovation, and Competence Building System*, 1–32.

Prebisch, R. (1950). *The economic development of Latin America and its principal problems*. United Nations. E/CN.12/89/REV.1

Sachs, J., & Warner, A. (1995). Natural Resource Abundance and Economic Growth. In *National Bureau of Economic Research* (No. 5398; Vol. 3). https://doi.org/10.3386/w5398

Sachs, J., & Warner, A. (2001). The curse of natural resources. *European Economic Review*, *45*(4–6), 827–838. https://doi.org/10.1016/S0014-2921(01)00125-8

Sadik-Zada, E. R., Loewenstein, W., & Hasanli, Y. (2021). Production linkages and dynamic fiscal employment effects of the extractive industries: input-output and nonlinear ARDL analyses of Azerbaijani economy. *Mineral Economics*, *34*(1), 3–18. https://doi.org/10.1007/s13563-019-00202-6

Sarmidi, T., Hook Law, S., & Jafari, Y. (2014). Resource Curse: New Evidence on the Role of Institutions. *International Economic Journal*, *28*(1), 191–206. https://doi.org/10.1080/10168737.2013.787110

Sen, R. (2020). Enhancing Local Content in Uganda. In J. Page & F. Tarp (Eds.), *Mining for Change* (pp. 1–24). Oxford University Press. https://doi.org/10.1093/oso/9780198851172.003.0001

Singer, H. W. (1950). The Distribution of Gains Between Investing and Borrowing Countries. *American Economic Review, Papers and Proceedings*, *44*, 473–485.

Stijns, J.-P. C. (2005). Natural resource abundance and economic growth revisited. *Resources Policy*, *30*(2), 107–130. https://doi.org/10.1016/J.RESOURPOL.2005.05.001

Svedberg, P., & Tilton, J. E. (2006). The real, real price of nonrenewable resources: Copper 1870-2000. *World Development*, *34*(3), 501–519. https://doi.org/10.1016/j.worlddev.2005.07.018

Tilton, J. E. (2014). Cyclical and secular determinants of productivity in the copper, aluminum, iron ore, and coal industries. *Mineral Economics*, *27*(1). https://doi.org/10.1007/s13563-014-0045-9

Torvik, R. (2009). Why do some resource-abundant countries succeed while others do not? *Oxford Review of Economic Policy*, *25*(2), 241–256. https://doi.org/10.1093/oxrep/grp015

Watkins, M. H. (1963). A Staple Theory of Economic Growth. In *Science politique* (Vol. 29, Issue 2).

Wright, G., & Czelusta, J. (2004). The Myth of the Resource Curse. *Challenge*, *47*(2), 6–38. https://web.stanford.edu/~write/papers/Wright Res Curse.pdf

Annex

Annex 1: Notes on data and its sources

- Thibault Fally's Database (Fally & Sayre, 2018)
    - Commodity trade
    - Commodity production

- EORA26. Backward linkages were calculated using the EORA26 input-output tables which cover 26 harmonized sectors. Backward linkages to the mining sector used in our regressions are the column sum which corresponds to the mining sector of the domestic Leontief matrices. Since we only consider the additional demand generated in other domestic sectors as demand in the mining sector increases, we do not include the cell which corresponds to the mining sector in the column sum.

- World Development Indicators:
    - GDP per capita (constant 2005 USD)
    - Investment - Gross capital formation (% of GDP)
    - Population growth
    - Population, total (in logs)
    - Population, ages 0-14 (% of total)
    - Trade openness Trade (% of GDP)
    - Inflation, consumer prices (annual %) - calculated as 1 + (CPIt- CPI t-1)/CPI t-1 (in logs)
    - Government effectiveness – World Governance Indicators
    - Fertility rate, total (births per woman) (extra control – not reported)
    - Barro-Lee: Average years of secondary schooling, age 15+, interpolated linearly – (extra control – not reported)

- 1946–2008 UCDP/PRIO Armed Conflict Dataset (Gleditsch et al., 2002)
    - Civil wars in a year
    - Interstate wars in a year

- Centre for Research on the Epidemiology of Disasters (CRED): Number of large natural disasters in a given year.

- Thyne-Powell's database (Powell & Thyne, 2011): Number of coup d'état in country in a year

Annex 2: Additional regressions

Table 3.6. Estimations in Table 3.3 Columns 1-5 without major mineral exporters

VARIABLES	(1)	(2)	(3)	(4)
	Growth per capita			
Gross fixed capital investment	0.0854*** (0.0321)	0.0265 (0.0212)	0.0352 (0.0221)	0.0248 (0.0213)
Log of population growth	0.0527 (0.330)	-0.00384 (0.321)	0.00390 (0.332)	0.0179 (0.322)
Population ages 0-14 (% of total)	-0.134** (0.0637)	-0.126** (0.0587)	-0.168*** (0.0541)	-0.122** (0.0597)
Mining commodity price index	-0.00699 (0.0484)	0.0102 (0.0528)	-0.00183 (0.0624)	0.00855 (0.0604)
Exports of goods and services (% of GDP)	0.0408*** (0.0125)	0.0345*** (0.0113)	0.0371*** (0.0118)	0.0352*** (0.0113)
Log of inflation	0.00120 (0.00112)	0.00119 (0.000939)	0.00109 (0.00112)	0.00117 (0.000932)
Log of population	0.000678 (0.00997)	-0.00290 (0.00950)	-0.00208 (0.00982)	-0.00232 (0.00950)
Log of GDP per capita (constant USD)	-0.0501*** (0.0100)	-0.0513*** (0.00708)	-0.0552*** (0.00785)	-0.0514*** (0.00709)
Mining backward linkages		0.00480 (0.00379)	0.00620 (0.00376)	0.00690* (0.00403)
Mining commodity price index * log of backward linkages			-0.0205 (0.0127)	-0.0136 (0.0148)
ΔLog of GDP per capita $_{t-1}$	0.249*** (0.0471)	0.230*** (0.0541)	0.248*** (0.0536)	0.228*** (0.0527)
ΔMining commodity price index $_t$	0.340*** (0.112)	0.275** (0.118)	0.318** (0.134)	0.298** (0.127)
ΔMining commodity price index $_{t-1}$	0.239* (0.137)	0.0508 (0.0880)	0.0986 (0.0962)	0.0798 (0.0995)
ΔMining commodity price index $_{t-2}$	0.106 (0.0944)	-0.00251 (0.0836)	0.0567 (0.0921)	0.0309 (0.0868)
ΔMining commodity price index $_{t-3}$	-0.0351 (0.0917)	-0.116 (0.0827)	-0.0968 (0.0822)	-0.0998 (0.0786)
ΔMining backward linkages(log) $_t$		0.00724 (0.00985)	0.00647 (0.0106)	0.00622 (0.0104)
ΔMining backward linkages(log) $_{t-1}$		-0.00126 (0.00416)	-0.00476 (0.00367)	-0.00429 (0.00364)
ΔMining backward linkages(log) $_{t-2}$		0.0108** (0.00439)	0.00489 (0.00408)	0.00495 (0.00406)
ΔMining backward linkages(log) $_{t-3}$		0.00550* (0.00307)	0.00634 (0.00393)	0.00627 (0.00381)
ΔMining commodity price index * log of mining backward linkages $_t$			0.0151 (0.0462)	0.0205 (0.0466)
ΔMining commodity price index * log of mining backward linkages $_{t-1}$			0.0406 (0.0559)	0.0367 (0.0535)
ΔMining commodity price index * log of mining backward linkages $_{t-2}$			0.0449* (0.0254)	0.0425* (0.0228)
ΔMining commodity price index * log of mining backward linkages $_{t-3}$			-0.0108 (0.0235)	-0.00982 (0.0216)
Major disasters $_t$		-0.00970*** (0.00257)		-0.00982*** (0.00256)
Coup d'état $_t$		-0.0206*** (0.00690)		-0.0205*** (0.00689)
Civil wars $_t$		-0.0258*** (0.00961)		-0.0256*** (0.00948)
Interstate wars $_t$		-0.0837** (0.0408)		-0.0823** (0.0401)
Constant	0.413* (0.224)	0.496*** (0.180)	0.524*** (0.188)	0.486*** (0.179)
Observations	3,825	3,774	3,774	3,774
R-squared	0.174	0.165	0.139	0.167
Number of Countries	138	135	135	135
Fixed Effects	Yes	Yes	Yes	Yes
Time Trend	Yes	Yes	Yes	Yes
Regional time trend	No	No	No	No

*** p<0.01, ** p<0.05, * p<0.1. Robust standard errors in parentheses

Table 3.7. Estimations in Table 3.3 Columns 1-4 using production data to calculate weights in equation (5)

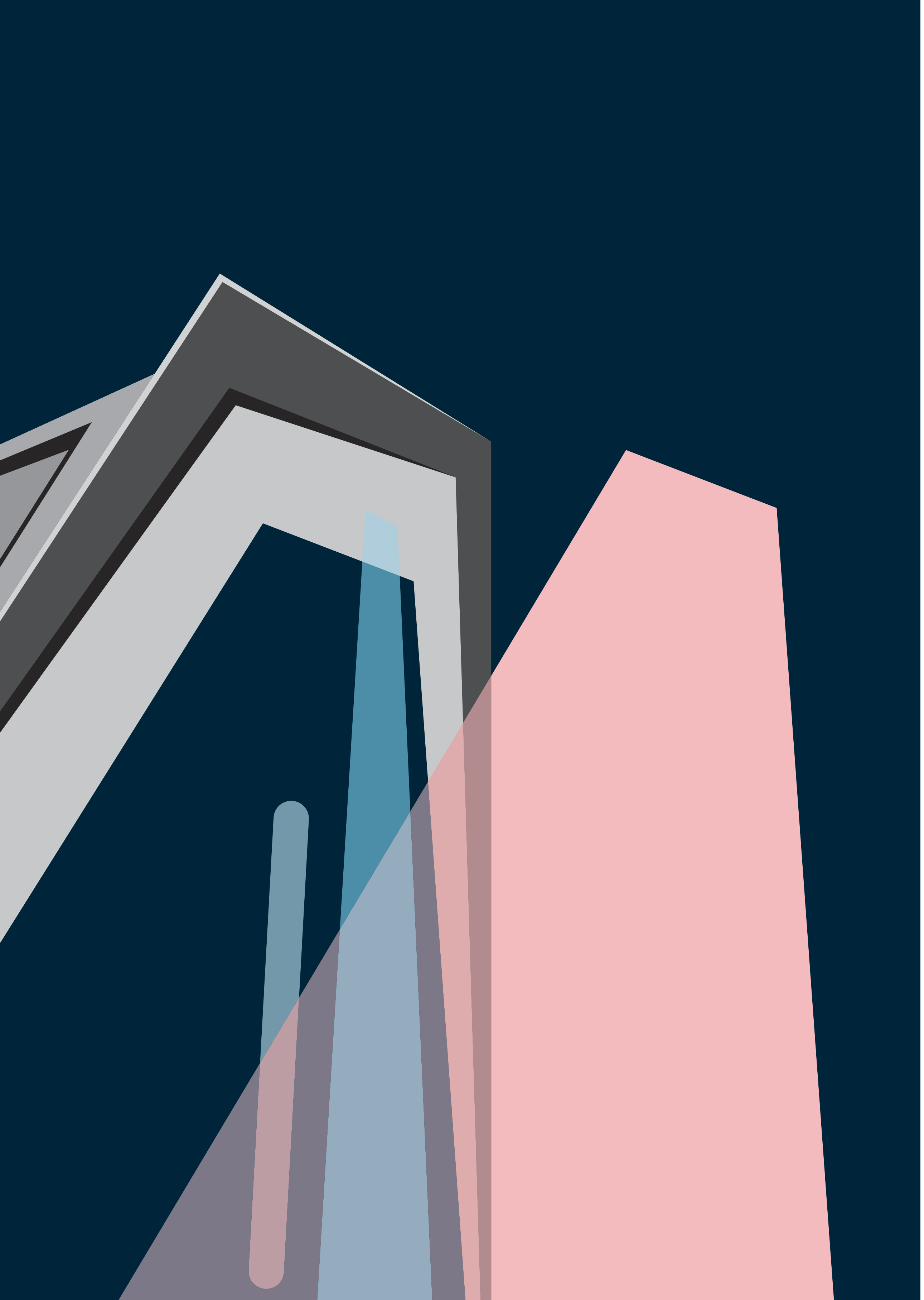
VARIABLES	(1)	(2)	(3)	(4)
	Growth per capita			
Gross fixed capital investment	0.0795**	0.0184	0.0288	0.0178
	(0.0332)	(0.0200)	(0.0208)	(0.0200)
Log of population growth	0.109	0.0604	0.0629	0.0803
	(0.311)	(0.300)	(0.310)	(0.301)
Population ages 0-14 (% of total)	-0.142**	-0.139**	-0.176***	-0.136**
	(0.0655)	(0.0626)	(0.0562)	(0.0633)
Mining commodity price index	0.0121	0.0217	0.0161	0.0247
	(0.0505)	(0.0553)	(0.0659)	(0.0643)
Exports of goods and services (% of GDP)	0.0284***	0.0232**	0.0249**	0.0235**
	(0.0104)	(0.00952)	(0.0103)	(0.00960)
Log of inflation	0.000925	0.000993	0.000854	0.000961
	(0.00120)	(0.00106)	(0.00126)	(0.00105)
Log of population	-0.00125	-0.00683	-0.00594	-0.00645
	(0.0104)	(0.00932)	(0.00965)	(0.00926)
Log of GDP per capita (constant USD)	-0.0542***	-0.0569***	-0.0608***	-0.0570***
	(0.0105)	(0.00672)	(0.00764)	(0.00681)
Mining backward linkages		0.00240	0.00293	0.00358
		(0.00329)	(0.00299)	(0.00324)
Mining commodity price index * log of backward linkages			-0.0177	-0.00914
			(0.0126)	(0.0162)
ΔLog of GDP per capita$_{t-1}$	0.246***	0.235***	0.250***	0.233***
	(0.0445)	(0.0525)	(0.0513)	(0.0510)
ΔMining commodity price index $_t$	0.389***	0.287**	0.334**	0.305**
	(0.128)	(0.129)	(0.148)	(0.138)
ΔMining commodity price index $_{t-1}$	0.322**	0.127	0.177*	0.148
	(0.140)	(0.0909)	(0.0985)	(0.106)
ΔMining commodity price index $_{t-2}$	0.107	-0.0168	0.0437	0.0119
	(0.107)	(0.0878)	(0.0934)	(0.0885)
ΔMining commodity price index $_{t-3}$	-0.0315	-0.121	-0.0958	-0.105
	(0.103)	(0.0924)	(0.0921)	(0.0884)
ΔMining backward linkages(log) $_t$		0.00609	0.00487	0.00483
		(0.00820)	(0.00871)	(0.00851)
ΔMining backward linkages(log) $_{t-1}$		-0.00228	-0.00469	-0.00429
		(0.00374)	(0.00359)	(0.00352)
ΔMining backward linkages(log) $_{t-2}$		0.00881**	0.00345	0.00325
		(0.00376)	(0.00389)	(0.00381)
ΔMining backward linkages(log) $_{t-3}$		0.00518*	0.00521	0.00522
		(0.00306)	(0.00424)	(0.00411)
ΔMining commodity price index * log of mining backward linkages$_t$			0.0225	0.0274
			(0.0464)	(0.0472)
ΔMining commodity price index * log of mining backward linkages$_{t-1}$			0.0352	0.0312
			(0.0570)	(0.0544)
ΔMining commodity price index * log of mining backward linkages$_{t-2}$			0.0495*	0.0463*
			(0.0273)	(0.0241)
ΔMining commodity price index * log of mining backward linkages$_{t-3}$			-0.00621	-0.00488
			(0.0264)	(0.0243)
Major disasters $_t$		-0.0105***		-0.0106***
		(0.00299)		(0.00299)
Coup d'état $_t$		-0.0206***		-0.0205***
		(0.00710)		(0.00707)
Civil wars $_t$		-0.0280**		-0.0276**
		(0.0109)		(0.0108)
Interstate wars $_t$		-0.0902**		-0.0895**
		(0.0441)		(0.0436)
Constant	0.474**	0.599***	0.624***	0.592***
	(0.234)	(0.174)	(0.184)	(0.173)
Observations	3,813	3,691	3,691	3,691
R-squared	0.166	0.160	0.134	0.161
Number of Countries	140	134	134	134
Fixed Effects	Yes	Yes	Yes	Yes
Time Trend	Yes	Yes	Yes	Yes
Regional time trend	No	No	No	No

*** p<0.01, ** p<0.05, * p<0.1. Robust standard errors in parentheses

Table 3.8. Estimations in Table 3.3 (Columns 1-3) and estimations in Table 3.4 (Columns 1-3) using with a CPI-deflated commodity price index

VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)
	Growth per capita					
Gross fixed capital investment	-0.007	-0.004	-0.020	-0.004	-0.002	-0.002
	(0.026)	(0.027)	(0.028)	(0.027)	(0.028)	(0.028)
Log of population growth	0.241	0.235	0.286	0.230	0.220	0.220
	(0.519)	(0.518)	(0.502)	(0.507)	(0.505)	(0.505)
Population ages 0-14 (% of total)	-0.270***	-0.271***	-0.219***	-0.268***	-0.270***	-0.270***
	(0.066)	(0.064)	(0.073)	(0.067)	(0.066)	(0.066)
Mining commodity price index	0.006	0.005	-0.001	0.002	0.000	0.000
	(0.025)	(0.025)	(0.025)	(0.025)	(0.024)	(0.024)
Exports of goods and services (% of GDP)	0.021*	0.021*	0.021*	0.020*	0.021*	0.021*
	(0.011)	(0.012)	(0.011)	(0.012)	(0.012)	(0.012)
Log of inflation	0.000	0.000	0.000	0.000	0.000	0.000
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Log of GDP per capita (constant USD)	-0.060***	-0.060***	-0.055***	-0.062***	-0.063***	-0.063***
	(0.009)	(0.009)	(0.008)	(0.010)	(0.010)	(0.010)
Log of population	-0.004	-0.005	-0.006	-0.005	-0.005	-0.005
	(0.014)	(0.015)	(0.014)	(0.014)	(0.014)	(0.014)
Mining backward linkages		0.005	0.010**		0.005	0.005
		(0.003)	(0.004)		(0.003)	(0.003)
Mining commodity price index * backward linkages (log)			-0.021			
			(0.020)			
ΔLog of GDP per capita$_{t-1}$	0.248***	0.246***	0.228***	0.249***	0.246***	0.246***
	(0.062)	(0.063)	(0.065)	(0.063)	(0.063)	(0.063)
ΔMining commodity price index $_{t}$	0.045*	0.044*	0.035	0.044*	0.042*	0.042*
	(0.024)	(0.024)	(0.024)	(0.023)	(0.023)	(0.023)
ΔMining commodity price index $_{t-1}$	0.015	0.010	0.012	0.017	0.012	0.012
	(0.023)	(0.024)	(0.028)	(0.023)	(0.024)	(0.024)
ΔMining commodity price index $_{t-2}$	0.022	0.019	0.011	0.024	0.021	0.021
	(0.016)	(0.017)	(0.026)	(0.017)	(0.018)	(0.018)
ΔMining commodity price index $_{t-3}$	-0.031	-0.032	-0.039	-0.030	-0.030	-0.030
	(0.035)	(0.036)	(0.045)	(0.035)	(0.036)	(0.036)
ΔMining backward linkages(log) $_{t}$		0.007	0.010		0.007	0.007
		(0.008)	(0.008)		(0.008)	(0.008)
ΔMining backward linkages(log) $_{t-1}$		-0.001	-0.002		-0.001	-0.001
		(0.004)	(0.004)		(0.004)	(0.004)
ΔMining backward linkages(log) $_{t-2}$		0.014***	0.013***		0.014***	0.014***
		(0.004)	(0.004)		(0.004)	(0.004)
ΔMining backward linkages(log) $_{t-3}$		-0.005	-0.004		-0.005	-0.005
		(0.006)	(0.006)		(0.006)	(0.006)
Major disasters $_{t}$			-0.011***			
			(0.003)			
Coup d'état $_{t}$			-0.024**			
			(0.010)			
Civil wars $_{t}$			-0.012			
			(0.009)			
Interstate wars $_{t}$			-0.083**			
			(0.039)			
ΔMining commodity price index * log of mining backward linkages$_{t}$			-0.012			
			(0.008)			
ΔMining commodity price index * log of mining backward linkages$_{t-1}$			0.015			
			(0.014)			
ΔMining commodity price index * log of mining backward linkages$_{t-2}$			-0.002			
			(0.010)			
ΔMining commodity price index * log of mining backward linkages$_{t-3}$			-0.007			
			(0.012)			
Governance effectiveness				0.010	0.011*	0.011*
				(0.006)	(0.006)	(0.006)
Constant	0.644**	0.664**	0.635**	0.664**	0.682**	0.682**
	(0.269)	(0.270)	(0.267)	(0.265)	(0.265)	(0.265)
Observations	3,060	3,029	3,029	3,045	3,029	3,029
Number of Countries	118	117	117	118	117	117
Adjusted R-squared	0.115	0.118	0.146	0.117	0.120	0.120
Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Time Trend	Yes	Yes	Yes	Yes	Yes	Yes
Regional time trend	No	No	No	No	No	No

*** p<0.01, ** p<0.05, * p<0.1. Robust standard errors in parentheses



CHAPTER 4

Alternative Related Variety, Macroeconomic Factors and Diversification: Extractive vs. Non-Extractive Products

Abstract

Export diversification is central to economic development; despite this, most countries rich in extractive resources have failed to diversify. In understanding the determinants of diversification different strands of literature emerge. One view highlights the role of macroeconomic and trade-related factors linked to the Dutch disease, such as the real exchange rate, type of commodity, and international commodity prices (Agosin et al., 2012; Lederman & Maloney, 2007). Another view focuses on the role of path dependence to explain diversification focusing typically on product relatedness measures: *'Countries' current productive capabilities of today will determine what they can produce tomorrow'*. The latter offers different advantages, such as looking at diversification outcomes at the product level instead of export concentration measures – which may be subject to several biases. However, such a framework pays little attention to the determinants that shape a country's productive capabilities that in turn allow for product relatedness. In this paper, we use an alternative measure to product relatedness, as proposed in Nomaler and Verspagen (2022), which adjusts to reflect a broader set of unobservable characteristics. Our regression framework also integrates macroeconomic factors and other relevant controls (i.e., international prices, exchange rate, energy and mineral dependency, GDP per capita) to explain diversification at the product level. We do this in a cross-country setting covering more than 5000 products between 1995 and 2019; furthermore, we distinguish between different types of products to understand how variables affect diversification in non-extractive sectors vis-à-vis extractive sectors. Results show that our measure for product relatedness is a strong predictor of diversification – especially for extractives, which seem to be more path-dependent than non-extractive products. However macroeconomic factors, such as international prices, level of development and commodity dependence, play a decisive role in explaining differences diversification patterns and excluding them may overestimate the predictive power of product relatedness.

4.1 Introduction

Diversification is central to economic development as it hinges upon a country's ability to produce a diverse range of technologically dynamic and sophisticated goods and services (Hausmann et al., 2005). Moreover, export diversification has been routinely promoted in countries rich in extractive resources as it is key in reducing the risks linked to commodity price fluctuations, among other prominent arguments. For instance, van der Ploeg & Poelhekke (2009) find that the positive direct effects of commodities on growth are trumped by the indirect negative effects of volatility associated with commodity prices).

Despite this, most countries rich in extractive resources have failed to diversify. For instance, from 1980 to 2010, it was observed that most oil and mineral producing economies experienced heightened export concentration (Ross, 2019). After prices fell in the mid-2010s, the economic hardships experienced by many extractive commodity exporters reignited the discussion about the relationship between extractive industries and diversification in order to understand better the conditions that promote it.

In understanding the determinants of diversification, or at least the inhibiting factors, different strands of literature emerge. On the one hand, one view highlights the role of macroeconomic and trade-related factors linked to the Dutch disease – which predicts that a surge in commodity exports drives up the real exchange rate hindering the development of manufacturing industries. Empirical studies in this vein have studied the relationship between export diversification and the real exchange rate with mixed results (Sekkat, 2016; Tran et al., 2017). Along the same lines, other scholars have looked into differences across commodities (Ahmadov, 2014; Lederman & Maloney, 2007) showing that export concentration is more strongly associated with oil producers and less so in mineral and other primary commodity exporters.

On the other hand, the evolutionary economic geography literature emphasizes that a country can more easily diversify into new products related to its existing products because such new products share resources, knowledge, and capacities similar to those that it already possesses (Boschma & Capone, 2015). In this view, thus, the production structure of a country is affected by its historical productive structure which follows a path-dependent process that, in turn, is underpinned by the relatedness among its products (Hidalgo et al., 2007).

Nonetheless, traditionally the related diversification approach has been critiqued due to the limited attention it has given to other factors which affect relatedness among industries, such as institutions, infrastructure, and the combination of factors of production (Boschma & Capone, 2015; Guo & He, 2017).

Additionally, there are other macroeconomic factors which could play a major role in the development of a country's capacity to diversify, such as the real exchange rate appreciation and global commodity prices. As initially explained by Krugman (1987), a country's capacity to produce a good is not exogenously given but instead evolves through a learning-by-doing process in key sectors, such as manufacturing. Therefore, when there is a real currency appreciation (as a result of higher exports of a booming commodity), this results in long-term, learning-by-doing losses as labor and production factors concentrate in the booming sector and away from manufacturing. Moreover, higher commodity prices on their own may play a role in incentivizing the production of extractive commodities at the expense of diversifying into other sectors. For instance, the increment in extractive commodity prices in the 2000s coincided with a notorious rise in the number of mineral commodities export-dependent countries (UNCTAD, 2019). In short, there are theoretical and empirical foundations that suggest that the resources and overlapping capabilities that affect industrial relatedness are shaped by commodity price shocks and real exchanges movements.

In this paper, thus, we investigate diversification determinants using an alternative measure for product relatedness based on Nomaler and Verspagen (2022), which we will refer to generically as 'related variety' while integrating commodity prices and macroeconomic factors in the analysis. Related variety, like other relatedness measures at the product level, relies on the conditional probability measures which captures whether a country has a comparative advantage in a tradeable good given that it has it in another one. However, this measure also accounts for information concerning the products in which a given country does not have comparative advantage to capture a broader set of unobserved factors (e.g., weak capabilities, institutional and geographical constraints, etc.) that also affect diversification (Nomaler & Verspagen, 2022).

Namely, we investigate the following questions:

- How does related variety explain the creation of comparative advantage in non-extractive products vis-a-vis extractive commodities ?
- How do macro-economic variables, i.e., the real exchange rate, mining price index, and commodity dependence, affect the probability of diversification in non-extractive products?

A basic approach to approximate the effect of related variety on diversification is the increment in the range of products that a country exports with comparative advantage. We expand this analysis by including exchange rates, commodity prices, commodity dependence, and other standard macro-economic factors that may impact diversification outcomes. The analysis thus sheds light on the mediating effect of the macroeconomic variables on the diversification processes for non-extractive products beyond path dependence as traditionally captured by relatedness measures.

The paper is structured as follows. Section 4.2 presents a brief overview of the theoretical and empirical literature on export diversification – especially with a focus on its link to natural resources. Section 4.3 presents the methodology and description of the data. Section 4.4 reports the results of the empirical analysis. Section 4.5 concludes and discusses possibilities for future research.

4.2 Theoretical and Empirical Background

There is an empirical literature that establishes that what countries export and how diversified those exports have important implications for a country's economic development (Hausmann et al., 2005; McMillan et al., 2014). Furthermore, in the case of resource-rich countries specializing in minerals and/or energy, export diversification is considered a key strategy to avoid price volatility, expand employment outside the resource sector, and prepare for resource depletion (Ross, 2019). Likewise, rising global efforts to reduce greenhouse gas emissions by consuming fewer fossil fuels make diversification among oil and gas exporters even more pressing.

Concerning the general economic benefits of diversification, several papers have identified a positive empirical association between export diversification and economic growth; this includes the work of Al-Marhub (2000), Klinger and Lederman (2006), and Hesse (2008). The latter two studies find that the relationship between export diversification and per capita income growth follows an inverted-U function, implying that countries get higher returns from diversifying their exports at lower levels of economic development than at very high ones.

To explain the positive relationship between diversification and growth several scholars have provided theoretical underpinnings – typically linking diversification to innovative activity. Acemoglu and Zilibotti (1997) explain that diversification is an endogenous process that is the result of producers' investment in a wide range of 'risky' sectors. Hausmann and Rodrik (2003) expand on that idea: diversification is not merely the result of comparative advantage but countries' diversification of their investments into new activities. Namely, the entrepreneurial cost-discovery process that entrepreneurs face results in significant cost uncertainties when attempting to move into new goods. If they succeed in developing new goods, the gains will be 'socialized' due to knowledge spillovers but the losses from failure end up being private. This often leads to an under-provision of investments into new activities and a suboptimal level of innovation.

Nonetheless, from an economic evolutionary perspective, innovation – more often than not – is a matter of recombining old ideas into a new base (and very rarely, the creation of a completely new reality). Besides, innovation requires at least some level of knowledge that is tacit and context-specific, and therefore, hard to transfer across countries (Maskell & Malmberg, 1999). Thus, the productive structure and technological transformation of a country will tend to be highly path-dependent: what a country currently produces to a large extent dictates what it will be able to produce in the future (Dosi et al., 1990; Winter & Nelson, 1982).

Evolutionary economic geography literature builds upon the latter idea to explain diversification patterns: a country will produce (and export) new products largely similar to those it already produces. This is because producing such new products requires productive capabilities, i.e., resources, knowledge, and capacities similar to those that the country already possesses (Hidalgo et al., 2007). In this view, if we consider two products, the possibility of becoming specialized in one (given specialization in the other) depends on whether they require the same capabilities – in other words, it depends on whether those two products relate (or not) in terms of productive capabilities . Studies in this strand, have established that product relatedness[49] is a determinant of diversification – either at national or regional levels (Boschma et al., 2012; Hausmann & Klinger, 2007; Neffke et al., 2011). They show, in other words, that diversification patterns are highly path dependent. Nonetheless, as pointed out in Boschma and Capone (2015) these studies do not explain differences in the diversification patterns across countries. Indeed, product relatedness measures employed in such studies (i.e., Hausmann & Klinger, 2007) rely on export co-occurrence to proxy for similar productive capabilities; but they do not explain *why* those goods are exported in some countries and not in others (Content & Frenken, 2016).

To learn more about the determinants of the direction and intensity of the diversification processes, more recent empirical frameworks have then incorporated the role of institutions and governance (e.g. Boschma & Capone, 2015; He & Zhu, 2018), as well as global linkages, captured by imports, FDI, and/or trade liberalization (Alonso & Martín, 2019; He et al., 2018) to shed further light into explaining differences. Most of these studies, however, have focused on within-country determinants.

All in all, a knowledge gap remains concerning the factors that play a role in the emergence and development of productive capabilities and more specifically those that enable entrepreneurs to engage in innovation activities which ultimately leads to diversification. According to Lall (1992), a country's technological capabilities are determined by the interplay of general capabilities (e.g., human capital); institutions, and incentives stemming from competition, factor markets, and naturally, macroeconomic factors, such as price changes, exchange rates, credit and foreign exchange availability, political stability or exogenous shocks (e.g., terms of trade). The following paragraphs focus on discussing some of the macroeconomic (and other country) characteristics that have been empirically tested in previous studies.

49 This namely refers to the product relatedness measures developed in Hausmann and Klinger (2007) and Hidalgo et al. (2007) which have been widely employed in that type of empirical analysis. Yet there are other measures capturing how related productive capabilities of different products are; for instance, Franken et al. (2007) who look at the hierarchical classification of products by the SIC scheme.

As pointed out by several scholars (Agosin et al., 2012; Alsharif et al., 2017; Ross, 2019; Wiig & Kolstad, 2012), even though diversification has been prescribed as essential in boosting economic development, how countries can achieve this remains relatively understudied. Scholarly works on the determinants of diversification, however, have at least identified some inhibiting factors, such as natural resource abundance; but the role that key macroeconomic factors play, such as the real exchange rate, still is inconclusive.

For instance, Esanov (2012) using a panel random-effects framework covering the 1980-2006 period, finds that export concentration is positively related to the share of natural resources in total exports; contrariwise, the study suggests a negative correlation of concentration with investment and trade freedom but no correlation with trade openness, inflation, FDI, or quality of institutions. Ahmadov (2014) using an IV setup which looks at the 1970-2010 period, further confirms that diversification is negatively associated with countries rich in resources but that this result applies only to countries that are rich in oil, located in Africa or the Middle East, and that have autocratic regimes. No effects are found for human capital, trade openness, and quality of government. Along the same lines, Bahar and Santos (2016), using a variety of non-resource export concentration indices for the period 1985-2010, find strong evidence that higher shares of natural resources are associated with lower non-resource export diversification. Finally, Alsharif et al. (2017) find that oil exports are negatively associated with diversification (in this case, measured by non-oil rents). These studies thus provide empirical evidence that the more a country depends on commodity resources the less likely it will achieve to diversify its basket of exports, in line with the outcomes predicted by the Dutch disease.

Other empirical studies have focused on the causal link between the real exchange rate and diversification. One reason for this is that currency exchange misalignments – namely overvaluation – is the main factor that explains export concentration according to the Dutch disease (Corden & Neary, 1982): Higher commodity prices in this model lead to an increment in commodity exports of the booming commodity sector leading to a real currency appreciation; this, in turn, reduces the competitiveness of other tradeables in international markets, further pushing the economy into specialization in the booming commodity sector. The second reason for investigating the effects of real exchange rates on diversification is that some scholars (e.g., Rodrik, 2008) have suggested – against mainstream economic prescriptions – that currency undervaluation can promote diversification in weak institutional frameworks as it can act as a production subsidy plus a consumption tax on tradeables.

Still, empirical evidence supporting the causal link between commodity/tradeable exports performance and the real exchange rate across countries is mixed. For instance, Sekkat (2016), using Granger causality tests and a GMM framework, finds evidence of some positive effect of undervaluation on the share of manufactures in total exports; yet currency misalignment (either over or undervaluation) does not affect exports concentration – a result that holds even when the sample was restricted to countries whose quality of institutions is considered low.

One explanation of why the link between real exchange rates and diversification remains unclear is because of the potential bi-directional causality and great heterogeneity among countries. Tran et al. (2017), based on Granger causality techniques on panel data from 1995-2013, find that the real exchange rate is a determinant of export diversification but in only three developing countries in their sample; yet for the whole sample of countries, it shows a two-way causality. They conclude the direction of real exchange rates to diversification is highly heterogeneous among developing countries. Furthermore, Agosin et al., (2012) use a GMM panel over the 1962–2000 period, and whereas they do not find significant effects of exchange rate overvaluation on diversification, they do find a negative effect associated with increasing terms of trade. They suggest that an increase in the price of the main exported commodity induces the reallocation of factors to that sector, reducing either the availability or increasing the costs of inputs for new products exports. The latter, thus, suggests that an increase in commodity prices may influence concentration not necessarily via real exchange movements but also due to factor reallocation. This also resonates with relatively recent commodity price trends. As pointed out in UNCTAD (2019), rising commodity prices between 1998 to 2017 contributed to changes in the export composition of commodity exporters – changes which typically consisted of further export of concentration in oil and, especially, mineral exports[50] (UNCTAD, 2019).

50 Commodity-dependent countries increased from 92 in 1998–2002 to 102 in 2013–2017. Yet, countries dependent upon agricultural exports went from 50 to 37 between these two periods. In contrast, mineral-dependent countries increased from 14 to 33, and the number of energy-dependent countries rose from 28 to 32. According to the classification of UNCTAD (2019), a country is commodity-dependent when more than 60% of its total exports are comprised of commodities.

Considering the discussion above, the current analysis combines empirical literature which looks at diversification at the product level, and macroeconomic variables, namely real exchange rate, prices, and export dependence – given their relevance for understanding the dynamics of extractive and non-extractive exports. Looking at product level diversification in the empirical framework instead of export concentration – which is a measure that can be easily contaminated by price fluctuations (Alsharif et al., 2017)[51] - and using an alternative measure for relatedness, this study sheds further light on how path dependence predicts diversification in non-extractive and extractive goods.

A final consideration here is that diversification in extractive commodities has received empirically little attention in recent years for obvious reasons (the empirical evidence is a logical deterrent not to go in that direction). Yet, not a lot is known on the determinants of this process: certainly, being able to diversify into extractive commodities is to a large extent 'God-given', but modern extractive resource industries often demand non-trivial technological, economic, political, and social processes (Ville & Wicken, 2012). Therefore, understanding how path dependency and macroeconomic factors play out for extractive products diversification vis-à-vis non-extractives may also contribute to understanding the overall dynamics of path dependency and diversification processes.

4.3 Methodology

4.3.1 Related Variety Calculation

We use a probability-based relatedness measure for related variety to account for diversification potential as developed in Nomaler and Verspagen (2022). Diversification in this context is defined as the increment in the number of products that a country exports with revealed comparative advantage (RCA)[52]. Akin to other commonly applied product relatedness measures, the measure we employ builds upon the idea that a country's ability to develop new products in the future is – at least in part – determined by its present specialization structure. First, $\boldsymbol{X}$ represents a binary matrix of RCA[53] with dimensions $m \times n$, where m corresponds to the number of products and n is the number of countries. A typical element in $\boldsymbol{X}$, represented by x_{ij}, takes a bivariate value, following the definition of RCA originally

51 Measuring diversification, can be problematic when looking at commodities. As pointed out in Alsharif et al. (2017), export concentration (i.e., commodity exports as a share of total exports) in the presence of a negative price shock could reflect a "pseudo diversification" process rather than genuine changes in the export composition.

52 The method presented is an adapted version to method employed in the development of the Upgrading Triangle presented in Annex 7.2 of the Greater Mekong Subregion 2030 and Beyond Report (ADB, 2021).

53 The RCA is calculated as:

$RCA = \frac{E_{ij}/E_j}{E_i/E}$ where E_{ij} denotes country j exports of product i and the summation over the relevant dimension is indicated by the absence of a subscript. It is also assumed that all countries export at least one product, and all products represent an export of at least one country.

proposed by Balassa (1965):

$$x_{ij} = \begin{cases} 1 \; if \; RCA \geq 1 \\ 0 \; otherwise \end{cases}$$

Further, a conditional probability (product-by-product) matrix, $\boldsymbol{G}$, is defined in the following manner:

$$\boldsymbol{G} = (\boldsymbol{X}\boldsymbol{X}')/s$$

where $\boldsymbol{X'}$ represents a transposed matrix and s is the vector containing the row-sum of $\boldsymbol{X}$ (i.e., the number of total exported products with comparative advantage by a given country)[54]. $\boldsymbol{G}$ thus is a non-symmetrical matrix with $m \times m$ dimensions where a typical element, g_{kl}, indicates the probability of a having a comparative advantage in product k conditional upon having comparative advantage in product l, based on the information provided in $\boldsymbol{X}$.

The resulting matrix already provides rich information about the probability of developing advantage. However, we also incorporate information that captures the lack of comparative advantage in a particular product to estimate better the probability that a country has a comparative advantage in another one.

Considering this, we define the matrix $\boldsymbol{Z} = \boldsymbol{O} - \boldsymbol{X}$, in which $\boldsymbol{O}$ is a matrix with only ones and with $m \times n$ dimensions. The elements of the matrix $\boldsymbol{Z}$ thus are defined as follows:

$$z_{ij} = \begin{cases} 1 \; if \; x_{ij} = 0 \\ 0 \; if \; x_{ij} = 1 \end{cases}$$

The corresponding conditional probability (product-by-product) matrix $\boldsymbol{H}$ is defined as:

$$\boldsymbol{H} = (\boldsymbol{X}\boldsymbol{Z}')'/t \; = (\boldsymbol{Z}\boldsymbol{X}')/t$$

where t represents the row-sum of $\boldsymbol{Z}$, i.e., the number of countries that export a given product with no comparative advantage. $\boldsymbol{H}$ is a non-symmetrical matrix with $m \times m$ dimensions where a typical element, denoted as h_{kl}, indicates the probability of having a comparative advantage in product k conditional upon not having comparative advantage in product l, based on the information provided in $\boldsymbol{Z}$. As the following step the two conditional probability matrices are added up and scaled by m (the vector containing the total number of products exported by a given country):

$$\boldsymbol{K} = (\boldsymbol{G} + \boldsymbol{H})/m$$

$\boldsymbol{K}$, therefore, is a matrix of marginal conditional probabilities, with $m \times m$ dimensions. As a final step, we obtain a matrix comprised of the estimation of the probabilistic part of the RCA – contained in $\boldsymbol{X}$ - that results from the specialization profile of the country:

$$\boldsymbol{E} = \boldsymbol{X}'\boldsymbol{K}$$

Thus, $\boldsymbol{E}$ is a non-autonomous, (i.e., country-specific) matrix with dimensions $m \times n$ where a typical cell in $\boldsymbol{E}$, denoted as e_{ij}, indicates the probability that country *j* has comparative in product *i* conditional on the information about the whole range of products in which *j* has comparative advantage as well on the information about the range of products in which it does not.

To summarize, the **related variety** probability estimation in $\boldsymbol{E}$, is based on the underlying assumption that if two products, A and B, demand the same capabilities to produce them, these products are related to each other (and likely to be produced by the same country). If B requires capabilities that are very different from capabilities to produce A, these will be unrelated to each other (and unlikely to be produced by the same country), and thus have a lower related variety. Thus, the related variety probability estimation**,** based on the method proposed in Nomaler and Verspagen (2022), accounts for the information which captures similar capabilities, hence the *relatedness*, but also incorporates valuable information captured in the *absence* of those capabilities, which also affect the probability of a country to competitively produce a given product[55] and gain comparative advantage in the international market.

54 This also corresponds to the vector conceptualized as ubiquity in Hausmann and Hidalgo (2010) where the more countries export a product, the more ubiquitous the product is. Assumedly, higher ubiquity indicates that the capabilities required for producing such a product are more accessible to a large number of countries, and thus, less likely to be of higher complexity.

55 To illustrate further why this is relevant, Nomaler and Verspagen (2022) show that the absence of specialization frequently coincides with the absence of some other specializations – a kind of *'anti-relatedness*' - which ultimately suggests some sort of competition in specialization.

4.3.2 Econometric Approach

We begin with a modified version of the model proposed in Hausmann and Klinger (2006, 2007), where we employ the related variety probability estimation described in section 3.1. We use 4-year intervals (as opposed to 1-year intervals) to account for the time it takes to develop new products[56]. The resulting equation is then as follows:

$$RCA_{i,c,t+4} = \alpha + \gamma RCA_{i,c,t} + \beta E_{i,c,t} + \mu_i + \mu_c + \mu_t + \varepsilon_{i,c,t} \quad (1)$$

where $RCA_{i,c,t}$ is a binary dependent variable which captures comparative advantage in product i in country c at the end of a 4-year period; and, $E_{i,c,t}$ is the related variety probability of product i in country c at the beginning of the period[57]. Subsequently, the parameter γ refers to the contribution of having comparative advantage in product i in country c at the beginning of the period to the probability of maintaining such comparative advantage four years later. In other words, it captures the persistence of comparative advantage. Likewise, the parameter β captures the effect of $E_{i,c,t}$ on having comparative advantage at the end of the period. Finally, μ_i, μ_c, and μ_t refer to product, country, and fixed effects.

Equation (1) then estimates the probability of diversification: The dependent variable captures whether a given country has a comparative advantage (RCA $\geq$ 1) in a given product of any sort, i.e., extractive and non-extractive products. To compare how diversification differs among different goods (i.e., non-extractive and extractive), a second specification is included where the dependent variable represents if a country has comparative advantage (RCA $\geq$ 1) in a given non-extractive product. For this, the sample is restricted to non-extractive products. A third specification considers a dependent variable that captures if a country has comparative advantage (RCA $\geq$ 1) in extractive commodities. For the latter, the sample is restricted to energy, metals, and minerals commodities[58].

56 Several studies have opted for 5-year periods for this reason (see, for instance, Alonso & Martín, 2019; Boschma & Frenken, 2009). In particular, Alonso and Martín (Alonso & Martín, 2019) replicate the analysis with 4-year intervals and find no significant difference between the 5-year and 4-year periods. Since the panel is built based on a dataset that extends over 24 years, 4-year periods fit the time period while allowing for a reasonable length of time for product development.

57 The latter term specifically refers to a typical cell, e_{ij}, contained in the E matrix defined in the previous section.

58 These includes all mining commodities classified under the HS2 codes 26 and 71 and energy commodities under HS4 codes 2709, 2701 and 2711. Energy products do not include any form of processed product.

In order to distinguish how relatedness measures impact upon the probability of gaining advantage in a new product from the impact upon maintaining comparative advantage (or preventing abandonment) in goods already produced, equation (1) is expanded as in Hausmann and Klinger (2007). The resulting equation is:

$$RCA_{i,c,t+4} = \alpha + \gamma RCA_{i,c,t} + \delta\left(1 - RCA_{i,c,t}\right) \times E_{i,c,t} + \vartheta\left(RCA_{i,c,t}\right) \times E_{i,c,t} + \mu_i + \mu_c + \mu_t + \varepsilon_{i,c,t} \quad (2)$$

where parameters δ and ϑ reveal the effect that related variety would have on gaining comparative advantage in a new product and in maintaining it after the end of 4 years, respectively. The term, $E_{i,c,t}$, is not included because it is collinear with the two interaction terms. We finally expand Equation (2) to include controls at the national level to account for the macroeconomic conditions and other controls, including commodity prices and real exchange rates, that, as hypothesized, may affect diversification efforts:

$$RCA_{i,c,t+4} = \alpha + \gamma RCA_{i,c,t} + \delta\left(1 - RCA_{i,c,t}\right) \times E_{i,c,t} + \vartheta\left(RCA_{i,c,t}\right) \times E_{i,c,t} + \theta X_{c,t} + \mu_i + \mu_c + \mu_t + \varepsilon_{i,c,t} \quad (3)$$

where $\boldsymbol{X}$ is a matrix of controls which include: the log of the country-specific mining price index as developed by Deaton (1999); b) the log of real effective exchange rate (REER) index (2010 = 100)[59]; and the log of GDP per capita (constant 2010 US dollars). It also includes two dummies capturing extractive commodity dependence: countries categorized as metal-, ore- and mineral-dependent take the value of 1, and 0 otherwise. Similarly, countries categorized as fuel- and gas-dependent take the value of 1, and 0 otherwise. In this way, a country can be energy-dependent, *or* mining-dependent, *or* not dependent on either type of commodity (there is no overlap among energy and mining dependence dummies). Likewise, we include a variable to capture investment as a share of GDP.

While a linear probability model could a be good initial departure point[60], estimation by probit (with an analogous specification to Equations (1) to (3)) has several advantages due to the binary nature of the dependent variable, $RCA_{i,c,t+4}$. In particular, we employ the Chamberlain-Mundlak correlated random effects (CRE) probit model in order to

59 This refers to the World Bank's definition of REER: the nominal effective exchange rate (a measure of the value of a currency against a weighted average of several foreign currencies) divided by a price deflator or index of costs.

60 Previous empirical applications (e.g., Alonso & Martín, 2019; Hausmann & Klinger, 2007) have relied on a linear probability models (LPM) as this approach is less computationally intensive and the maximum likelihood with fixed effects is subject to incidental parameters problems when groups are small yielding inconsistent estimates (Greene, 2004). However, our sample allows for a large number of groups and the correlated random effects probit model circumvents the issue of incidental parameters problem (Wooldridge, 2010, 2019).

ensure the consistency of parameter estimates when including fixed effects, and to provide a more accurate estimation of the magnitude of the marginal effects (Chamberlain, 1982; Wooldridge, 2010). This model allows to control for unobserved heterogeneity in a non-linear set up, and at the same time, it considers potential correlations of individual-specific effects (in this case, product-specific effects) with observed characteristics, e.g., estimated related variety probability measure. The CRE approach introduces the group-level mean of each of the covariates, $\overline{x_\iota}$, in the probit specification. Adding $\overline{x_\iota}$ to control for unobserved heterogeneity (equivalent to $\mu_i + \mu_c + \mu_t$ as done in Equations (1) to (3)) is intuitive as it allows us to estimate the effect of changing $x_{c,i,t}$ while holding country- and/or product-effects fixed (Wooldridge, 2002). The correlated random effects model is then given by:

$$P\left(RCA_{i,c,t+4} = 1 \middle| x_{i,c,t}\right) = \Phi[(\psi + \beta x_{i,c,t} + \xi \overline{x_\iota})\,(1 + \sigma_a^2)^{-1/2}] \quad (4)$$

where $x_{i,c,t}$ refers to a vector of observable variables at the product- and country-level described in equations (1) to (3), $\overline{x_\iota}$ is the group-level mean (i.e., country and/or product) of each of these variables[61]; and σ_a^2 is the variance for the part of the random effects not captured by the averages $\overline{x_\iota}$. Year, and energy and mining dependence dummies are included in $x_{i,c,t}$ but excluded in $\overline{x_\iota}$. Note that in this setup, if $\xi = 0$ we would obtain the traditional random effects probit model.

This CRE model is our preferred specification and so its analogous specification for Equations (1) to (3) are reported in the results section – although comparisons with linear probability based on the Hausmann and Klinger (2007) basic models are provided in the Annex[62]. We also run the model specifications separately for the $RCA_{i,c,t+4}$ of all products, $RCA_{i,c,t+4}$ for non-extractive products, and $RCA_{i,c,t+4}$ for extractive commodities. In all specifications, standard errors are clustered at the country level.

4.3.3 Data

To calculate RCAs and related variety measures described in Section 2, we employ bilateral trade data from the BACI 2021 dataset that covers the 1995-2019 period with data collected for more than 5000 products and 220 countries. The BACI 2021 database constructed by CEPII is directly based on UN Comtrade data; it reconciles exporter and importer declarations and defines products at the 6-digit level from the Harmonized System (HS) nomenclature.

61 The CRE specification in equation (4) incorporates a multi-way fixed effect approach which corresponds to the specifications in the LPM model. For this we employ product- and country-level mean terms (where group-level means are generated separately). Time-effects are incorporated in the model by including year dummy variables. In particular, we follow the routine suggested in the Chamberlain RE pooled MLE model described in Wooldridge (2010).

62 Table 4.5 in Annex reports the marginal effects of the LPM and CRE probit model in Equation (1) where different fixed effects are used: first, year, country and product effects, and then, product-time and country-time effects (as done in Klinger, (2006) in an LPM setting). In Table 4.6 and Table 4.7 the results for all coefficients/marginal effects are presented for Equation (1) and (2) using LPM and CRE probit model also using fixed effects. Results are comparable and remain robust through all specifications. Yet LPM coefficient values tend to be higher.

The price index is calculated using price data from the major extractive commodities[63] extracted from the World Bank's Pink Sheet; commodity trade data from Thibault Fally's dataset[64], and GDP data from the World Development Indicators. The real exchange index (REER), governance effectiveness index, and GDP per capita data were obtained from the World Development Indicators database.

The commodity dependence binary variables were built upon the corresponding categorization in UNCTAD (2019).

Table 4.1. Summary Statistics

	N	Av.	SD	Min	Max
Related variety (E_i)	2,958,320	0.02	0.02	-0.06	0.16
RCA	2,958,320	0.19	0.39	0.00	1.00
Non-extractives RCA	2,910,735	0.19	0.39	0.00	1.00
Extractives RCA	47,585	0.23	0.42	0.00	1.00
Country-specific Mining Price Index (log)	2,676,055	0.11	0.25	0.00	1.48
REER Index (log)	1,699,518	4.58	0.14	4.03	5.73
Mining Commodity Dependence	2,676,055	0.10	0.30	0.00	1.00
Energy Commodity Dependence	2,676,055	0.14	0.35	0.00	1.00
Log GDP p.c. (Constant 2010 US$)	2,676,055	9.01	1.41	5.26	11.64
Log of Investment % of GDP	2,568,498	2.71	0.35	0.48	4.69

Table 4.1 summarizes the data employed in the analysis. Values in Table 4.1 for related variety (E_i) show that on average products have a value of 0.02, with a standard variation of 0.02 ranging from -0.06 to a maximum of 0.16. About 20% of products (in general and for the non-extractive category) were exported with a comparative advantage (i.e., an RCA equal or above to 1). In the case of extractive products, this is slightly higher, as 23% of exports showed comparative advantage.

63 This includes the following commodities and their corresponding HS4 codes: coal (2701), crude oil (2709), gas (2711); Aluminum(2606); Copper (2603); Iron ore (2601); Lead (2601); Nickel (2604); Tin(2609); Zinc (2608); Gold (7108); Silver (7106); and Platinum (7110).

64 Thibault Fally's database also relies on the BACI database; yet it uses the HS-1992 nomenclature in order to cover a longer period, i.e. from 1995 to 2014 (Fally & Sayre, 2018).

4.4 Results

The estimates of equation (1) and its analogous probit specification are presentedin Table 4.2 in Models (1) to (3). Results indicate that havingcomparative advantage, $(RCA_{i,c,t})^{*} E_{i,c,t,}$ is higher than on developing new products, $(1\text{-}RCA_{i,c})^{*} E_{i,c,t.}$ Specifically, an increase of 0.02 (a standard deviation) in the related variety estimate, raises the probability of gaining comparative advantage in a new product (all products category) four years later by 5.8 percentage points, (Model 4); in new non-extractive products by 5.7 (Model 5); and in new extractive commodities by 8.0 percentage points (Model 6).

The above then highlights that path dependence may play a bigger role in extractives' diversification than in non-extractives – probably because, on average, the latter requires a more complex and/or diverse set of capabilities.

Furthermore, an increment of 0.02 (a standard deviation) in the related variety estimate increases the predicted probability of maintaining comparative advantage in products (all products category) four years later by 7.2 percentage points (Model 4); and in non-extractive products by 7.2 (Model 5). For extractives, this change would be equivalent to an increment of 6.0 percentage points (Model 6). This suggests that for extractive commodities, path dependence has a stronger effect on 'developing' new (extractive) products vis-à-vis non-extractive products, but it also has a weaker effect on preventing abandonment[65].

65 To test whether related variety coefficients are statistically different for non-extractive products than for extractive products, we carried out additional regressions in a pooled sample using the LPM approach in which the terms *Related variety,* $E_{i,c,t}$, $(1\text{-} RCA_{i,c,t})^{*} E_{i,c,t}$ and $(RCA_{i,c,t})^{*} E_{i,c,t}$, are included, plus their respective interactions with a dummy variable that captures whether if the product is either a mineral, metal, or energy commodity. The results are shown in Table 4.8 in Annex.

Table 4.2. Results – Basic Estimation

	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	All products $RCA_{i',c,t+4}$	Non-extractive $RCA_{i',c,t+4}$	Extractive $RCA_{i',c,t+4}$	All products $RCA_{i',c,t+4}$	Non-extractive $RCA_{i',c,t+4}$	Extractive $RCA_{i',c,t+4}$
$RCA_{i,c,t}$	0.285***	0.284***	0.340***	0.268***	0.266***	0.353***
	(0.00436)	(0.00439)	(0.00691)	(0.00568)	(0.00577)	(0.00765)
Related variety, $E_{i,c,t}$	3.163***	3.138***	3.512***			
	(0.186)	(0.187)	(0.300)			
$(1\text{-} RCA_{i,c,t})^{*} E_{i,c,t}$				2.915***	2.869***	3.975***
				(0.212)	(0.213)	(0.334)
$(RCA_{i,c,t})^{*} E_{i,c,t}$				3.612***	3.606***	3.026***
				(0.229)	(0.231)	(0.350)
Observations	2,958,320	2,910,735	47,585	2,958,320	2,910,735	47,585
Country Clusters	228	228	228	228	228	228

*** p<0.01, ** p<0.05, * p<0.1. Note: Country-clustered standard errors are shown in parenthesis. All models refer to the CRE probit estimation; coefficients refer to average marginal effects.

Models 4 to 6 in Table 4.3 show the results of equation (3) where macroeconomic controls, i.e., the log of the mining price index, the log of the real exchange rate, and log of GDP per capita, are incorporated. The related variety effect on diversification, $E_{i,c,t,}$ in models 1, 3, and 5 in Table 4.3 remains positive and significant at the 1% level. However, the size of the effect is now smaller: a standard deviation increase (0.02) in related variety is associated with an increase in the probability of diversification of 5.1 percentage points (Model 1), in non-extractive products by 5.0 percentage points (Model 3); and in extractive commodities by 5.2 percentage points (Model 5).

Similarly, the effect of related variety on introducing a new product and maintaining comparative advantage remains positive and highly significant but the effects have reduced regardless of the type of product, as seen in Models 2, 4, and 6. A standard deviation increase (0.02) in related variety, is associated with an increase in the probability of diversification four years later of 4.8 percentage points in non-extractives products (Model 4) and 7.0 percentage points in extractive products (Model 6). Yet related variety has a stronger role in preventing abandonment in non-extractives than in extractives – as earlier observed. The above further underlines that developing comparative advantage in new non-extractive goods is less path-dependent than in mining and energy commodities; in other words, diversifying into non-mining or energy products requires bigger efforts or countries specialized in extractive sectors.

Regarding macroeconomic variables, we find some important differences as well. The mining price index coefficient reveals that an increase equivalent to a standard deviation (0.25) in the log of the price index is associated with a reduced probability of having comparative advantage in non-extractive products four years later equivalent to 12 percentage points (i.e., 0.48*0.25*100), significant at the 1% level (Model 3 and 4). A rather similar effect is found for all products (Model 1 and 2), also significant at the 1% level. Yet, there is no significant effect found for extractive products.

Moreover, the level of economic development shows a negative association with diversification overall. Models 1 to 4 suggest that an increase of 1.4 (a standard deviation in the sample) in the log of GDP per capita is associated with a reduction in the probability of diversification for all products and non-extractives equivalent to 4.2 percentage points (i.e., 0.03*1.4*100), results significant at the 5% and 10% levels respectively. This is in line with economic theory that states that export diversification increases at low levels of development but contracts at higher levels (Hesse, 2008; Klinger & Lederman, 2006).

The negative relationship however appears to be much larger and robust with extractive products. Models 5 and 6 in Table 4.3 indicate that an increment of 1.4 in the log of GDP per capita is associated with a reduction in the probability of having comparative advantage in extractive commodities equivalent to 13.3 to 13.6 percentage points, significant at the 1% level. This highlights that the more developed countries are, the less likely they will be to specialize in these goods.

The real exchange rate (REER) does not appear to be significant at any level across these specifications. This is consistent with the previous empirical works that failed to find a relationship between diversification and exchange rates. A possible explanation could be the vast number of currency management regimes and the circular causal relationship which was discussed in the literature review.

Finally, the introduction of controls did not have a noticeable effect on the marginal effects for the initial comparative advantage variable, $RCA_{i,c,t}$ – unlike the related variety marginal effects which became smaller. For this, the introduction of relevant macroeconomic variables linked to the macroeconomic environment is crucial to have a clearer picture of diversification determinants beyond path dependency. Moreover, results in Table 4.3 show that if the magnitude of the coefficients is compared – based solely on the variation (standard deviation) across countries, macroeconomic factors may play an equal, or stronger, role in explaining different diversification outcomes.

Table 4.3. Results - Estimation with macroeconomic controls

	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	All products $RCA_{i',c,t+4}$	All products $RCA_{i',c,t+4}$	Non-extractive $RCA_{i',c,t+4}$	Non-extractive $RCA_{i',c,t+4}$	Extractive $RCA_{i',c,t+4}$	Extractive $RCA_{i',c,t+4}$
$RCA_{i,c,t}$	0.295***	0.290***	0.294***	0.290***	0.336***	0.356***
	(0.005)	(0.007)	(0.005)	(0.007)	(0.009)	(0.011)
Related variety, $E_{i,c,t}$	2.537***		2.514***		2.600***	
	(0.200)		(0.200)		(0.348)	
$(1- RCA_{i,c,t})^* E_{i,c,t}$		2.627***		2.403***		3.475***
		(0.234)		(0.224)		(0.387)
$(RCA_{i,c,t})^* E_{i,c,t}$		2.726***		2.567***		2.099***
		(0.238)		(0.226)		(0.407)
Price Index (log)	-0.470***	-0.472***	-0.479***	-0.478***	-0.198	-0.213
GDP per capita (log)	-0.030**	-0.029**	-0.029*	-0.028*	-0.095***	-0.097***
	(0.015)	(0.014)	(0.015)	(0.015)	(0.022)	(0.022)
REER Index (log)	0.018	0.019	0.018	0.018	-0.011	-0.012
	(0.014)	(0.014)	(0.014)	(0.014)	(0.019)	(0.019)
Observations	1,699,518	1,699,518	1,671,028	1,671,028	28,490	28,490
Country Clusters	92	92	92	92	92	92

*** p<0.01, ** p<0.05, * p<0.1. Note: Country-clustered standard errors are shown in parenthesis. All models refer to the CRE probit estimation with product, country, and year effects; coefficients refer to average marginal effects.

Models in Table 4.4 incorporate further controls: i.e., mining and energy commodity dependence dummies, and the log of investment as a share of GDP. Results in Table 4.4 indicate that the related variety effect on having comparative advantage – regardless of the type of products – remains significant at the 1% level. The size of the marginal effect, however, decreases slightly. However, it must be said that in the specifications where the variable for investment is introduced the marginal effects increase again slightly. To illustrate this, a standard deviation (0.02) increase in related variety according to model 5 would be associated with an increment of diversification in a new product four years later equivalent to 3.5 percentage points (Model 7), and if investment is controlled for, 4.4 percentage points (Model 8). Likewise, the equivalent increase in the probability of diversification in extractives would be 4.5 percentage points (Model 11), and if investment is controlled for, 4.9 percentage points (Model 12) (although, investment is not significant in the extractive diversification models). In any case, path dependence in new product diversification appears again to be higher for extractives than for non-extractives, as earlier noted.

Furthermore, mining commodity dependence is negatively associated with having comparative advantage in the category of all products and non-extractives. Specifically, having mining dependency is associated with a reduction in the predicted probability of diversification in all products equivalent to 1.3 percentage points (Models 1 and 3) and non-extractive products, equivalent to 1.0-1.5 percentage points (Models 5 to 8) significant at the 10% and 5% level (depending on the specification). Controlling for investment, however, seems to attenuate the effect as can be seen throughout Models 1 to 9; whenever this variable is introduced the effect of mining dependency seems to lose significance (or is significant at a lower significance level), with the marginal effect further shrinking. Results in Table 4.4 also show that mining commodity dependence and diversification in extractive commodities have a positive and highly significant relationship. Namely, mining dependence is associated with an increment in the probability of having comparative advantage in extractives equivalent to 4.9-5.3 percentage points (Models 9 to 12), significant at the 1% level.

Similarly, energy dependency shows the same pattern although the effect appears somewhat less robust than for mining: being dependent on fossil fuels and other energy products is associated with a decrease in diversification in new products (either in the all products or non-extractive products category) of between 1.3 and 1.4 percentage points, significant at the 10% and 5% level. In the specifications where the investment control is introduced, the negative effect loses significance. Likewise, results in Models 9 to 12 suggest that energy dependence is associated with an increment in the probability of diversification between 1.8 and 2.0 percentage points, significant at the 10% significance level. Recent divergence in the diversification trajectories of different oil countries and the overall trend towards higher mining dependence (UNCTAD, 2019) could explain why in recent years the effect of certain dependence could be now stronger for mining.

The effect of mining prices on non-extractive diversification – while smaller – remains negative and significant, even after controlling for commodity dependence and investment. To illustrate this effect, an increase of a standard deviation (0.25) in the log of the price index is associated with a reduced probability of having comparative advantage in non-extractive products four years later equivalent to 1.0-1.3 percentage points (Models 5 to 8), effects significant at the 1% level. Similar effects and significance are found for the specification in which all products are considered. Prices remain insignificant in the specifications for extractive products' diversification.

Table 4.4. Results - Estimation with macroeconomic controls, commodity dependence dummies, and investment (CRE Probit)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
VARIABLES	All products $RCA_{i',c,t+4}$	All products $RCA_{i',c,t+4}$	All products $RCA_{i',c,t+4}$	All products $RCA_{i',c,t+4}$	Non-extractive $RCA_{i',c,t+4}$	Non-extractive $RCA_{i',c,t+4}$	Non-extractive $RCA_{i',c,t+4}$	Non-extractive $RCA_{i',c,t+4}$	Extractive $RCA_{i',c,t+4}$	Extractive $RCA_{i',c,t+4}$	Extractive $RCA_{i',c,t+4}$	Extractive $RCA_{i',c,t+4}$
$RCA_{i,c,t}$	0.295***	0.293***	0.281***	0.284***	0.294***	0.292***	0.279***	0.282***	0.358***	0.353***	0.369***	0.366***
	(0.003)	(0.003)	(0.004)	(0.005)	(0.003)	(0.003)	(0.004)	(0.005)	(0.007)	(0.006)	(0.007)	(0.007)
Related variety, $E_{i,c,t}$	2.097***	2.211***			2.088***	2.203***			1.708***	1.814***		
	(0.113)	(0.114)			(0.113)	(0.114)			(0.296)	(0.296)		
$(1- RCA_{i,c,t})^* E_{i,c,t}$			1.784***	2.065***			1.754***	2.039***			2.269***	2.450***
			(0.185)	(0.176)			(0.185)	(0.176)			(0.386)	(0.387)
$(RCA_{i,c,t})^* E_{i,c,t}$			2.386***	2.402***			2.394***	2.409***			1.321***	1.378***
			(0.126)	(0.133)			(0.127)	(0.133)			(0.308)	(0.307)
Price Index (log)	-0.050***	-0.042***	-0.051***	-0.041***	-0.052***	-0.043***	-0.053***	-0.043***	0.009	0.010	0.009	0.011
	(0.011)	(0.011)	(0.011)	(0.011)	(0.011)	(0.011)	(0.011)	(0.011)	(0.014)	(0.015)	(0.014)	(0.015)
GDP per capita (log)	-0.010***	-0.012***	-0.010***	-0.012***	-0.009***	-0.011***	-0.010***	-0.012***	-0.016***	-0.015***	-0.016***	-0.015***
	(0.001)	(0.002)	(0.002)	(0.002)	(0.001)	(0.002)	(0.002)	(0.002)	(0.003)	(0.004)	(0.003)	(0.004)
Mining dependence	-0.013**	-0.009	-0.013**	-0.009	-0.014**	-0.010*	-0.015**	-0.011*	0.049***	0.053***	0.049***	0.053***
	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.015)	(0.015)	(0.015)	(0.015)
Energy dependence	-0.013*	-0.010	-0.013**	-0.010	-0.013*	-0.010	-0.014*	-0.011	0.018	0.020*	0.018*	0.020*
	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)	(0.008)	(0.008)	(0.011)	(0.011)	(0.011)	(0.011)
Investment % of GDP (log)		0.013**		0.013**		0.013**		0.013**		-0.005		-0.006
		(0.006)		(0.006)		(0.006)		(0.006)		(0.013)		(0.014)
Observations	2,676,055	2,568,498	2,676,055	2,568,498	2,632,720	2,526,537	2,632,720	2,526,537	43,335	41,961	43,335	41,961
Country Clusters	178	165	178	165	178	165	178	165	178	165	178	165

*** p<0.01, ** p<0.05, * p<0.1. Note: Country-clustered standard errors are shown in parenthesis. All models refer to the CRE probit estimation with product, and year effects; coefficients refer to average marginal effects.

4

Once controls for commodity dependence and investment are introduced, the negative relationship between GDP per capita and diversification remains negative but appears less strong. Specifically, results indicate that a one standard deviation increment (1.4) in the log of GDP per capita is associated with a reduction in the probability of diversification for all products and non-extractives of between 1.3 and 1.7 percentage points (Models 1 to 8), significant at the 1% level. The effect for extractives however is equivalent to 2.2-2.3 percentage points (Models 9 to 12), also significant at the 1% level. The results again highlight that in advanced countries diversification becomes increasingly difficult to attain but also that these countries are less likely to move into extractive commodities – as earlier mentioned.

Finally, investment is (expectedly) positively associated with diversification in the all-products and non-extractive products models. Specifically, an increase of one standard deviation (0.35) in the log of the share of investment as GDP is associated with an increment in the probability of diversification equivalent to 0.455 percentage points, significant at the 1% level (Models 6 and 9). Results fail to find the same effect for extractive products suggesting that, on average, countries with higher levels of investment are less likely to develop towards extractive commodity sectors (perhaps deliberately) – akin to the dynamic observed for more advanced economies.

Estimations based on Table 4.4 (i.e., Models 3-4, 7-8, and 11-12) were also carried out with additional macroeconomic controls, i.e., log of inflation (from World Development Indicators), and a proxy to account for the quality of institutions, i.e., government effectiveness index (World Governance Indicators). These, however, were not significant in any of the models. Also, to test whether the relationship between product diversification and economic development, i.e., log of GDP per capita, follows a non-linear function, its squared term was introduced in the estimation of models reported in Table 4. The significance of this coefficient was not very high (10%), yet the coefficients indicate a potential nonlinear relationship between GDP per capita and diversification. Namely, this relationship suggests – as highlighted in previous studies (i.e., Hesse, 2008; Klinger & Lederman, 2006) – that, at lower levels of development, export diversification increases but after a certain high-income point it begins to decline. Including these controls did not change much the significance and/or size of the estimated coefficients reported. Results of the above estimations are found in Annex (See Table 4.9).

4.4.1 Discussion of Results

A few observations can summarize our results: The related variety measure we use in our analysis (Nomaler & Verspagen, 2022) is a strong predictor of diversification. Our results confirm that path dependence, proxied by this measure, does play a role in predicting what countries produce with comparative advantage and what they do not. Specifically, our results show that this measure plays a weaker role in developing comparative advantage in non-extractive products vis-à-vis extractive products. This suggests that, indeed, diversifying in non-extractives requires somewhat “bigger jumps” due to more diverse and (probably complex) productive capabilities requirements.

However, related variety on its own does not reveal much about the underlying determinants and macroeconomic incentives facilitating (or hampering) diversification efforts. Results in the previous section show that the effect of related variety is affected by the inclusion of macroeconomic variables (e.g., international prices and investment) and it also impacts diversification across sectors differently (in this case, extractive sectors vs other sectors). Likewise, the magnitude of the marginal effects (if the standard deviation in the sample is considered) shows that macroeconomic factors play a crucial role in explaining differences. Our results support the idea that while path dependence is a good predictor, it is not deterministic. Diversification seems to hinge upon a whole range of macroeconomic factors that ultimately shape the incentives which lead to differences in diversification patterns. In this study, a few are identified and discussed.

Firstly, extractive commodity prices (captured by the country-specific mining index) show a consistent negative association with product diversification in non-extractive products. If extractive commodity dependence and investment are controlled for, the effect of commodity prices on diversification – although smaller – remains negative and significant. This is consistent with previous studies which have highlighted the negative relationship between commodity price shocks and export diversification (i.e., Agosin et al., 2012). Results however also show that mining price indices, however, do not incentivize diversification into other non-extractives. Higher prices, thus, may incentivize extracting more of a commodity but are not necessarily conducive to new extractive sectors probably because of the exogenous nature of these resources (i.e., a country either has lithium or not). Additionally, higher prices may not be sufficient to offset the high barriers and requirements involved in developing a new extractive sector.

Likewise, energy- and mining-dependent countries (especially the latter) are less likely to diversify into non-extractive commodity products. Since the effect seems to be particularly strong for mining products, this finding partially contradicts previous studies that indicate that only oil hampers diversification (e.g., Ahmadov, 2014). Possibly this is because while the export concentration in energy-dependent countries remains high, there have been a few mixed experiences more recently[66].

66 Energy dependent countries, such as Oman, Trinidad and Tobago, and Qatar became more diversified in the 1995-2017 period; yet others such as Azerbaijan, Venezuela and Nigeria became even more concentration (UNCTAD, 2019).

Yet in this regard, results suggest that investment can attenuate commodity dependence effects on diversification as investment is positively associated with diversification in non-extractive sectors (and not with extractive commodities). This finding supports the view that diversification is an endogenous process stemming from investments (e.g., Acemoglu and Zilibotti, 1997) as well as previous empirical works (e.g. Esanov, 2012).

Results do not show that the real exchange rate index is statistically associated with diversification (or the lack thereof). The lack of a clear empirical relationship of currency movements with diversification could be attributed not only to the potential bi-directional causality between the variables but also because of the current diversity in exchange rate regimes.

We further confirm – once commodity dependence is controlled for – that at lower levels of development – proxied by GDP per capita – there is more room for diversification, regardless of the type of product considered. However, results also suggest that the more developed a country is, the less likely it will be to diversify into (mining and energy) commodities.
Finally, our results remain robust across estimations in which other controls, such as inflation, and governance effectiveness, are included.

4.5 Conclusion

The analysis here presented shows that non-extractive diversification is less path-dependent than extractives, and thus requires stronger efforts to attain. If countries want to diversify their export portfolio this may require taking more than a few small steps to achieve that goal and so, the entrepreneurial cost of discovery in non-extractive sectors will be higher.
Furthermore, these results confirm that macroeconomic incentives, namely those provided by international prices, are crucial in establishing the direction of diversification; in this case, results suggest that higher commodity prices tend to push countries away from non-extractive exports.

The exact way in which prices lower the probability of diversification into non-extractives is less clear. It is possible that in some countries this channel is the real exchange rate (as the Dutch disease would suggest). Yet this study could not confirm that on average this is the main way in which it operates. Agosin et al. (2012) give another possible explanation: higher commodity prices will incentivize the allocation of factors into the extractive sector which will increase the costs of inputs and/or reduce their availability necessary for producing other goods competitively.

Considering that it is likely that the demand for minerals and metals will remain high, or even increase, it should be considered that diversifying into new non-extractives may be harder because incentives make the relative cost of inputs (and overall innovative activity) higher. Further research into how macroeconomic conditions reduce incentives of entrepreneurs to move into new non-extractive products would be necessary. Another possible research agenda would be to look at how the institutional setup in a more disaggregated manner (for instance, by looking at political economy aspects) facilitates or discourages non-extractive diversification.

Bibliography

Acemoglu, D., & Zilibotti, F. (1997). Was Prometheus Unbound by Chance? Risk, Diversification, and Growth. *Source: The Journal of Political Economy*, *105*(4), 709–751.

ADB. (2021). *The Greater Mekong Subregion 2030 and Beyond*. https://doi.org/10.22617/TCS210015-2

Agosin, M. R., Alvarez, R., & Bravo-Ortega, C. (2012). Determinants of Export Diversification Around the World: 1962-2000. *World Economy*, *35*(3), 295–315. https://doi.org/10.1111/j.1467-9701.2011.01395.x

Ahmadov, A. K. (2014). *Blocking the Pathway Out of the Resource Curse: What Hinders Diversification in Resource-Rich Developing Countries?* https://www.princeton.edu/~pcglobal/conferences/GLF/ahmadov.pdf.

Alonso, J. A., & Martín, V. (2019). Product relatedness and economic diversification at the regional level in two emerging economies: Mexico and Brazil. *Regional Studies*, *53*(12), 1710–1722. https://doi.org/10.1080/00343404.2019.1605441

Alsharif, N., Bhattacharyya, S., & Intartaglia, M. (2017). Economic diversification in resource rich countries: History, state of knowledge and research agenda. *Resources Policy*, *52*, 154–164. https://doi.org/10.1016/J.RESOURPOL.2017.02.007

Bahar, D., & Santos, M. (2016). *Natural resources and export concentration: on the most likely casualties of Dutch disease* (Center for International Development at Harvard University).

Balassa, B. (1965). Trade Liberalisation and "Revealed" Comparative Advantage1. *The Manchester School*, *33*(2), 99–123. https://doi.org/10.1111/J.1467-9957.1965.TB00050.X

Boschma, R., & Capone, G. (2015). Institutions and diversification: Related versus unrelated diversification in a varieties of capitalism framework. *Research Policy*, *44*(10), 1902–1914. https://doi.org/10.1016/j.respol.2015.06.013

Boschma, R., Minondo, A., & Navarro, M. (2012). *The emergence of new industries at the regional level in Spain A proximity approach based on product-relatedness* (12.01; Papers in Evolutionary Economic Geography). https://doi.org/10.1093/jeg/lbs010

Chamberlain, G. (1982). Multivariate regression models for panel data. *Journal of Econometrics*, *18*(1), 5–46. https://doi.org/10.1016/0304-4076(82)90094-X

Content, J., & Frenken, K. (2016). Related variety and economic development: a literature review. *Http://Dx.Doi.Org/10.1080/09654313.2016.1246517*, *24*(12), 2097–2112. https://doi.org/10.1080/09654313.2016.1246517

Corden, W. M., & Neary, J. P. (1982). Booming Sector and De-Industrialisation in a Small Open Economy. *The Economic Journal*, *92*(368), 825. https://doi.org/10.2307/2232670

Deaton, A. (1999). Commodity prices and growth in Africa. *Journal of Economic Perspectives*, *13*(3), 23–40. https://doi.org/10.1257/jep.13.3.23

Dosi, G., Pavitt, K., & Soete, L. (1990). The Economics of Technical Change and International Trade. *LEM Book Series*. https://ideas.repec.org/b/ssa/lembks/dosietal-1990.html

Esanov, A. (2012). *Economic Diversification: Dynamics, Determinants and Policy Implications*. https://resourcegovernance.org/sites/default/files/RWI_Economic_Diversification.pdf

Fally, T., & Sayre, J. (2018). *Data on Commodity Trade - Thibault Fally*. https://are.berkeley.edu/~fally/data.html

Guo, Q., & He, C. (2017). Production space and regional industrial evolution in China. *GeoJournal*, *82*(2), 379–396. https://doi.org/10.1007/s10708-015-9689-4

Hausmann, R., & Hidalgo, C. A. (2010). *Country Diversification, Product Ubiquity, and Economic Divergence Faculty Research Working Paper Series Ricardo Hausmann* (No. 201; Center for International Development). www.hks.harvard.edu

Hausmann, R., Hwang, J., Rodrik, D., & Kennedy, J. F. (2005). *What You Export Matters*. http://www.nber.org/papers/w11905

Hausmann, R., & Klinger, B. (2006). *Structural Transformation and Patterns of Comparative Advantage in the Product Space* (No. 128; CID Working Papers).

Hausmann, R., & Klinger, B. (2007). *The Structure of the Product Space and the Evolution of Comparative Advantage* (No. 146; CID Working Papers). http://www.cid.harvard.edu/cidwp/128.htm.

He, C., Yan, Y., & Rigby, D. (2018). Regional industrial evolution in China. *Papers in Regional Science*, *97*(2), 173–198. https://doi.org/10.1111/PIRS.12246

He, C., & Zhu, S. (2018). Evolution of Export Product Space in China: Technological Relatedness, National/Local Governance and Regional Industrial Diversification. *Tijdschrift Voor Economische En Sociale Geografie*, *109*(4), 575–593. https://doi.org/10.1111/TESG.12309

Hesse, H. (2008). *Export Diversification and Economic Growth* (No. 21; Commission on Growth and Development).

Hidalgo, C. A., Winger, B., Barabási, A. L., & Hausmann, R. (2007). The product space conditions the development of nations. *Science*, *317*(5837), 482–487. https://doi.org/10.1126/science.1144581

Klinger, B., & Lederman, D. (2006). *Diversification, Innovation, and Imitation inside the Global Technological Frontier** (No. 3872; Policy Research Working Paper). http://econ.worldbank.org.wps3872

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. https://doi.org/10.1016/0304-3878(87)90005-8

Lall, S. (1992). Technological capabilities and industrialization. *World Development*, *20*(2), 165–186. https://doi.org/10.1016/0305-750X(92)90097-F

Lederman, D., & Maloney, W. F. (2007). Trade Structure and Growth. In D. Lederman & W. F. Manoley (Eds.), *Natural Resources Neither Curse nor Destiny* (pp. 15–40). The World Bank, Stanford University Press.

Maskell, P., & Malmberg, A. (1999). Localised learning and industrial competitiveness. *Cambridge Journal of Economics*, *23*(2), 167–185. https://doi.org/10.1093/CJE/23.2.167

McMillan, M., Rodrik, D., & Verduzco-Gallo, Í. (2014). Globalization, Structural Change, and Productivity Growth, with an Update on Africa. *World Development*, *63*, 11–32. https://doi.org/10.1016/j.worlddev.2013.10.012

Neffke, F., Henning, M., & Boschma, R. (2011). How Do Regions Diversify over Time? Industry Relatedness and the Development of New Growth Paths in Regions. *Economic Geography*, *87*(3), 237–265. https://doi.org/10.1111/J.1944-8287.2011.01121.X

Nomaler, Ö., & Verspagen, B. (2022). *Some new views on product space and related diversification* (#2022-011; UNU-MERIT Working Paper Series).

Rodrik, D. (2008). *The Real Exchange Rate and Economic Growth* (Brookings Papers on Economic Activity). Sachs and Warner.

Ross, M. L. (2019). What do we know about export diversification in oil-producing countries? *The Extractive Industries and Society*, *6*(3), 792–806. https://doi.org/10.1016/J.EXIS.2019.06.004

Sekkat, K. (2016). Exchange rate misalignment and export diversification in developing countries. *Quarterly Review of Economics and Finance*, *59*, 1–14. https://doi.org/10.1016/j.qref.2015.08.001

Tran, T. A. D., Phi, M. H., & Diaw, D. (2017). Export diversification and real exchange rate in emerging Latin America and Asia: A South–North vs. South-South decomposition. *Journal of International Trade and Economic Development*, *26*(6), 649–676. https://doi.org/10.1080/09638199.2017.1286680

UNCTAD. (2019). *The State of Commodity Dependence 2019*.

van der Ploeg, F., & Poelhekke, S. (2009). Volatility and the natural resource curse. *Oxford Economic Papers*, *61*(4), 727–760. https://doi.org/10.1093/oep/gpp027

Ville, S., & Wicken, O. (2012). The Dynamics of Resource-Based Economic Development : Evidence from Australia and Norway. *Department of Economics, University of Wollongong, Working Paper 04-12*, 55. http://ro.uow.edu.au/commwkpapers/241

Wiig, A., & Kolstad, I. (2012). If diversification is good, why don't countries diversify more? The political economy of diversification in resource-rich countries. *Energy Policy*, *40*(1), 196–203. https://doi.org/10.1016/j.enpol.2011.09.041

Winter, S. G., & Nelson, R. R. (1982). *An Evolutionary Theory of Economic Change*. https://papers.ssrn.com/abstract=1496211

Wooldridge, J. M. (2010). *Econometric Analysis of Cross Section and Panel Data* (2nd ed.). MIT Press.

Wooldridge, J. M. (2019). Correlated random effects models with unbalanced panels. *Journal of Econometrics*, *211*(1), 137–150. https://doi.org/10.1016/J.JECONOM.2018.12.010

Annex

Annex 1: Additional regressions

Table 4.5. Comparison of Marginal Effects for Related Variety based on Equation (1)

	(1)	(2)	(3)	(4)
	LPM	**CRE Probit**	**LPM**	**CRE Probit**
	All products $RCA_{i,c,t+4}$	All products $RCA_{i,c,t+4}$	All products $RCA_{i,c,t+4}$	All products $RCA_{i,c,t+4}$
Related variety, $E_{i,c,t}$	4.913***	3.163***	6.859***	4.539***
	(0.301)	(0.186)	(0.391)	(0.0478)
Year	Yes	Yes	-	-
Country	Yes	Yes	-	-
Product	Yes	Yes	-	-
Country*Year	-	-	Yes	Yes
Product*Year	-	-	Yes	Yes
N	2,958,319	2,958,320	2,957,792	2,958,320

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. Models 2 and 4 report average marginal effects. Country-clustered SEs are shown in parenthesis.

Table 4.6. Results – Equation 1: CRE Probit and LPM with Fixed Effects

	(1)	(2)	(3)	(4)	(5)	(6)
	LMP	**CRE Probit**	**LMP**	**CRE Probit**	**LMP**	**CRE Probit**
VARIABLES	All products $RCA_{i,c,t+4}$	All products $RCA_{i,c,t+4}$	Non-extractive $RCA_{i,c,t+4}$	Non-extractive $RCA_{i,c,t+4}$	Extractive $RCA_{i,c,t+4}$	Extractive $RCA_{i,c,t+4}$
$RCA_{i,c,t}$	0.540***	0.285***	0.539***	0.284***	0.553***	0.340***
	(0.0108)	(0.00436)	(0.0109)	(0.00439)	(0.0110)	(0.00691)
Related variety, $E_{i,c,t}$	4.913***	3.163***	4.911***	3.138***	3.656***	3.512***
	(0.301)	(0.186)	(0.303)	(0.187)	(0.360)	(0.300)
Observations	2,958,319	2,958,320	2,910,734	2,910,735	47,585	47,585
Adj./Pseudo R-squared	0.411	0.344	0.411	0.345	0.396	0.315
Country Clusters	228	228	228	228	228	228

*** $p<0.01$, ** $p<0.05$, * $p<0.1$. Note: Country-clustered SEs are shown in parenthesis. Coefficients are reported for LMP with fixed effects and average marginal effects reported for CRE Probit. All models include year, product and country effects

Table 4.7. Results – Equation 2: CRE Probit and LPM with Fixed Effects

	(1)	(2)	(3)	(4)	(5)	(6)
	LMP FE	**CRE Probit**	**LMP FE**	**CRE Probit**	**LMP FE**	**CRE Probit**
VARIABLES	All products $RCA_{i,c,t+4}$	All products $RCA_{i,c,t+4}$	Non-extractive $RCA_{i,c,t+4}$	Non-extractive $RCA_{i,c,t+4}$	Extractive $RCA_{i,c,t+4}$	Extractive $RCA_{i,c,t+4}$
$RCA_{i,c,t}$	0.494***	0.268***	0.491***	0.266***	0.563***	0.353***
	(0.0119)	(0.00568)	(0.0121)	(0.00577)	(0.0126)	(0.00765)
$(1- RCA_{i,c,t})^* E_{i,c,t}$	3.643***	2.915***	3.578***	2.869***	4.027***	3.975***
	(0.301)	(0.212)	(0.302)	(0.213)	(0.395)	(0.334)
$(RCA_{i,c,t})^* E_{i,c,t}$	5.680***	3.612***	5.702***	3.606***	3.286***	3.026***
	(0.362)	(0.229)	(0.367)	(0.231)	(0.461)	(0.350)
Observations	2,958,319	2,958,320	2,910,734	2,910,735	47,585	47,585
Adj./Pseudo R-squared	0.412	0.3461	0.412	0.3468	0.396	0.3170
Country Clusters	228	228	228	228	228	228

*** p<0.01, ** p<0.05, * p<0.1. Note: Country-clustered SEs are shown in parenthesis. Coefficients are reported for LMP with fixed effects and average marginal effects reported for CRE Probit. All models include year, product and country effects

Table 4.8. Statistical difference between commodities and non-commodity products

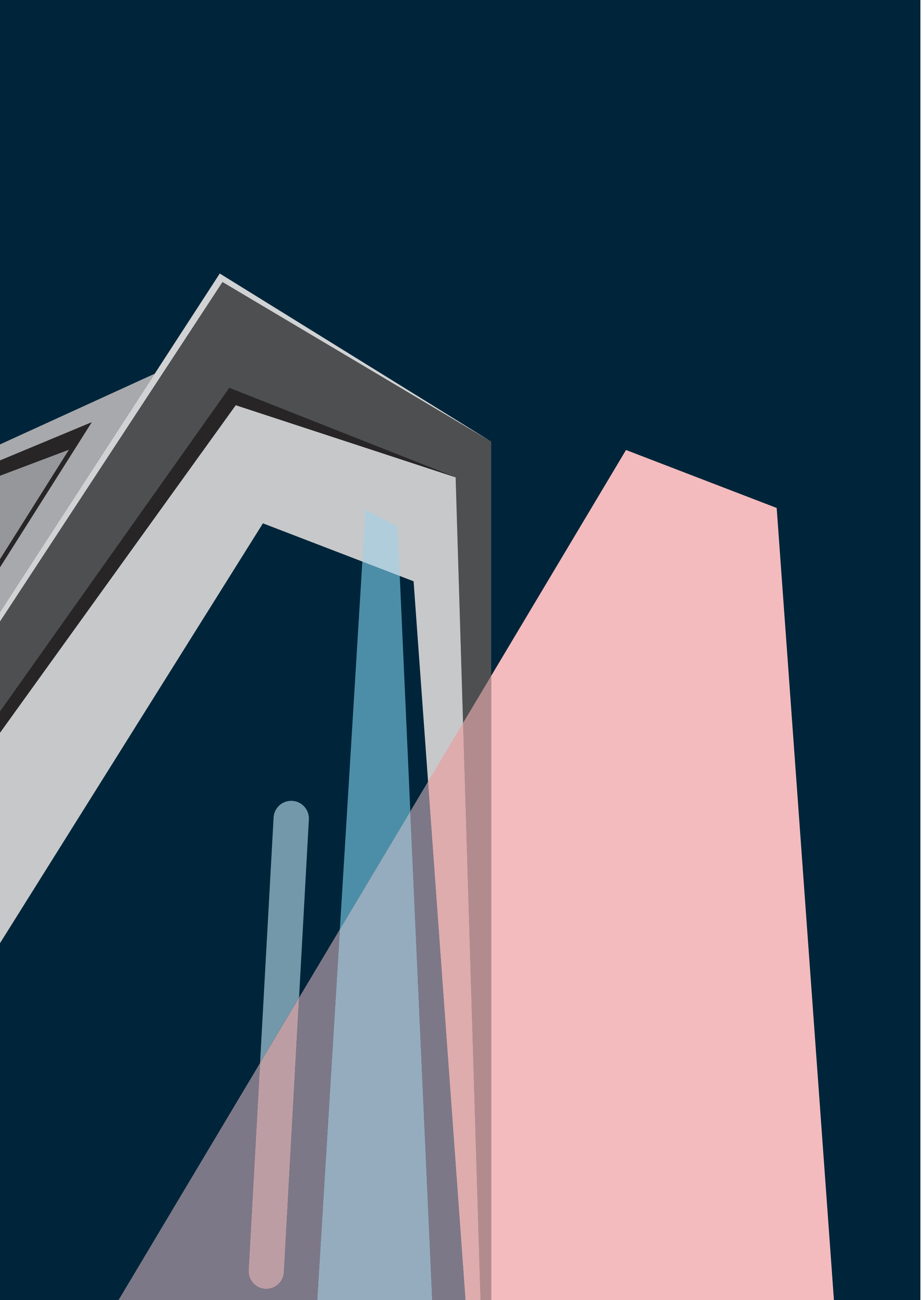
	(1)	(2)
	LPM	**LMP**
	All products $RCA_{i,c,t+4}$	All products $RCA_{i,c,t+4}$
$RCA_{i,c,t}$	0.539*** (0.011)	0.491*** (0.012)
$RCA_{i,c,t}$. Extractive Commodity Dummy	0.044*** (0.011)	0.107*** (0.012)
$(1- RCA_{i,c})^* E_{i,c}$		3.620*** (0.300)
$(RCA_{i,c})^* E_{i,c}$		5.727*** (0.367)
$(1- RCA_{i,c})^* E_{i,c}$. Extractive Commodity Dummy		-0.564* (0.294)
$(RCA_{i,c})^* E_{i,}$. Extractive Commodity Dummy		-3.421*** (0.442)
$E_{i,c,t}$	4.929*** (0.302)	
$E_{i,c,t}$. Extractive Commodity Dummy	-1.838*** (0.304)	
Constant	0.022*** (0.003)	0.038*** (0.004)
N	2,958,319	2,958,319
R-squared	0.412	0.413
Country Clusters	228	228

*** p<0.01, ** p<0.05, * p<0.1. Note: Country-clustered SEs are shown in parenthesis. All models include product, country, and year-specific fixed effects.

Table 4.9 . More controls based on Table 4.4: Governance effectiveness, inflation and log of GDP per capita² (CRE probit)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	All products $RCA_{i,c,t+4}$	All products $RCA_{i,c,t+4}$	All products $RCA_{i,c,t+4}$	Non-extractive $RCA_{i,c,t+4}$	Non-extractive $RCA_{i,c,t+4}$	Non-extractive $RCA_{i,c,t+4}$	Extractive $RCA_{i,c,t+4}$	Extractive $RCA_{i,c,t+4}$	Extractive $RCA_{i,c,t+4}$
$RCA_{i,c,t}$	0.284***	0.285***	0.286***	0.282***	0.283***	0.284***	0.366***	0.368***	0.367***
	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.007)	(0.007)	(0.007)
$(1\text{-RCA})^* E_{i,c,t}$	2.081***	2.050***	2.093***	2.055***	2.024***	2.065***	2.446***	2.399***	2.522***
	(0.175)	(0.179)	(0.179)	(0.174)	(0.179)	(0.179)	(0.386)	(0.378)	(0.393)
$(RCA)^* E_{i,c,t}$	2.413***	2.376***	2.384***	2.420***	2.384***	2.392***	1.376***	1.292***	1.334***
	(0.133)	(0.135)	(0.134)	(0.134)	(0.135)	(0.135)	(0.302)	(0.304)	(0.302)
Price Index (log)	-0.039***	-0.041***	-0.040***	-0.041***	-0.043***	-0.042***	0.013	0.011	0.011
	(0.011)	(0.011)	(0.011)	(0.011)	(0.011)	(0.011)	(0.016)	(0.016)	(0.015)
GDP per capita (log)	-0.014***	-0.039**	-0.012***	-0.014***	-0.038**	-0.012***	-0.017**	-0.095***	-0.015***
	(0.003)	(0.015)	(0.002)	(0.003)	(0.015)	(0.002)	(0.007)	(0.032)	(0.004)
Mining dependence	-0.009	-0.012*	-0.011*	-0.011*	-0.014**	-0.013**	0.052***	0.044***	0.052***
	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.015)	(0.015)	(0.016)
Energy dependence	-0.009	-0.010	-0.011	-0.009	-0.011	-0.011	0.022*	0.021*	0.023*
	(0.008)	(0.007)	(0.007)	(0.008)	(0.007)	(0.007)	(0.012)	(0.012)	(0.012)
Governance effectiveness	0.003			0.003			0.004		
	(0.004)			(0.004)			(0.008)		
Investment % of GDP(log)	0.013**	0.013**	0.012**	0.013**	0.014**	0.012**	-0.005	-0.004	-0.009
	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.014)	(0.013)	(0.015)
GDP per capita² (log)		0.002*			0.001*			0.005**	
		(0.001)			(0.001)			(0.002)	
Inflation (log)			-0.003			-0.003			-0.007
			(0.004)			(0.004)			(0.008)
Observations	2565851	2568498	2478424	2523911	2526537	2437826	41940	41961	40598

*** p<0.01, ** p<0.05, * p<0.10. Note: Country-clustered SEs are shown in parenthesis. Coefficients reported refer to marginal effects. All models include controls for product and year-specific effects.



CHAPTER 5

Is the Dutch Disease Well and Alive? A Cross-country Assessment of Mining Spillovers on Employment in the 2002-2014 Period

Abstract

According to the influential Dutch disease model of Corden and Neary (1982), the expansion of a booming extractive sector crowds out employment in key sectors (i.e., manufacturing). To this day, these potential negative labor spillovers remain a cause of concern for policymakers. Several empirical studies have looked at the effects of different resource booms on employment spillovers at the regional level in Australia, Chile, Canada, Sweden, and the US. While these papers provide valuable insights into the local dynamics of employment at the regional level, country-wide effects have been less studied. The present paper explores the employment spillovers that the expansion of the mining sector due to increased demand had on other non-mining sectors over the 2002-2014 period. We employ a sample of 40 countries from the WIOD dataset and we utilize a regression specification based on Moretti (2010), extended in Fleming & Measham (2014). We further extend the analysis by adopting a GMM model approach to address potential endogeneity issues. We use two measures for employment changes in the mining sector: one that captures changes due to domestic demand and another that captures changes due to exogenous sources of demand, i.e., exports, following the method described in Foster-McGregor (2019). We confirm the findings of previous regional studies: there is no evidence of negative spillovers on manufacturing jobs, regardless of the source of the expansion of mining jobs (domestic or exports). However, we do find evidence of negative effects in the agricultural sector and positive effects on construction and services employment. A comparison of these effects between countries with relatively high and low manufacturing output show that these are only significant in the latter countries; thus, negative and positive spillovers are expected to be observed only when manufacturing output is relatively low. Finally, we find that elasticities at the national level are moderate if compared to regional effects: an 10% increment in mining employment would lead to a 1%-2% increment in construction employment.

5.1 Introduction

Understanding the indirect effects, that extractive industries have on employment in other sectors at different scales has a two-fold motivation. Firstly, it allows for the assessment of the overall economic impacts of mining, i.e., oil, gas and mineral operations. The mining industry is well-known for its capital-intensive nature limiting direct employment opportunities, thus, understanding the magnitude of employment generation in other sectors sector is essential for policy makers. Measuring spillovers becomes even more relevant as mining operations move towards higher levels of automation which further reduce direct employment opportunities – a trend that will have stronger adverse effects for low-skilled jobs in developing countries (Cosbey et al., 2016; Leeuw & Mtegha, 2018).

This question has been particularly addressed at the regional level as many of the environmental and social costs related to the exploitation of extractive resources are locally observed. The assessment of positive spillovers of mining employment, consequently, is highly linked to social licensing and the relation with the local community where it takes place. Most empirical studies have addressed this matter by calculating indirect employment effects based on input-output methodologies (e.g. Aroca, 2001; Ejdemo & Söderholm, 2011). The underlying idea is that positive spillovers – even in key sectors, such as manufacturing – are possible if forward or backward linkages are well-developed (Morris et al., 2012). Equally important for indirect employment opportunities would be the extractive region's ability to offer (and ideally produce) consumption goods and services that are demanded by mining workers (GIZ, 2016).

Secondly, it allows for the assessment of a greater source of concern: that related to the Dutch disease (Corden & Neary, 1982). While the exploitation of natural resources, namely of energy and mineral commodities, offers the possibility to increase a country's income, it could also lead to negative employment effects on other tradeable good sectors especially in the manufacturing industry – ultimately pushing the country toward deindustrialization.
Corden & Neary's Dutch disease model (1982) considers a booming tradeable sector, i.e., extractives, and the lagging tradeable sector i.e., agriculture and manufacturing, as well as the non-tradeable sector, i.e., including, services in general, retail and construction. The model operates mainly through two effects: The first is *the resource movement effect*: the booming sector increases its demand for production factors, including labor, drawing out labor from the lagging tradeable sector. The direct impact of this effect is minimal as the extractive sector is a capital-intensive industry with low employment requirements. The second is the *spending effect*: The additional revenue brought about by the booming sector increases the demand for the non-tradeable sector, pushing prices up in this sector. This moves more labor away from the lagging sector toward the non-tradeable sectors. Moreover, the increased demand for the booming sector's commodities gives rise to a real exchange appreciation reducing the

competitiveness of the lagging sectors' exports, further shrinking manufacturing industries, and moving production toward the non-tradeable and booming sectors. In short: The Dutch disease predicts an expansion of the extractive and service sectors at the expense of the agriculture and manufacturing industries.

As theorized by Krugman (1987), Matsuyama (1992), and Torvik (2001), the Dutch disease phenomenon could translate into a long-term adverse loss of competitiveness and ultimately growth because of the lost opportunities of learning-by-doing which take place predominantly in the manufacturing sector. Sachs & Warner (1995) were the first of several scholars to empirically establish the negative relation between natural resources and growth[67]. Yet in recent years, others have provided empirical evidence showing that long-term growth is not hampered by the abundance of natural resources[68] (Alexeev & Conrad, 2009; Brunnschweiler & Bulte, 2008; Cavalcanti et al., 2019; James, 2015; Lederman & Maloney, 2007b). Furthermore, Gerelmaa & Kotani (2016) show that prior to the 1990s empirical evidence does support the Dutch disease hypothesis but not after. They explain that in the latter period (1990-2010), according to sector output, manufacturing had developed sufficiently– even in resource-rich countries – allowing countries to escape the effects of the Dutch disease.

The present study, thus, further investigates the effects of the Dutch disease but instead of focusing on sectoral output, it looks at employment growth in the manufacturing and other non-mining tradeable sectors (i.e. refining industries and agriculture). Moreover, this is done at the country level – an important departure from previous studies e.g. Fleming & Measham (2014, 2015); Moritz, Ejdemo, Söderholm, & Wårell, (2017); Weber, (2012, 2014) which provide valuable insights into these issues from a strictly regional perspective. However, there are some limitations when analyses are done at this level. As explained in Fleming and Measham (2014), regional studies may not capture macroeconomic effects of mining expansion where the high exchange rate triggered by increasing mining exports could negatively impact manufacturing and other tradeable sectors across the country – as predicted by the Dutch disease. Likewise, the expansion of mining production within a mining region may generate additional demand for services and products *outside* the mining region which would eventually translate into job creation; a regional study, in this case, would also fail to capture positive spillovers which occur in the same country but outside the region analyzed. While measuring negative and positive spillovers (if any) is a relevant consideration for policymakers, the main objective of this study is to explore whether the expansion of extractive activities, reflected in mining employment changes, leads to the detriment of non-mining tradeable sectors, i.e., manufacturing and agriculture, and the expansion of services as predicted by the Dutch disease.

For this, we make a distinction between employment creation due to foreign and domestic demand as the adverse effects of the expansion of mining in the Dutch disease are linked to foreign demand (and its subsequent rising exchange rates which hamper competitiveness in other tradeable sectors) but not necessarily to the expansion of mining due to internal demand. Thus, exploring the different employment spillovers – triggered by foreign and domestic demand of mining output – may lead to a better understanding of the overall costs and opportunities of mining expansion.

Specifically, we explore the following questions:

- What are the effects of employment growth in the mining sector (due to changes in demand) on non-mining sectors' employment growth?
- Are the effects different if the source of demand is foreign, i.e., exports, instead of domestic?

To explore the effects that the expansion of the mining sector had on other non-mining sectors over the 2002-2014 period, we employ a sample of 40 countries from the WIOD dataset. We utilize the regression specification based on Moretti, extended in Fleming & Measham (2014). We further extend the analysis by adopting a GMM model approach to address potential endogeneity issues. While we control for aggregate changes in total employment in mining, we use two measures that capture employment changes in mining *only* due to demand: one that captures changes due to domestic demand and another that captures changes due to exogenous sources of demand, i.e. exports, following the method described in Foster Mc-Gregor (2019).

Finally, we test whether the adverse effects of Dutch disease are less likely to materialize in countries where the manufacturing sector is high as suggested in Gerelmaa and Kotani (2016). For this, we split the sample based on the level of manufacturing output and observe if the estimated elasticities differ across groups.

The paper is structured as follows: The following section discusses empirical methods and evidence surrounding employment spillovers of extractive industries, it is followed by a section in which the data and methodology are explained in detail. The fourth section presents our empirical results and the last section concludes.

67 For a thorough survey of the literature of the Dutch disease and its evolution, see Badeeb, Lean, & Clark (2017).

68 These studies employ different measures to capture abundance of natural resources, for example: primary sector exports over GDP and total exports (Lederman & Maloney, 2007b); the GDP share of total natural resource and mineral resource exports (Brunnschweiler & Bulte, 2008) or oil and natural gas production as share of GDP (James, 2015). Furthermore, studies which have employed oil production or deposit specific measures (Alexeev & Conrad, 2009; Cavalcanti et al., 2011) have found overall positive effects on growth.

5.1.1 Empirical Background: Mining Operations Impacts on Labor

To evaluate the potential of local economic impacts of mining projects, ex-ante assessments, i.e., projections, of indirect employment effects (also referred to as multipliers) are typically based on input-output projections. In this vein, the World Bank refers to a generic benchmark for multipliers: for every job in the mining sector (including oil and gas) between 1 and 4 additional jobs are created in the local economy[69] (Eftimie et al., 2009).

Scholar's works have also employed this method in region-specific cases[70]. Aroca (2001) estimated that during the 1990s in the Chilean Region II (now Antofagasta), multipliers lay between 3.1 and 5.7 for private mining firms and between 1 and 1.7 for the rest of the mining sector. Ejdemo & Söderholm (2011) simulate the employment impacts of an iron ore project in Northern Sweden and find that for every 1 job in mining 1–1.5 jobs would be created elsewhere in the local economy. However, some consider that these projections are less reliable due to a number of assumptions that are necessary in input-output modeling, such as the unconstrained supply of labor and inputs – arguably an implausible scenario in most regions where extractive activities take place (let alone in a developing country). Weber (2012), for instance, points out that compared to ex-post econometric-based approaches, input-output projections in some regions in the US were upward biased. More importantly, input-output methods do not allow us to observe the crowd-out effects as contended by the Dutch disease.

For this, more recent scholarly works have focused on providing ex-post estimations of spillover effects of mining activities making use of different econometric techniques. Marchand (2012) analyzed mining operations in Western Canada during 1971–2006 and found that for every ten mining jobs created during boom periods, approximately three construction jobs, two retail jobs, and four and a half service jobs are created. Weber (2012, 2014) studied the effects of the greater natural gas production in the US in the 2000s concluding that gas production did little to crowd out manufacturing employment and that each mining-related job created more than one non-mining job. Another study in the Appalachia region of the US reached a similar conclusion: while there were marginal positive spillovers from the expansion of coal operations during the 1970s, there were no adverse effects on manufacturing (Black et al., 2005). Fleming & Measham (2014, 2015) analyzed local mining multipliers in different regions in Australia during 2001-2011. They find large positive impacts of mining expansion on employment in construction and services, i.e., professional, rental, and transport. They do not find crowding-out effects on manufacturing industries. Similar effects on services during the 2000s boom were identified in Northern Sweden by Moritz et al., (2017).

The above studies illustrate that at the regional level, indirect impacts of employment are concentrated in services; however, there are no signs of crowding out of manufacturing employment. This aligns with the findings of Cavalcanti, Da Mata, & Toscani (2019) who compare oil-rich municipalities with municipalities without oil in Brazil from 1940 to 2000 in a quasi-experiment setup. Unlike previous studies, they do find that oil operations have a significant negative relation to agriculture employment; namely, they identify that workers in low-productivity agriculture migrated to formal service sectors, increasing the overall wealth of those municipalities (Cavalcanti et al., 2019).

Empirical studies at the regional level provide sound evidence that, at least in the context of industrialized and emerging countries, there are few reasons to believe that the Dutch disease would hamper manufacturing. Nonetheless, there are several dynamics at the national level that cannot be captured at the regional level. As already mentioned, regional studies may not be able to capture aggregate Dutch disease effects which, therefore, require for the effects to be studied at the national level.

5.1.2 Data

Our data consists of a 13-year panel and 40 countries from the WIOD database. The sample includes 36 developed economies and 7 developing economies. The sample also includes top countries in terms of energy and mineral commodities production: Australia, Brazil, Canada, China, Indonesia, India, Mexico, Norway, Russia, and the US. This, however, does not imply that the rest of the economies do not have a mining sector. For instance, mining operations in Finland, Sweden, Poland, and the Netherlands (also included in the sample) have also important economic contributions during the period analyzed. All data employed in the following analysis is from WIOD unless indicated otherwise.

69 This figure is, however, based on South Australian mining operations (Eftimie et al., 2009). However, many such studies report local employment multipliers to be higher in less developed countries. For example, a GIZ meta-study reports that the median employment multiplier value of mining projects in Canada, Australia, Romania, New Zealand and South Africa is 1.92, but for Mali, Zambia and Tanzania the average reported value is 2.84 (GIZ, 2016). Another World Bank meta-study reports that indirect employment multipliers could be as high as 14 based on the Peruvian locality of Yanacocha (McMahon & Remy, 2002).

70 Note that the terms 'local' and 'regional' refer to sub-national levels. In the studies here cited, 'local' refers to the immediate vicinity in which mining operations take place without having a formal geographical delimitation. Thus, 'local' makes reference to a small administrative unit, such as town, city or district – rather than a large area. Studies region-specific focus refer to one or several specific administrative units, such as municipalities, states or provinces, where mining operations occur. For example, Ejdemo and Söderholm (2011) refer to the municipality of Pajala as 'Northern Sweden', whereas Marchand (2012) lists 8-17 provinces for the 'Western Canada' region.

5.2 Methodology

5.2.1 Mining employment growth measures

To be able to observe if employment expansion due to exports, as predicted by the Dutch disease, has different effects due to domestic demand, we follow the decomposition method of Foster-McGregor (2019) which in turn builds on Los, Timmer, & de Vries (2015), and Wang, Wei, Yu, & Zhu (2017). The method allows us to observe changes in employment growth at the national level specifically due to changes in demand levels. The description in this sub-section is a synthesized version of the method in the study of Foster-McGregor (2019).

Based on a basic input-output setup, we begin by defining the reconstruction of vector $\mathbf{k}$ – a vector that contains employment requirements, i.e., the ratio of employment to gross output, for each sector:

$$\mathbf{k} = \hat{\mathbf{p}}\mathbf{L}^{-1}\mathbf{f} \qquad (3)$$

where $\hat{\mathbf{p}}$ is a diagonalized matrix with the values of the $\mathbf{p}$ vector in the diagonal elements and zeros in all non-diagonal elements. The $\mathbf{p}$ vector expresses how much labor is required to produce an additional dollar in any given sector; this is derived by dividing all employment. A vector, $\mathbf{k}$, is then defined to capture the labor required in all stages of production of a final product. The matrix $\mathbf{L}$ is the well-known Leontief inverse matrix which shows by how much output rises in each sector of an economy when there is a one-dollar unit increase in final demand. $\mathbf{f}$ represents the final demand vector of any given sector. Thus, the reconstruction of the employment requirement k in (3) allows observing how employment labor requirements move as final demand changes, or as intermediate inputs changes according to the Leontief inverse matrix.

The decomposition then proceeds by constructing one plus the growth rate of employment, $\dot{\boldsymbol{k}}$, between two time periods (0 and 1) (or), which is expressed as follows:

$$1 + \dot{\boldsymbol{k}} = \frac{\boldsymbol{k}_1}{\boldsymbol{k}_0} = \frac{\hat{\boldsymbol{p}}_1\boldsymbol{L}_1\boldsymbol{f}_1}{\hat{\boldsymbol{p}}_0\boldsymbol{L}_0\boldsymbol{f}_0} \qquad (4)$$

To disentangle the drivers of employment growth in a given sector, the expression in (4) is further decomposed in this manner:

$$\frac{\hat{\boldsymbol{p}}_1\boldsymbol{L}_1\boldsymbol{f}_1}{\hat{\boldsymbol{p}}_0\boldsymbol{L}_0\boldsymbol{f}_0} = \frac{\hat{\boldsymbol{p}}_1\boldsymbol{L}_1\boldsymbol{f}_1}{\hat{\boldsymbol{p}}_0\boldsymbol{L}_1\boldsymbol{f}_1} \times \frac{\hat{\boldsymbol{p}}_0\boldsymbol{L}_1 f_1}{\hat{\boldsymbol{p}}_0\boldsymbol{L}_0 f_1} \times \frac{\hat{\boldsymbol{p}}_0\boldsymbol{L}_0\boldsymbol{f}_1}{\hat{\boldsymbol{p}}_0\boldsymbol{L}_0\boldsymbol{f}_0} \qquad (5)$$

with the first term on the right-hand side in this expression showing effects due to employment requirements (i.e., the ratio of employment to gross output); the second, interindustry input requirements; and the last one, final demand.

Based on Foster-McGregor (2019)[71], we then modify the decomposition to express the rates of employment growth:

$$\dot{\boldsymbol{k}} \approx \ln\left(\frac{\hat{\boldsymbol{p}}_1\boldsymbol{L}_1\boldsymbol{f}_1}{\hat{\boldsymbol{p}}_1\boldsymbol{L}_1\boldsymbol{f}_1}\right) + \ln\left(\frac{\hat{\boldsymbol{p}}_0\boldsymbol{L}_1\boldsymbol{f}_1}{\hat{\boldsymbol{p}}_0\boldsymbol{L}_0\boldsymbol{f}_1}\right) + \ln\left(\frac{\hat{\boldsymbol{p}}_0\boldsymbol{L}_0\boldsymbol{f}_1}{\hat{\boldsymbol{p}}_0\boldsymbol{L}_0\boldsymbol{f}_0}\right) \qquad (6)$$

We further decompose employment growth due to domestic final demand and production of exports as:

$$\dot{\boldsymbol{k}}^D \approx \ln\left(\frac{\hat{\boldsymbol{p}}_1\boldsymbol{L}_1\boldsymbol{f}_1^D}{\hat{\boldsymbol{p}}_1\boldsymbol{L}_1\boldsymbol{f}_1^D}\right) + \ln\left(\frac{\hat{\boldsymbol{p}}_0\boldsymbol{L}_1\boldsymbol{f}_1^D}{\hat{p}_0 L_0 f_1^D}\right) + \ln\left(\frac{\hat{\boldsymbol{p}}_0\boldsymbol{L}_0\boldsymbol{f}_1^D}{\hat{\boldsymbol{p}}_0\boldsymbol{L}_0\boldsymbol{f}_0^D}\right) \qquad (7)$$

$$\dot{\boldsymbol{k}}^E \approx \ln\left(\frac{\hat{\boldsymbol{p}}_1\boldsymbol{L}_1\boldsymbol{f}_1^E}{\hat{\boldsymbol{p}}_1\boldsymbol{L}_1\boldsymbol{f}_1^E}\right) + \ln\left(\frac{\hat{\boldsymbol{p}}_0\boldsymbol{L}_1\boldsymbol{f}_1^E}{\hat{p}_0 L_0 f_1^E}\right) + \ln\left(\frac{\hat{\boldsymbol{p}}_0\boldsymbol{L}_0\boldsymbol{f}_1^E}{\hat{\boldsymbol{p}}_0\boldsymbol{L}_0\boldsymbol{f}_0^E}\right) \qquad (8)$$

The measures we will use for the present analysis will then take the last term on the right-hand in (7) and (8) which express changes in the rate of employment growth due to changes in $\boldsymbol{f}^D$, i.e., domestic final demand, and changes in $\boldsymbol{f}^E$, in exports in the case of the mining sector. Since the latter terms only capture a subset of the changes in total mining employment, we also control for the effects of changes in total mining employment, i.e. $\dot{\boldsymbol{k}}$ in (6), in some of our specifications.

71 For brevity purposes, the $\hat{\boldsymbol{p}}$ matrix is not disaggregated as it is originally done in Foster-McGregor (2019).

5.2.2 Econometric approach

The econometric approach we employ is based on Fleming & Measham (2014) – which is an extension of the elasticities model originally put forth by Moretti (2010) to quantify jobs in a city's tradable and non-tradable sectors due to exogenous increments in the number of jobs in the tradable sector. While this model was initially carried out at the city level, it has also been applied to analyze positive and negative spillover effects in studies at the regional level in mining regions in Australia, Canada, Sweden, and the US (Black et al., 2005; Fleming & Measham, 2014, 2015; Marchand, 2012; Moritz et al., 2017).

The reduced form model in Moretti (2010) is:

$$\ln E^{NM}_{c,t+1} - \ln E^{NM}_{c,t} = \alpha + \beta(\ln E^{M}_{c,t+1} - \ln E^{M}_{c,t}) + \delta year_t + \varepsilon_{c,t} \quad (9)$$

where $\ln E^{NM}_{c,t+1} - \ln E^{NM}_{c,t}$ is the change in the growth rate of sector-specific (non-mining) employment, e.g., manufacturing or agriculture, in country c between time t and time $t+1$. This would be equivalent to obtaining the yearly difference of employment growth of a given sector as captured in $\dot{k}$ as defined in equation (6). Similarly, $\ln E^{M}_{c,t+1} - \ln E^{M}_{c,t}$ is the change in the growth rate for mining employment. To control for structural changes (including macroeconomic adjustments or employment shocks) across years, the dummy variable $year$ is included. $\varepsilon_{c,t}$ is the error term.

Since we are interested in exploring the expansion of mining employment as the result of a booming export sector, we distinguish changes in the employment growth rate in the mining sector due to domestic demand $\ln E^{MDD}_{c,t+1} - \ln E^{MDD}_{c,t}$ from mining employment growth due to exports, $\ln E^{MX}_{c,t+1} - \ln E^{MX}_{c,t}$. These latter terms, thus, refer to the yearly difference of the last term on the right-hand side of equations (7) and (8), respectively.

To control for variables that may influence changes in employment indicators, we include a matrix of covariates, $\boldsymbol{X}$, which are country- and year-specific. This includes the GDP per capita growth and the ratio of energy to non-energy commodities[72,73].GDP per capita growth is included to control for procyclical responses; naturally, some sectors will be more strongly correlated with economic growth, e.g., construction services, than others, e.g., public services. Furthermore, the ratio of energy to non-energy commodities is included to control for the heterogeneous impacts of energy commodities relative to non-energy commodities. As identified in Foster-McGregor et al. (2018), the former commodities have adverse economic effects and the latter do not. It would be plausible then that higher energy to non-commodity ratio is linked to lower employment in key sectors such as manufactures.

This results in the following:

$$\ln E^{NM}_{c,t+1} - \ln E^{NM}_{c,t} = \alpha + \beta(\ln E^{MDD}_{c,t+1} - \ln E^{MDD}_{c,t}) + \gamma(\ln E^{MX}_{c,t+1} - \ln E^{MX}_{c,t}) + \gamma(\ln E^{M}_{c,t+1} - \ln E^{M}_{c,t}) + \theta' \boldsymbol{X}_{c,t} + \delta year_t + \varepsilon_{c,t} \quad (2)$$

where β and γ are the parameters measuring the elasticity between mining employment due to domestic demand and due to exports and non-mining sector jobs. In other words, when jobs in the mining sector due to exports grow by 1%, the non-mining sector in the question sector grows by γ %.

Several papers following Moretti (2010) have empirically isolated the causal effect of the employment of the mining sector on employment in the non-mining sector by employing an instrumental variable approach. Fleming et al., (2015), for instance, employ the number of coal seam wells as an instrument to better capture the change in mining employment due to the expansion of the mining projects and reduce the potential endogeneity issues. While we use decomposition measures that 'isolate' the effects of different demand sources on employment, these may still be subject to endogeneity. For this, we also address potential endogeneity in our analysis which may occur due to reverse causality as the direction of employment spillovers can go both ways. For instance, construction employment can expand as the result of the expansion of mining as building a mine naturally requires construction inputs. But it could also work in the opposite direction: the expansion of construction requires cement, steel, and other inputs which eventually result in higher demand for mining inputs and therefore mining employment. Our empirical strategy thus uses a system-GMM model (i.e., the Arellano–Bover/Blundell–Bond dynamic panel model) to reduce potential endogeneity issues – which are more likely to arise in a country-level setup. The system-GMM model allows us to provide consistent estimators even in the presence of simultaneity and other issues such as unobserved heterogeneity[74]. Our GMM estimations are also compared to estimations using OLS and fixed-effects models. The results are calculated using year-by-year changes as indicated in the model. For the last part of our analysis, where we test if the effects of Dutch disease are less likely to appear in countries with a higher level of manufacturing, we split the sample based on the level of manufacturing output. A dummy variable is used to identify the countries with higher manufacturing output based on the initial median value of the share of manufacturing output

72 GDP data is taken from the World Development Indicators. The ratio is calculated using the logarithm of production values for fuel (coal, oil and gas) and nonfuel mining commodities (aluminum, iron, steel, copper, gold, silver, nickel, tin, and zinc) from Thibault Fally's dataset on Commodity Trade.

73 We employ other controls, i.e., regional dummies and a developing country status dummy, specifications but were not significant so they were excluded from the estimation reported.

74 The GMM estimator works by removing the "effect" of past values (or alternatively average values of future observations to avoid losing information) of the variables (Roodman, 2009a); this adjustment furthermore allows for the lagged values of the dependent variable to be used as *internal* instruments.

in GDP (27%) using data from WIOD[75]. The estimation consists of a similar GMM approach to the one applied earlier; however, we interact this dummy variable with the explanatory variables of interest (i.e., changes in total mining employment, due to domestic demand, and due to exports). By including these interaction terms we can distinguish the differences in elasticities across the two groups while avoiding the issue of instrument proliferation we would have if we split the sample in two groups[76].

5.3 Results

Table 5.1 presents summary statistics. As can be seen, the highest variation in log employment values is found in refining activities followed by agriculture and mining. The lowest variation was then seen in the public services and services sectors. The terms that capture changes in mining employment due to domestic demand or to exports also show high variation – especially if this is due to exports.

Table 5.1. Summary Statistics

Variable	N	Mean	SD	Min	Max
Mining employment (log)	480	1.00	0.11	0.50	1.52
Mining employment due to changes in domestic demand (log)	480	1.09	0.17	0.08	2.03
Mining employment due to changes in foreign demand (log)	480	1.11	0.19	0.36	2.26
Manufacturing employment (log)	480	1.00	0.06	0.77	1.33
Refining activities employment (log)	474	1.01	0.27	0.00	3.25
Agriculture employment (log)	480	1.00	0.11	0.72	2.70
Construction employment (log)	480	1.01	0.08	0.66	1.40
Services employment (log)	480	1.03	0.05	0.91	1.47
Public services employment (log)	480	1.02	0.03	0.92	1.18
GDP per capita (log)	480	9.97	0.93	6.83	11.42
Energy to non-energy mining production value ratio (log)	480	-0.81	2.88	-4.61	15.50
Share of manufacturing output in total gross output	480	0.25	0.08	0.08	0.49
Observations	480				

75 For instance, countries below the established threshold for manufacturing output include Australia, Canada, Great Britain, Netherlands, Portugal and Russia; likewise, countries above the threshold include Germany, Indonesia, Japan, Korea, and Mexico.

76 In a GMM estimation if the number of instruments is larger than the number of panels (in this case, countries), one incurs an issue of instrument proliferation. This results in the overfitting of endogenous variables reducing the reliability of the estimations (Roodman, 2009b). While a possibility is to restrict the number of instruments, GMM estimates are highly sensitive to how said is done. By estimating the GMM model with the whole sample using interaction terms it is possible to distinguish effects across groups (as it would by splitting the sample) but with the same set of instrument restrictions which provides more efficient estimations.

The average change in growth rates for all countries in each of the selected sectors can be seen in Figure 5.1. The figure shows the contraction of mining employment due to foreign and domestic demand following the financial crisis and the expansion following recovery. This trend was closely followed by manufacturing, construction, and refining activities and to a lesser extent by services.

Figure 5.1 also, shows that when commodity prices peaked in 2012, there was a contraction of mining employment due to domestic and foreign demand which was not seen in other sectors. Finally, while it is difficult to establish a clear average trend, the agriculture and public services sector experienced less movement and in the opposite direction after 2008.

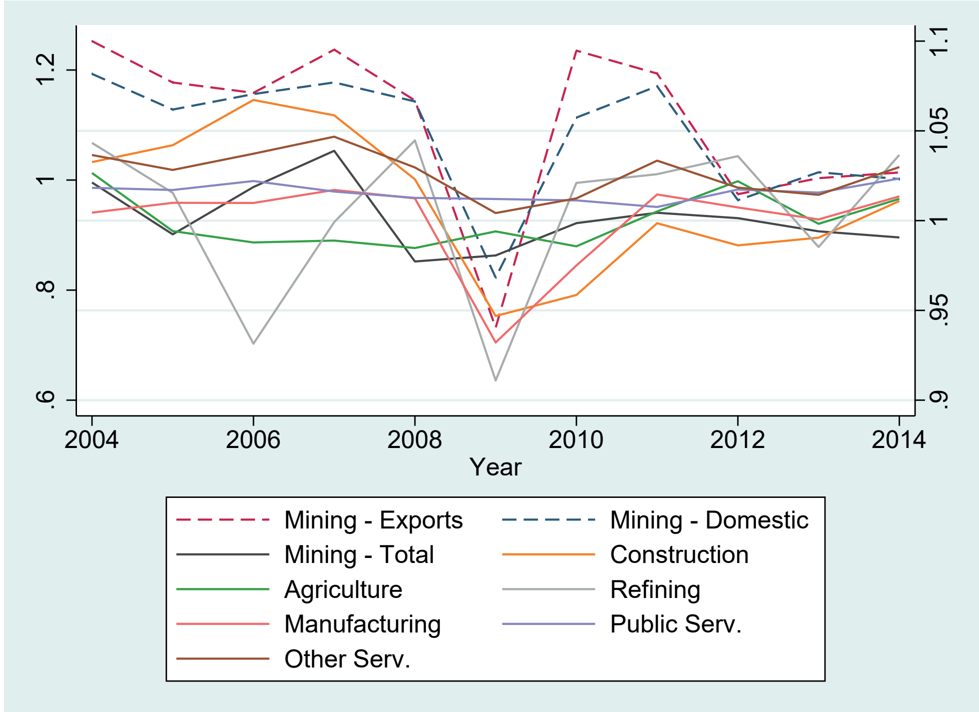


Figure 5.1. Total employment (in logs) of mining and selected sectors, and the subset of employment (in logs) due to domestic demand and exports
Source: Author's elaboration with WIOD data.
Note: The y-axis on the left corresponds to the scale of total employment in mining (total), construction, agriculture, refining activities, manufacturing, public services, and services; and the y-axis on the right to subset of employment in the mining sector either due to exports or to domestic demand.

Having discussed the overall trends, we will now present the results of the econometric analysis: first, the effects of aggregate mining employment on non-mining sectors employment followed by the effects of domestic demand and foreign demand separately.

Results in Columns 1, 2, and 4 in Table 5.2 indicate that the aggregate mining employment effects on manufacturing and refining employment are not significant in any of the models. In the case of mining employment expansion due to domestic demand, the results for the OLS and FE models (Columns 1 and 2) indicate a positive relationship with the creation of manufacturing jobs, significant at the 10% level. Namely, the results indicate that a 10% increment in mining employment due to domestic demand correlates with an additional 0.21-0.26% employment in the manufacturing sector[77]. This effect, however, loses significance in the GMM model (Columns 3 and 4) – a somewhat expected result due to potential simultaneity bias which is not addressed in the FE/OLS models.

More importantly, however, is that our results do not show any significant negative effects for mining employment growth due to foreign demand. Controls indicate that GDP is positively linked to manufacturing employment – a result that is consistently positive in all models (columns 1-3). Lastly, we do not find a negative effect on the ratio of energy to non-energy commodities on manufacturing employment; the coefficient is positive but is only significant in the FE estimation (Column 2).

Based on our results, thus, we find no evidence to support the notion that expanding domestic employment in the mining sector would lead to reduced employment in the manufacturing sector, as hypothesized in the Dutch disease. Our results moreover, align with the body of regional studies that do not find any detrimental effects on manufacturing activities (e.g. Black et al., 2005; Cavalcanti et al., 2019; Moritz et al., 2017).

Regarding refining activities, coefficients in columns 5-8 from Table 5.2 show that, on average, growth of employment in mining – regardless of the source of demand or as an aggregate - does not translate into significant negative or positive effects for that sector's employment. Likewise, the energy to non-energy ratio is insignificant. Lastly, GDP per capita growth had a negative effect significant at the 10% in the FE model (column 6) – the effect however disappears in the other specifications including GMM models.

The above suggests that mining extraction activities are decoupled from mineral processing activities – which is not necessarily negative per se: in primary sectors, including mining, processing activities do not always generate greater domestic value-added (Korinek, 2020). However, from a policy perspective, it should not be assumed that the expansion of mining projects will lead to higher employment opportunities in downstream sectors, as our results demonstrate.

77 While our preferred specification is the GMM, it is worth mentioning about the interpretation of the OLS/FE results: Given the low levels in mining employment, a 10% change in absolute number of jobs is relatively small, but a 0.26% increase in manufacturing jobs would be much larger as well as its overall impacts as manufacturing is more important in the economy. In this case, however, due to potential simultaneity, these elasticities are best interpreted as a correlation.

Table 5.2. Results for manufacturing and refining activities

	1	2	3	4	5	6	7	8
	Δ Manufacturing employment (log)				Δ Refining activities employment (log)			
	OLS	Fixed Effects	GMM	GMM	OLS	Fixed Effects	GMM	GMM
Δ Mining employment – total (log)	0.0230	0.0234		-0.0619	0.203	0.194		0.568
	(0.97)	(0.83)		(-1.28)	(1.41)	(1.18)		(1.28)
Δ Mining employment - Domestic demand (log)	0.0267**	0.0214*	0.0390	0.103	-0.0275	-0.0153	-0.358	-0.431
	(2.30)	(1.69)	(0.80)	-1.4	(-0.29)	(-0.17)	(-1.18)	(-1.33)
Δ Mining employment - Exports (log)	0.0204	0.0179	0.0159	0.0315	-0.0453	-0.0402	-0.139	-0.0526
	(1.27)	(1.17)	(0.92)	-1.12	(-0.63)	(-0.41)	(-1.25)	(-0.36)
Δ GDP p.c. (log)	0.306***	0.523***	0.687***	0.122	-0.925	-1.711*	1.245	1.096
	(3.12)	(7.24)	(3.39)	-0.28	(-1.43)	(-1.89)	(0.60)	(0.53)
Energy to non-energy mining value ratio	0.00107	0.00522***	0.000599	0.000584	-0.000483	0.00233	-0.000226	0.000298
	(0.85)	(7.35)	(0.69)	-0.53	(-0.61)	(0.22)	(-0.09)	(0.13)
Δ Manufacturing employment (log), t-1	-0.553***	-0.568***	-0.448***	-0.462***				
	(-7.54)	(-8.00)	(-3.92)	(-3.71)				
Δ Refining activities employment (log), t-1					-0.435***	-0.438***	-0.154**	-0.149*
					(-4.88)	(-14.14)	(-2.41)	(-1.80)
Constant	0.0564***	0.00297	0.0528***	-0.0413	-0.170**	0.0726*	0.0349	0.0749
	(6.00)	(0.35)	(3.23)	(-1.41)	(-2.53)	(1.93)	(0.55)	(0.87)
N	440	440	440	440	429	429	429	429
R-sq	0.466	0.493			0.245	0.249		
adj. R-sq	0.446	0.474			0.216	0.220		
Time effects								
Fixed effects								
Sargan p-value			0.0000113	0.000908			0.0000136	0.0000422
Hansen p-value			0.644	0.228			0.409	0.365
AR1 p-value			0.0123	0.0305			0.0153	0.0174
AR2 p-value			0.233	0.535			0.626	0.690
Instruments (j)			37	37			37	37

*** p<0.01, ** p<0.05, * p<0.10; t-statistics in parentheses.

Table 5.3 indicates that changes in mining employment in total do not have any significant effects on employment within agriculture (including forestry and fisheries). The same holds for changes in mining employment due to domestic demand where no significant effects are found possibly due to the lack of strong linkages and/or complementarities among natural resource sectors (i.e., mining and agriculture).

However, when it comes to changes in mining employment due to exports, the results suggest a negative impact upon agriculture jobs. Although effects in Columns 1-3 in Table 5.3 are insignificant and negative, the coefficient turns significant at the 10% level once the control for aggregate changes in the mining sector is introduced in the GMM model (Column 4). The negative elasticities suggest that a 10% increment in mining employment due to exports is linked to a reduction of agricultural employment equivalent to 0.8%. This aligns with previous empirical studies which suggest that the expansion of mining activity in a region can crowd out employment in the agricultural sector (Fleming & Measham, 2015). Nonetheless, the coefficients in our estimations indicate that at the national level effects are considerably smaller if compared to regional effects[78]. GDP per capita growth coefficients – insignificant in all models – show that the sector has little procyclicality – an expected result given the inelasticity in demand for agricultural products.

Moving forward to construction, our results indicate that changes in total mining employment have no significant impact upon employment in this sector, as seen in Columns 5, 6, and 8 in Table 5.3. The same is observed for changes due to exports (Columns 5-8).

Nevertheless, changes in mining employment due to domestic demand show a positive and significant effect on construction jobs across all models; generally speaking, housing demand and infrastructure investments are highly linked to mining activity (Measham et al., 2014). According to the elasticities in Table 5.3, a 10% increment in mining employment due to domestic demand are linked to an increment of 0.5%-0.6% in construction employment based on the OLS and FE estimations (significant at the 10% and 1% level, respectively). More importantly, our preferred specifications (GMM) suggest that a 10% increment in mining employment due to domestic demand is linked to an increment of 1.6%-1.9% in construction employment (significant at the 5% level). While the effects are consistent with those identified in regional studies, they are somewhat smaller[79].

Lastly, similar to the case of manufacturing, the coefficients on GDP per capita growth are positive and significant across all models which suggests a strong procyclical behavior of the sector, as expected.

78 Using two-stage least square estimations, Fleming et al. (2015), calculate a -0.34 elasticity between these sectors in selected regions in Australia; in other words, a 10% expansion of coal seam gas employment would lead to a reduction of 3.4% reduction of employment in the agricultural sector.

79 In Measham (2012), the calculated elasticity for construction is around 0.5 for two boom periods (1997-2006) in the US.

Table 5.3. Results for agriculture and construction activities

	1	2	3	4	5	6	7	8
	Δ Agriculture employment (log)				Δ Construction activities employment (log)			
	OLS	Fixed Effects	GMM	GMM	OLS	Fixed Effects	GMM	GMM
Δ Mining employment – total (log)	-0.0368	-0.0394		-0.107	0.0309	0.0367		-0.0782
	(-0.62)	(-0.47)		(-0.68)	(1.27)	(1.65)		(-0.79)
Δ Mining employment - Domestic demand (log)	0.00115	0.000890	-0.394	-0.364	0.0643***	0.0540*	0.158**	0.186**
	(0.05)	(0.04)	(-1.34)	(-1.31)	(3.40)	(1.79)	(2.49)	(2.41)
Δ Mining employment - Exports (log)	-0.0325	-0.0328	-0.0714	-0.0843*	0.00421	-0.00203	0.0115	0.00255
	(-1.21)	(-1.60)	(-1.36)	(-1.90)	(0.28)	(-0.13)	(0.44)	(0.08)
Δ GDP p.c. (log)	-0.0196	0.00557	-0.868	-0.937	0.707***	1.160***	0.587**	0.486*
	(-0.08)	(0.02)	(-0.97)	(-0.95)	(5.04)	(5.21)	(2.13)	(1.76)
Energy to non-energy mining value ratio	-0.000488	-0.00291	0.000998	0.000945	0.00171	0.00987***	0.00158	0.00159
	(-0.15)	(-0.94)	(0.74)	(0.69)	(0.80)	(12.70)	(0.90)	(0.92)
Δ Agriculture employment (log), t-1	-0.450**	-0.450***	-0.461***	-0.467***				
	(-2.17)	(-6.12)	(-4.70)	(-4.97)				
Δ Construction activities employment (log), t-1					-0.275***	-0.326***	-0.249	-0.262
					(-3.95)	(-6.15)	(-1.41)	(-1.38)
Constant	0.0147	0.00101	0.0290	0.0336	0.0251	0.00744	-0.00165	0.00415
	(0.96)	(0.07)	(0.73)	(0.78)	(1.63)	(0.86)	(-0.11)	(0.26)
N	440	440	440	440	440	440	440	440
R-sq	0.223	0.224			0.314	0.379		
adj. R-sq	0.194	0.195			0.288	0.355		
Time effects	Yes	Yes			Yes	Yes		
Fixed effects	No	Yes			No	Yes		
Sargan p-value			0.567	0.494			0.00362	0.0132
Hansen p-value			0.131	0.195			0.222	0.309
AR1 p-value			0.0101	0.0123			0.0584	0.0368
AR2 p-value			0.602	0.556			0.810	0.777
Instruments (j)			37	37			37	37

*** p<0.01, ** p<0.05, * p<0.10; t-statistics in parentheses.

Table 5.4 presents the results for services, which encompasses two aggregate sectors – services (which includes retail and various professional services) and public services[80]. First, we find that for changes in total mining employment there are no significant effects on services and public services (Columns 1-4 and 5-8, respectively). Similarly, the coefficients for mining employment changes due to domestic demand are insignificant also in both services and public services.

In the case of services, changes in mining employment due to exports do have a positive and significant elasticity. As shown in Table 5.4, a 10% increment in mining employment due to domestic demand is linked to a 0.1%-0.2% increment in services employment based on the OLS and FE estimations (Columns 1 and 2), significant at the 10% and 1% level, respectively. Our preferred specification., i.e., the GMM models (in Columns 3 and 4) indicate a similar effect, i.e., a 10% increment in mining employment due to exports results in a 0.2% increment in service employment. This aligns with previous empirical studies which find positive effects for professional and retail services (e.g. Marchand, 2012; Moritz et al., 2017). Moreover, this positive effect on service employment provides support to the predicted effects of Dutch disease (i.e., expansion of services as a result of higher mining exports), but the effects are not particularly pronounced at the national level.

Moving on to public services, the results are different to those for construction and services. Although the OLS and FE models indicate a positive and significant elasticity (at the 1% and 10%, respectively), elasticities in the GMM models are not significant. This result aligns with previous studies that have failed to find any mining employment spillovers on government employment (Moritz et al., (2017)

Lastly, the ratio of energy to non-energy commodities is not significant in most models – including the GMM specifications. The GDP per capita growth coefficients which appear positive and significant in the OLS and FE models (Columns 1-2 and 5-6) suggest some procyclicality of employment in services and public services; yet these are not significant in the GMM models.

80 See Annex for details on which sectors are considered in this category.

Table 5.4. Results for services: services, and public services

	1	2	3	4	5	6	7	8
	Δ Services employment (log)				Δ Public services activities employment (log)			
	OLS	Fixed Effects	GMM	GMM	OLS	Fixed Effects	GMM	GMM
Δ Mining employment – total (log)	0.0106	0.0121		-0.0273	0.0178	0.0176		0.00701
	(0.63)	(0.60)		(-0.56)	(1.26)	(1.53)		(0.15)
Δ Mining employment - Domestic demand (log)	-0.00469	-0.0104	-0.0314	-0.0256	-0.00417	-0.00533	-0.0248	-0.0266
	(-0.44)	(-1.29)	(-0.68)	(-0.54)	(-0.44)	(-0.66)	(-0.74)	(-0.78)
Δ Mining employment - Exports (log)	0.0211**	0.0176***	0.0232**	0.0205*	0.0192**	0.0188***	0.0158	0.0167
	(2.02)	(3.39)	(2.22)	(1.97)	(2.25)	(2.78)	(1.65)	(1.62)
Δ GDP p.c. (log)	0.209**	0.494***	0.407	0.387	0.171***	0.229**	0.392	0.392
	(2.07)	(3.14)	(1.37)	(1.33)	(2.60)	(2.12)	(1.58)	(1.59)
Energy to non-energy mining value ratio	0.00104	0.00387***	0.000791	0.000765	0.000459	0.000927	0.000286	0.000293
	(1.10)	(6.70)	(1.29)	(1.30)	(0.89)	(1.31)	(0.72)	(0.74)
Δ Services employment (log), t-1	-0.347***	-0.366***	-0.124	-0.0969				
	(-3.92)	(-14.80)	(-0.90)	(-0.70)				
Δ Public services activities employment (log), t-1					-0.439***	-0.450***	-0.251	-0.253
					(-6.42)	(-10.66)	(-1.31)	(-1.34)
Constant	0.0210***	0.00697	0.0164*	0.0163*	-0.00653	0.00303	-0.0118	-0.0119
	(3.10)	(0.88)	(1.98)	(2.00)	(-1.12)	(0.65)	(-0.97)	(-0.96)
N	440	440	440	440	440	440	440	440
R-sq	0.261	0.317			0.250	0.264		
adj. R-sq	0.233	0.291			0.221	0.236		
Time effects	Yes	Yes			Yes	Yes		
Fixed effects	No	Yes			No	Yes		
Sargan p-value			0.134	0.138			0.0644	0.0456
Hansen p-value			0.302	0.298			0.317	0.265
AR1 p-value			0.00903	0.00864			0.0176	0.0132
AR2 p-value			0.691	0.719			0.752	0.742
Instruments (j)			37	37			37	37

*** p<0.01, ** p<0.05, * p<0.10; t-statistics in parentheses.

5.3.1 Differences across countries according to manufacturing levels

In this last part of the analysis, we explore differences in elasticities across countries with a higher level of manufacturing. The dummy variable *manufacturing* is assigned to the group with a higher level of manufacturing output[81]. To adequately interpret results in this subsection consider the following: the GMM models presented contain non-interaction terms of our variables of interest, i.e., changes in mining employment - either total or due to changes in domestic demand or exports. Coefficients of non-interacted terms, e.g., *Δ Mining employment – total (log),* have a direct interpretation; they are the estimated elasticity for the group of countries with relatively lower manufacturing output. The interaction terms with the manufacturing dummy, e.g. *Δ Mining employment – total (log) * manufacturing*, capture the difference among the lower and higher manufacturing countries. The elasticity in this latter group, then, is derived from the sum of the estimated coefficient of the non-interaction term (i.e. the estimate for the countries with lower manufacturing) and the estimated coefficient of the interaction term.

Having explained the interpretation of interaction terms, we proceed to discuss the results in Tables 5.5 to 5.7. For manufacturing employment, we do not find any statistical difference among the two groups as can be seen in Columns 1-3 in Table 5.5. This then confirms our previous findings as well as other empirical evidence that fails to identify evidence of negative spillovers in manufacturing as mining employment grows.

For refining activities, in Column 4, however, we find a positive elasticity for mining employment due to domestic demand on refining employment (significant at the 10% level). Yet, as we control for mining employment in Columns 5-6, the significance disappears. These results highlight that it should not be assumed that the expansion of mining employment resulting from higher demand would translate into positive spillovers in jobs in downstream industries. Nevertheless, it cannot be ruled out that this possibility could materialize more easily in countries with stronger manufacturing industries – as the elasticity in Column 4 suggests.

81 Recall that this is done on the basis of median values of manufacturing output in 2000. This means that those countries above the median value of manufacturing have the value of 1, and labeled *manufacturing,* otherwise, they have the value of 0.

Table 5.5. Results – Manufacturing and refining activities employment with interactions term for countries with higher manufacturing

	1	2	3	4	5	6
	Δ Manufacturing employment (log)			Δ Refining activities employment (log)		
	GMM	GMM	GMM	GMM	GMM	GMM
Δ Mining employment – total (log)		-0.0871 (-1.00)	-0.0748 (-0.88)		1.163 (1.41)	0.733 (1.13)
Δ Mining employment – total (log) * *manufacturing*		-0.0329 (-0.13)	-0.0000424 (-0.00)		-1.308 (-1.30)	-0.868 (-1.01)
Δ Mining employment - Domestic demand (log)	0.0372 (1.20)	0.0461 (0.92)	0.0494 (0.91)	-0.227 (-1.05)	0.120 (0.20)	-0.268 (-0.94)
Δ Mining employment - Domestic demand (log) * *manufacturing*	-0.0363 (-0.89)	-0.0529 (-1.39)	-0.0601 (-1.19)	0.480* (1.84)	-0.399 (-0.88)	0.202 (0.65)
Δ Mining employment - Exports (log)	0.00322 (0.23)	-0.000760 (-0.04)	-0.00188 (-0.08)	-0.0159 (-0.18)	0.00308 (0.01)	-0.179 (-0.33)
Δ Mining employment - Exports (log) * *manufacturing*	0.0198 (0.81)	0.0276 (1.05)	0.0196 (0.63)	-0.177 (-1.20)	-0.0266 (-0.13)	-0.368 (-0.75)
Energy to non-energy mining value ratio			0.00673 (0.56)			0.00414 (0.98)
Energy to non-energy mining value ratio * *manufacturing*			-0.00736 (-0.50)			-0.0115 (-0.75)
Δ GDP p.c. (log)	0.471** (2.19)	0.304 (0.54)	0.805 (1.36)	-1.083 (-0.90)	4.452 (0.93)	1.546 (0.27)
Δ Manufacturing employment (log), t-1	-0.503*** (-7.69)	-0.418** (-2.19)	-0.430* (-1.69)			
Δ Refining activities employment (log), t-1				-0.422*** (-9.17)	0.0900 (0.82)	-0.158 (-0.92)
Constant	-0.0212 (-1.02)	-0.0566** (-2.43)	-0.0317 (-1.17)	0.0959 (0.86)	-0.0165 (-0.06)	0.0451 (0.54)
Observations	440	440	440	429	429	429
Sargan p-value	0.0000016	0.00504	0.00870	4.27e-12	0.0121	0.0000535
Hansen p-value	0.304	0.208	0.138	0.192	0.418	0.439
AR1 p-value	0.0398	0.0369	0.0570	0.0233	0.0299	0.0112
AR2 p-value	0.895	0.339	0.496	0.0376	0.218	0.714
Instruments (j)	37	37	37	37	37	37

*** p<0.01, ** p<0.05, * p<0.10; t-statistics in parentheses.

Our results suggest that mining employment expansion does crowd out employment in agriculture but only in countries with a lower level of manufacturing – as seen in Table 5.6. While in Column 1 the results are not significant, as further controls are introduced, the elasticity of mining employment due to exports becomes significant at the 10% level. In Column 3, the total mining employment coefficient remains negative and becomes significant at the 1% level. The results for the interacted terms remain insignificant in all cases, implying that the crowding-out effect does not appear in countries with higher manufacturing output.

According to Column 3 in Table 5.6, a 10% increment in mining employment would be linked to a 4% reduction in agriculture employment in countries with lower shares of manufacturing. If the elasticity for mining employment due to exports is considered, a 10% increase in mining employment would lead to a 1% reduction in agriculture employment – which is about twice the effect calculated in the estimation with all countries (Table 5.3).

Fleming and Measham (2015) find similar results in Queensland, Australia for the 2001-2011 period, and explain that workers in agriculture moved to the local mining sector, services, or construction. While it is not possible to assume this happened across our sub-sample of countries, it could be a plausible explanation. The exact mechanisms behind these labor movements happen in countries with lower shares of manufacturing are not entirely clear. Yet, a possibility would be that in more manufacturing-intensive countries there already has been an absorption of agricultural workers in the manufacturing sector, there is fewer room for this type of dynamic. Overall, these findings support the notion that countries with a stronger manufacturing sector are less likely to experience effects linked to Dutch disease.

In line with the above, results concerning the construction sector also show that effects are significantly more likely in countries with lower levels of manufacturing. The expansion of construction services in response to mining employment due to domestic demand appears strong in Columns 4-6 in Table 5.6. Akin to agriculture, elasticities appear positive and significant only in the non-interacted terms. This would imply that for a 10% increment in mining employment due to domestic demand, there would be between an increment in construction employment between 1.3% and 1.7%. The coefficients for the group where manufacturing is higher are insignificant or have a net effect close to zero[82]. This, again, aligns with the expectation that the expansion of services, including construction, is less likely to appear in the group with higher manufacturing output.

Moving on to services, changes in mining (total) employment are linked to an expansion of service jobs exclusively in the sub-sample with lower manufacturing levels. As can be seen in Column 1 of Table 5.7, the total mining employment coefficient is significant at the 1% level, indicating that a 10% increment in mining is linked to a 1.2% increment in service employment; yet, as all controls are introduced the elasticity loses significance.

82 In Column 4, where the elastcity of the term *ΔMining employment - Domestic demand (log) * manufacturing* is significant, the the net effect would be 0.128 –0.132 = 0.004.

Table 5.6. Results – Agriculture and construction employment with interaction terms for countries with higher manufacturing

	1	2	3	4	5	6
	Δ Agriculture employment (log)			Δ Construction employment (log)		
	GMM	GMM	GMM	GMM	GMM	GMM
Δ Mining employment – total (log)		-0.289	-0.429***		-0.0653	0.0723
		(-1.46)	(-3.27)		(-0.74)	(0.69)
Δ Mining employment – total (log) * *manufacturing*		0.519	0.394		-0.0118	-0.169
		(1.37)	(1.38)		(-0.09)	(-0.99)
Δ Mining employment - Domestic demand (log)	0.00703	-0.103	0.0276	0.128***	0.141***	0.168**
	(0.17)	(-1.06)	(0.21)	(4.01)	(2.93)	(2.59)
Δ Mining employment - Domestic demand (log) * *manufacturing*	-0.0751	-0.372	-0.145	-0.132***	-0.0231	0.0259
	(-1.01)	(-1.10)	(-1.46)	(-3.11)	(-0.26)	(0.23)
Δ Mining employment - Exports (log)	-0.0207	-0.148*	-0.0916*	-0.0206	-0.00706	0.0257
	(-0.46)	(-1.87)	(-1.85)	(-1.10)	(-0.17)	(0.56)
Δ Mining employment - Exports (log) * *manufacturing*	-0.0277	0.146	-0.000395	0.0387	0.00598	-0.0223
	(-0.51)	(0.95)	(-0.01)	(1.58)	(0.14)	(-0.39)
Energy to non-energy mining value ratio			0.0238			0.00731
			(1.31)			(0.85)
Energy to non-energy mining value ratio * *manufacturing*			-0.0195			0.00197
			(-0.92)			(0.17)
Δ GDP p.c. (log)	-0.189	-0.400	1.754	1.111***	1.043**	1.288**
	(-0.77)	(-0.52)	(1.16)	(3.67)	(2.35)	(2.19)
Δ Agricultural employment (log), t-1	-0.416***	-0.516***	-0.620***			
	(-5.56)	(-4.73)	(-3.64)			
Δ Construction employment (log), t-1				-0.213***	-0.214	-0.216*
				(-2.91)	(-1.51)	(-1.78)
Constant	0.00456	0.134	-0.0493	-0.0111	0.0165	-0.0588*
	(0.26)	(1.53)	(-0.66)	(-1.03)	(0.82)	(-1.88)
Observations	440	440	440	440	440	440
Sargan p-value	2.03e-11	0.00523	0.0280	0.0000210	0.0168	0.0329
Hansen p-value	0.164	0.305	0.196	0.247	0.244	0.167
AR1 p-value	0.0247	0.0150	0.111	0.000414	0.0319	0.0119
AR2 p-value	0.416	0.911	0.478	0.478	0.833	0.905
Instruments (j)	37	37	37	37	37	37

*** p<0.01, ** p<0.05, * p<0.10; t-statistics in parentheses.

In Column 2, the interacted term coefficient, while significant, indicates that the net effect is close to zero and in Column 3 this term loses significance. This confirms, then, that positive spillovers in services are felt only across the group with lower manufacturing output.

Likewise, changes in mining employment due to exports only appear significant in the lower-manufacturing group and appear significant across Columns 1-3 in Table 5.7. Accordingly, a 10% increment in mining employment due to exports would be linked to an expansion in service employment between 0.3% and 0.8%. The effects are smaller than for construction – but respond to a different source of demand. Finally, as with previous regressions shown in Table 5.4, the elasticity of public services remains insignificant across all groups and estimations.

All in all, results concerning agriculture, construction, and services confirm that Dutch disease-related effects are less likely to materialize in countries with a higher level of manufacturing activity as suggested by Gerelmaa and Kotani (2016). However, these effects do not involve manufacturing, which is the main concern associated with the Dutch disease. It should be noted that because countries in our sample are mainly developed and emerging economies, industrial development is probably strong enough to withstand negative externalities linked to higher mining demand. Therefore, we do not find any statistical effects in any of the groups – even if the countries in our sample are below the established manufacturing output threshold used to create the two groups. Should the study be replicated in a sample with a substantially lower manufacturing capacity/level, results would likely differ.

Table 5.7. Results – Services and public services employment with interaction terms for countries with higher manufacturing

	1	2	3	4	5	6
	Δ Services employment (log)			Δ Public services employment (log)		
	GMM	GMM	GMM	GMM	GMM	GMM
Δ Mining employment – total (log)		0.122*** (3.06)	0.0808 (0.88)		-0.0547 (-0.44)	-0.0721 (-0.60)
Δ Mining employment – total (log) * *manufacturing*		-0.165** (-2.29)	-0.0779 (-0.43)		-0.00265 (-0.02)	-0.0627 (-0.41)
Δ Mining employment - Domestic demand (log)	-0.00655 (-0.18)	-0.0576 (-1.27)	-0.0324 (-0.35)	-0.00805 (-0.32)	0.0317 (0.85)	0.0162 (0.36)
Δ Mining employment - Domestic demand (log) * *manufacturing*	-0.00144 (-0.04)	-0.0134 (-0.19)	-0.0331 (-0.27)	-0.0124 (-0.35)	-0.00802 (-0.26)	-0.0270 (-0.33)
Δ Mining employment - Exports (log)	0.0269** (2.39)	0.0515*** (3.06)	0.0840* (1.80)	0.0178 (1.19)	0.00247 (0.10)	-0.00201 (-0.06)
Δ Mining employment - Exports (log) * *manufacturing*	-0.0304 (-1.32)	-0.0420 (-1.44)	-0.0628 (-0.83)	-0.0141 (-0.83)	0.00704 (0.30)	0.00709 (0.18)
Energy to non-energy mining value ratio			0.000978 (0.89)			-0.00227 (-0.45)
Energy to non-energy mining value ratio * *manufacturing*			-0.000840 (-0.55)			0.00329 (0.45)
Δ GDP p.c. (log)	0.242 (0.85)	0.763** (2.18)	0.317 (0.73)	0.169** (2.45)	0.484 (1.03)	0.502 (0.71)
Δ Services employment (log), t-1	-0.301*** (-8.80)	0.0567 (0.71)	-0.0190 (-0.07)			
Δ Public services employment (log), t-1				-0.0796 (-0.82)	0.00440 (0.02)	0.0198 (0.09)
Constant	-0.0151 (-1.06)	0.0108 (1.11)	-0.0106 (-0.34)	-0.00905 (-1.31)	0.0105 (0.93)	-0.0260 (-0.73)
Observations	440	440	440	440	440	440
Sargan p-value	1.65e-08	0.300	0.233	0.623	0.548	0.942
Hansen p-value	0.263	0.306	0.113	0.146	0.101	0.187
AR1 p-value	0.000313	0.00101	0.0383	0.00800	0.0306	0.0392
AR2 p-value	0.140	0.411	0.925	0.746	0.570	0.385
Instruments (j)	37	37	37	37	37	37

*** $p<0.01$, ** $p<0.05$, * $p<0.10$; t-statistics in parentheses.

5

5.5 Conclusion

The objective of this paper is to shed light on the positive and negative impacts of expanding mining activity by focusing on employment changes linked to foreign and domestic demand at the national level – since most of the evidence has focused primarily on regional effects. We do not find any evidence to support the notion that the manufacturing sector is hampered by the expansion of mining employment – the main concern linked to the Dutch disease. These results hold even across countries with relatively low manufacturing output, such as, Australia, Canada, Netherlands, or Russia. Similarly, we do not find any negative or positive effects on employment linked to downstream industries, such as defining activities.

However, it is not possible to rule out the adverse effects of the Dutch disease in manufacturing in mineral-rich countries with an incipient level of industrial development, such as Ghana or Peru. In this regard, it should be considered that our sample mainly covers high-income countries, and some emerging economies, such as Brazil, Russia, Turkey, and Mexico. Therefore, our findings should not be extended to countries with limited industrial capacity. Although the biggest concern for many policymakers is the loss of employment in the manufacturing sector, we do find negative spillovers in other tradeable sectors, i.e., agriculture (which includes forestry, and fisheries). Yet, this strong effect appears only in countries with a relatively low level of manufacturing output. Based on the Australian case, Fleming & Measham (2015) hypothesize that this is the result of agricultural workers migrating to other service sectors (or even mining) but could also be attributed to investments in labor-saving technologies in agriculture. They highlight, though, the need for further research in that regard as the underlying mechanisms are not yet clear. Likewise, it also remains unclear how this crowd-out effect would play out in less developed countries. Indeed, there is great heterogeneity in the added value of primary sectors, land use, and agricultural productivity. Therefore, the extent to which negative spillovers could hamper the economy would depend on how strategic and well-developed the natural resource sectors are in each country.

In terms of positive spillovers associated with the expansion of mining employment, our findings suggest a consistent and important positive effect on the construction sector. It is worth mentioning that the effect was linked to mining employment changes due to domestic demand and not exports. These findings are supportive of previous empirical studies where it is found that construction is strongly linked to mining activity in selected regions in Australia or the US. However, under closer inspection, the effects, again, are seen only in the group with a relatively lower level of manufacturing output.

Furthermore, the expansion of mining employment due to exports also translates into additional jobs in the service sector (but not in public services). The spillover effects, nonetheless, are smaller than the ones observed in construction; and, like the latter case, these effects are exclusively observed in the group of countries with lower manufacturing.

Finally, we find that in most cases, elasticities at the national level are rather moderate if compared to regional effects. Moretti (2010) indicates that the local multipliers represent the upper-bound values for a country-wide setting; accordingly, our results are in line with this expectation. Yet, from an employment opportunities perspective, our results confirm that the mining sector provides limited room for generating significant positive employment spillovers at the national level.

Bibliography

Alexeev, M., & Conrad, R. (2009). The Elusive Curse of Oil. *Review of Economics and Statistics*, *91*(3), 586–598. https://doi.org/10.1162/rest.91.3.586

Aroca, P. (2001). Impacts and development in local economics based on mining: The case of the Chilean II region. *Resources Policy*, *27*(2), 119–134. https://doi.org/10.1016/S0301-4207(01)00013-7

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. https://doi.org/10.1016/J.RESOURPOL.2016.10.015

Black, D., McKinnish, T., & Sanders, S. (2005). The economic impact of the coal boom and bust. In *Economic Journal* (Vol. 115, Issue 503). https://doi.org/10.1111/j.1468-0297.2005.00996.x

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. https://doi.org/10.1016/J.JEEM.2007.08.004

Cavalcanti, T., Da Mata, D., & Toscani, F. (2019). Winning the oil lottery: the impact of natural resource extraction on growth. *Journal of Economic Growth*, *24*(1), 79–115. https://doi.org/10.1007/s10887-018-09161-z

Cavalcanti, T., Mohaddes, K., & Raissi, M. (2011). Growth, development and natural resources: New evidence using a heterogeneous panel analysis. *Quarterly Review of Economics and Finance*, *51*(4), 305–318. https://doi.org/10.1016/j.qref.2011.07.007

Corden, W. M., & Neary, J. P. (1982). Booming Sector and De-Industrialisation in a Small Open Economy. *The Economic Journal*, *92*(368), 825. https://doi.org/10.2307/2232670

Cosbey, A., Mann, H., Maennling, N., Toledano, P., Martin, J. G., & Brauch, D. (2016). *Mining a Mirage? Reassessing the shared-value paradigm in light of the technological advances in the mining sector*. www.iisd.org

Eftimie, A., Heller, K., & Strongman, J. (2009). *Gender Dimensions of the Extractive Industries*. http://siteresources.worldbank.org/EXTOGMC/Resources/eifd8_gender_equity.pdf

Ejdemo, T., & Söderholm, P. (2011). Mining investment and regional development: A scenario-based assessment for Northern Sweden. *Resources Policy*, *36*(1), 14–21. https://doi.org/10.1016/j.resourpol.2010.08.008

Fleming, D. A., & Measham, T. G. (2014). Local job multipliers of mining. *Resources Policy*, *41*, 9–15. https://doi.org/10.1016/J.RESOURPOL.2014.02.005

Fleming, D. A., & Measham, T. G. (2015). Local economic impacts of an unconventional energy boom: the coal seam gas industry in Australia. *Australian Journal of Agricultural and Resource Economics*, *59*(1), 78–94. https://doi.org/10.1111/1467-8489.12043

Foster-McGregor, N. (2019). Global Value Chains and Employment in Asia. *Asian Development Review*, *36*(2), 100–130. https://www.adb.org/sites/default/files/publication/525971/asian-development-review-volume-36-number-2.pdf

Foster-McGregor, N., Sartorello Spinola, D., & Verspagen, B. (2018). *ON THE DEVELOPMENT AND IMPACT OF COMMODITY PRICES AND CYCLES Inclusive and Sustainable Industrial Development Working Paper Series WP 8 | 2018*.

Gerelmaa, L., & Kotani, K. (2016). Further investigation of natural resources and economic growth: Do natural resources depress economic growth? *Resources Policy*, *50*, 312–321. https://doi.org/10.1016/j.resourpol.2016.10.004

GIZ. (2016). *Linkages to the Resource Sector The Role of Companies, Government and International Development Cooperation*. www.giz.de

James, A. (2015). The resource curse: A statistical mirage? *Journal of Development Economics*, *114*, 55–63. https://doi.org/10.1016/j.jdeveco.2014.10.006

Korinek, J. (2020). The mining global value chain. In *OECD Trade Policy Papers* (Issue 235). https://doi.org/10.1787/2827283e-en

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. https://doi.org/10.1016/0304-3878(87)90005-8

Lederman, D., & Maloney, W. F. (2007). Trade Structure and Growth. In D. Lederman & W. F. Manoley (Eds.), *Natural Resources Neither Curse nor Destiny* (pp. 15–40). The World Bank, Stanford University Press.

Leeuw, P., & Mtegha, H. (2018). The significance of mining backward and forward linkages in reskilling redundant mine workers in South Africa. *Resources Policy*. https://doi.org/10.1016/j.resourpol.2018.02.004

Los, B., Timmer, M. P., & de Vries, G. J. (2015). How important are exports for job growth in China? A demand side analysis. *Journal of Comparative Economics*, *43*(1), 19–32. https://doi.org/10.1016/J.JCE.2014.11.007

Marchand, J. (2012). Local labor market impacts of energy boom-bust-boom in Western Canada. *Journal of Urban Economics*, *71*(1), 165–174. https://doi.org/10.1016/J.JUE.2011.06.001

Matsuyama, K. (1992). *Agricultural Productivity, Comparative Advantage, and Economic Growth*.

McMahon, G., & Remy, F. (2002). *Global Mining Large Mines and Local Communities: Forging Partnerships, Building Sustainability* (G. McMahon & F. Remy (Eds.)).

Moretti, E. (2010). Local multipliers. *American Economic Review*, *100*(2), 373–377. https://doi.org/10.1257/aer.100.2.373

Moritz, T., Ejdemo, T., Söderholm, P., & Wårell, L. (2017). The local employment impacts of mining: an econometric analysis of job multipliers in northern Sweden. *Mineral Economics*, *30*(1), 53–65. https://doi.org/10.1007/s13563-017-0103-1

Morris, M., Kaplinsky, R., & Kaplan, D. (2012). "One thing leads to another"—Commodities, linkages and industrial development. *Resources Policy*, *37*(4), 408–416. https://doi.org/10.1016/J.RESOURPOL.2012.06.008

Roodman, D. (2009a). How to do xtabond2: An introduction to difference and system GMM in Stata. In *The Stata Journal* (Vol. 9, Issue 1).

Roodman, D. (2009b). A Note on the Theme of Too Many Instruments. *Oxford Bulletin of Economics and Statistics*, *71*(1), 135–158. https://doi.org/10.1111/j.1468-0084.2008.00542.x

Sachs, J., & Warner, A. (1995). Natural Resource Abundance and Economic Growth. In *National Bureau of Economic Research* (No. 5398; Vol. 3). https://doi.org/10.3386/w5398

Torvik, R. (2001). Learning by doing and the Dutch disease. *European Economic Review*, *45*(2), 285–306. https://doi.org/10.1016/S0014-2921(99)00071-9

Wang, Z., Wei, S.-J., Yu, X., & Zhu, K. (2017). *Measures of Participation in Global Value Chains and Global Business Cycles*. 1–33. https://doi.org/10.3386/w23222

Weber, J. G. (2012). The effects of a natural gas boom on employment and income in Colorado, Texas, and Wyoming ☆. *Energy Economics*, *34*, 1580–1588. https://doi.org/10.1016/j.eneco.2011.11.013

Weber, J. G. (2014). A decade of natural gas development: The makings of a resource curse? *Resource and Energy Economics*, *37*, 168–183. https://doi.org/10.1016/j.reseneeco.2013.11.013

Annex

Sector Groups

- **Agriculture**: All activities under A, Agriculture, forestry, and fishing. Includes:

Crop and animal production, hunting and related service activities	A01
Forestry and logging	A02
Fishing and aquaculture	A03

- **Mining:** All activities under B, Mining and quarrying
- **Manufacturing:** All activities under C, Manufacturing. Includes:

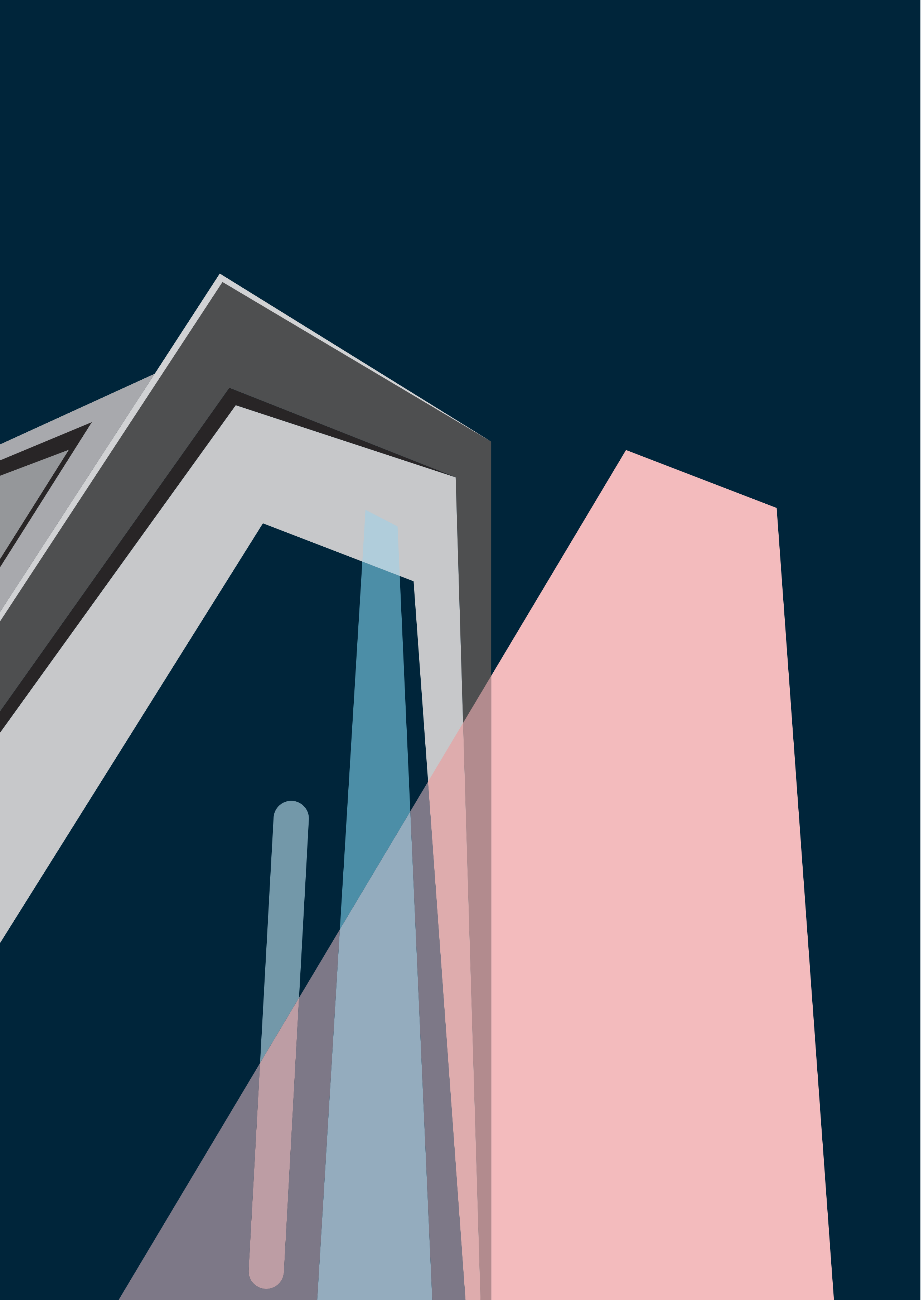
Manufacture of food products, beverages, and tobacco products	C10-C12
Manufacture of textiles, wearing apparel and leather products	C13-C15
Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials	C16
Manufacture of paper and paper products	C17
Printing and reproduction of recorded media	C18
Manufacture of chemicals and chemical products	C20
Manufacture of basic pharmaceutical products and pharmaceutical preparations	C21
Manufacture of rubber and plastic products	C22
Manufacture of other non-metallic mineral products	C23
Manufacture of basic metals	C24
Manufacture of fabricated metal products, except machinery and equipment	C25
Manufacture of computer, electronic and optical products	C26
Manufacture of electrical equipment	C27
Manufacture of machinery and equipment n.e.c.	C28
Manufacture of motor vehicles, trailers, and semi-trailers	C29
Manufacture of other transport equipment	C30
Manufacture of furniture; other manufacturing	C31_C32

- **Refining activities:** All activities under C19, Manufacture of coke and refined petroleum products
- **Construction.** All activities under F, Construction.
- **Services.** Includes:

Wholesale and retail trade and repair of motor vehicles and motorcycles	G45
Wholesale trade, except of motor vehicles and motorcycles	G46
Retail trade, except of motor vehicles and motorcycles	G47
Repair and installation of machinery and equipment	C33
Electricity, gas, steam and air conditioning supply	D35
Water collection, treatment and supply	E36
Sewerage; waste collection, treatment and disposal activities; materials recovery; remediation activities and other waste management services	E37-E39
Land transport and transport via pipelines	H49
Water transport	H50
Air transport	H51
Warehousing and support activities for transportation	H52
Postal and courier activities	H53
Accommodation and food service activities	I
Publishing activities	J58
Motion picture, video, and television program production, sound recording and music publishing activities; programming and broadcasting activities	J59_J60
Telecommunications	J61
Computer programming, consultancy and related activities; information service activities	J62_J63
Financial service activities, except insurance and pension funding	K64
Insurance, reinsurance and pension funding, except compulsory social security	K65
Activities auxiliary to financial services and insurance activities	K66
Real estate activities	L68
Legal and accounting activities; activities of head offices; management consultancy activities	M69_M70
Architectural and engineering activities; technical testing and analysis	M71
Scientific research and development	M72
Advertising and market research	M73
Other professional, scientific, and technical activities; veterinary activities	M74_M75
Administrative and support service activities	N
Other service activities	R_S

- **Public Services:** Includes

Public administration and defense; compulsory social security	O84
Education	P85
Human health and social work activities	Q



CHAPTER 6

Conclusion

General trends, such as urbanization and high growth rates in emerging economies, as well as the transition to a low-carbon economy guarantee that in the upcoming years demand for extractive commodities (especially minerals and metals) will keep growing (Hund et al., 2020; McKinsey, 2013). This demand represents a big opportunity for many countries which are rich in these resources, especially for those still categorized as developing economies. According to some projections if effectively managed extractive sectors could lift as many as 540 million people out of poverty (McKinsey, 2013). However, historically extractive sectors were considered problematic based on several arguments, such as the enclave nature of their operations, the Dutch disease, and commodities price volatility. Prescriptions of how to deal with these issues have included the prudent macroeconomic management of debt and exchange rates. More recently, the promotion of industrial development via diversification and inter-industrial linkages was also added to the list of policy recommendations, not only to avoid the problematic aspects linked to the expansion of extractive sectors but also to turn these into an asset for structural change.

6.1 Contributions and limitations

This dissertation contributes to the literature which explores the relationship between the exploitation of extractive resources and structural change, firstly, by providing an ex-post assessment of production linkages, at the macro-level in country-specific settings (Chapter 2) and cross-country scenarios (Chapter 3). Chapter 2 provided a detailed account of how linkages evolved; it concludes that extractive sectors have become more enclave– not less – during the period analyzed, including flagship cases like Australia and Chile. Results also suggest most countries have strengthened their position as commodity producers in global value chains. Yet, a few countries, including Norway, and Malaysia, were prominent exceptions. Heterogeneity in performance underlines that while there are general trends, there are also macroeconomic factors and policies that can prompt countries to go in different directions. Chapter 2 shows that in a business-as-usual scenario, extractive sectors will continue to operate as an enclave – despite the many new opportunities that the new technological paradigm has opened for the developing new industries surrounding natural resources (Perez, 2010).

In Chapter 3, econometric results show that stronger backward linkages – which are key due to their importance for the generation of domestic added-value – have a positive short-term effect on growth; but statistically higher backward linkages do not play a role in long-run GDP per capita growth. Chapter 3 does not conclude that the efforts to develop upstream industries should be abandoned altogether; rather, it suggests that policy recommendations aimed at the development of linkages should look instead at the quality of said linkages – namely so that these linkages allow for horizontal migration of knowledge to contribute to a diversified economy and export basket. This conclusion is supportive of the numerous studies that have pointed out that suppliers in the mining industry in developing countries in the aggregate lack competitiveness in international markets and must absorb all entrepreneurial costs and risks with marginal support (Figueiredo & Piana, 2016). Lastly, Chapter 3 finds that commodity prices have a strong negative effect on mining linkage development. This conclusion may seem less relevant in light of the lack of long-term effects of the reduction in linkage development in the short and long run. Nonetheless, the negative effect that commodity prices seem to exert on linkage formation raises a couple of concerns as it could be indicative of a reduction of productive capabilities in specific sectors, observed in the inability to domestically offer services, inputs, and machinery to the mining sector. It could also be indicative of distortions in the incentives at the meso-level in which the mining sector is less compelled to invest in services, machinery, and other (innovative) inputs due to the higher profit margins that high prices offer, ultimately leading to a subpar productivity performance of the extractive sector (Castaño et al., 2019; Tilton, 2014). Chapter 3 concludes that supplier backward linkages should be rather strategic – namely favoring a 'depth' instead of 'breadth' perspective. This analysis also raises further questions about the role of commodity prices and the effects they have on the productive capabilities of a country.

Considering the latter, the second contribution of this dissertation is to look further into the determinants of export diversification (Chapter 4) – another essential policy prescription to reduce economic volatility in resource-rich countries. The latter is of particular importance since the 1990s as there has been a visible increment in mining- and energy-commodity-dependent countries (UNCTAD, 2019). The results strongly suggest that – on average, commodity prices - have had a strong negative effect on diversification in non-extractive sectors. This supports the findings of Agosin et al. (2012), who attribute export concentration to the reallocation of production factors away from non-extractive sectors, reducing and/or making very costly accessing inputs necessary for diversification; yet, this suggests that it is a distortion of incentives rather than the direct effect of real exchange rate appreciation (as put forth by the Dutch disease) that drives factor reallocation. Moreover, results with respect to path dependence suggest that when it comes to producing and exporting a new (non-extractive) product requires bigger jumps to develop the necessary productive capabilities. In this regard, these findings highlight the complexity of the challenge: Firstly, the inertia that path dependence exerts on non-extractive products is relatively weaker than in extractive products, requiring bolder entrepreneurial efforts to produce something 'new'. Secondly, commodity price upswings reduce the incentives that reduce the availability of necessary inputs to produce something 'new'. Consequently, the discovery process for innovation and diversification outside the extractive is far from an attractive endeavor. Findings in Chapters 3 and 4 then suggest that the response to commodity prices – i.e., more enclaveness and less diversification – is a logical one: incentives to diversify the productive structure of a country become distorted on different fronts.

Finally, this dissertation seeks to contribute to the Dutch disease literature by exploring whether the factors and dynamics hypothesized in the model of Corden and Neary (1982) still hold. Firstly, this is done by looking at the effect of higher prices on growth (Chapter 3) and export diversification (Chapter 4); and secondly, by looking at the effects of mining expansion on manufacturing jobs which in previous literature had only been explored at the sub-national level.

In Chapter 3, the results indicate that high commodity prices do not exert a negative effect on long-term growth. This aligns with a growing body of literature which suggests that studies focused on more recent decades the Dutch disease effects on growth are no longer observed (for instance, Badeeb et al., 2017; Gerelmaa & Kotani, 2016) Moreover, results in Chapter 4 indicate that, on average, no empirical association between real exchange movements and export concentration is observed – contrary to Dutch disease forecasts. Nevertheless, this result does not indicate that currency appreciation would not lead to economic concentration in specific countries. Specifically, results in Chapters 3 and 4, suggest that the Dutch disease mechanisms are not observed systematically as they used to be several decades ago.

The latter is also supported by findings in Chapter 5 which show that employment expansion in the mining sector does not crowd out employment in manufacturing – at least in the 40-country sample employed. Nonetheless, the expansion of mining employment driven by exports does seem to have negative employment spillovers in agriculture, and positive in services – as predicted by the Dutch disease. The effects of mining expansion on services and agriculture, however, are observed in the sub-sample of countries with relatively lower manufacturing levels. These results suggest that the Dutch disease employment movements *partly* hold, and they do so under the condition that manufacturing output is relatively low. More importantly, results show that mining employment spillovers do not affect negatively the manufacturing sector – the main concern surrounding the Dutch disease since manufacturing is still considered the engine of growth (Szirmai & Verspagen, 2015).

Thus, the contributions here described could be summarized as follows: While many hypothesized factors linked to the Dutch disease have previously explained the resource curse via reduced employment in manufacturing and the loss of competitiveness in manufactured exports, this does not seem to be the case in more recent periods.

However, the claim that the mining sector operates as a commodity producer in isolation from the rest of the economy, on average, still holds. Likewise, commodity prices emerge as a strong factor that disincentivizes export diversification and productive linkages to the mining sector. In short, commodities price increments (such as the ones observed in the 2000s boom) suggest a potentially negative effect on productive capacities in both the short- and long-run.

However, the above conclusions are by no means deterministic – certainly, exceptions exist. The analyses presented as part of this dissertation have several limitations:

a) The exact mechanisms that explain the negative effect of prices on linkages and diversification are not entirely clear. Some hints have been provided based on literature (e.g., Castaño et al., 2019) but further qualitative and quantitative research in this respect is needed. Especially, because the dynamics linked to prices seem to play both on the supply and demand sides (i.e., producers may be less incentivized to innovate and diversify thus having fewer products to offer, and mining firms may have reduced interest to acquire those).
b) Chapter 3 is not able to capture the quality of linkages – much of the evidence highlighted in successful cases of natural resource-based industrialization pays attention to linkages in the context of a knowledge-based economy. Evidence in Chapter 2 and other studies (Korinek, 2020) indicate linkages are highly linked to services – but how technology-intensive these are in the sample used in Chapter 3 remains unknown.
c) There are data limitations in terms of mining sector-specific policies and human capital variables in Chapter 3. Namely, there is insufficient cross-country data that specifically captures the presence of policies linked to the extractive sectors, such as resource management and local content policies. Likewise, the analysis of the effect of commodity prices and linkages includes broad human capital controls (e.g., tertiary education completion rates). Mining suppliers require very specialized forms of knowledge; therefore, the introduction of proxies capturing human capital in specific fields linked to extractive industries, such as the number of geology engineers per capita, is likely a better approach. Yet, this data is only available for a handful of countries.
d) The samples in the analyses in Chapters 2 and 5 exclude low-income countries. In particular, it cannot be ruled out that employment in manufacturing could be negatively affected by the expansion of mining in a low-income country. Ghana's case illustrates the emergence of the extractive sectors when the country still fell under the World Bank low-income category: the beginning of extractive production was accompanied by a structural change that moved agricultural workers into services. During this period there was a mild increment in the expansion of manufacturing as well (World Bank, 2018). This may indicate that the dynamics observed in Chapter 5 could also hold in low-income countries but further research in this regard would be needed.
e) The dissertation does not focus on political economy aspects which could potentially provide other information concerning how (un)sustainable a resource-based development is – especially in lower levels of economic development. Other

studies paying special attention to the policies surrounding extractive resources taxation and revenue management and their link to the upgrading of the productive structure could provide a more detailed perspective on the matter.

5.2 Policy implications and final remarks

As the conclusion above mentions, the exploitation of extractive resources is neither 'good' nor 'bad' for growth; however, using this sector as a basis for broader industrialization has been a rather difficult task to materialize – even when many of the Dutch disease woes are no longer empirically observed. Results suggest that the development of innovations/novel products outside the extractive sector is a task difficult to realize on a broader level (not only in mining upstream industries). In any scenario (even those with no natural resources), entrepreneurs face great costs and uncertainties as they attempt to develop new products. If they succeed, the gains are socialized but if they lose, the risks and costs are absorbed privately leading to subpar diversification and innovation investments and performance (Hausmann & Rodrik, 2003). In the presence of strong commodity prices in a resource-rich country, the incentives to engage in the discovery process further dwindle, with investments and production focusing on the sectors for which demand is 'guaranteed' (extractives) and so appear less risky to governments and the private sector. A laissez-faire approach therefore should not be taken. It has further been suggested that horizontal intervention policies, that provide general infrastructure, education investments, and R&D services, are far from sufficient, and policy approaches instead require specific interventions (Atienza et al., 2018). How specific these are or in which areas they should occur are beyond the scope of this dissertation. Yet, based on the results discussed here, countries rich in extractive commodities should reconsider the development of linkages – firstly as they do not represent a panacea for economic development, and secondly, because the mining sector is rife with barriers (Molina, 2018; Pietrobelli et al., 2018). The development of linkages then should be seen rather as a strategic policy focusing more on a) the technological/innovative quality of the linkages, i.e., products and services, and b) stimulating broader applicability of the knowledge generated so that it can be utilized in other non-commodity sectors and support broader diversification efforts.

With respect to diversification away from extractive products, in some ways it remains a black box (Wiig & Kolstad, 2012) – more is known about what stops it than what stimulates it (besides the natural inertia that path dependency provides). Specific policy recommendations cannot be derived from the current work, with further research needed on county-specific cases to determine what is needed to spur entrepreneurial activity and higher export performance.

Finally, concerning structural change, results indicate that as extractive sectors expand, workers tend to move toward services without necessarily affecting negatively manufacturing sectors. Still, countries should make sure to foster the adequate development of both sectors: services have been found to provide great potential for increasing aggregate productivity levels (Owusu et al., 2021) but there is a lot of heterogeneity in this regard. More importantly, there is no reason to believe that manufacturing has lost its key role in fostering more sophisticated production capabilities and stimulating other sectors.

To conclude, this dissertation supports partly the message that natural resources are neither a curse nor destiny (Lederman & Maloney, 2007). But at the same time, it highlights that some of the necessary strategies to truly achieve sustained economic growth (for instance, through diversification) are particularly hard to attain. Moreover, in light of the future heightened demand for mining commodities, it is unlikely that governments in both developed and developing countries will shut down commodities production altogether. Those countries that do follow this path should proceed with caution and consider that once this road is taken, policy efforts should be better targeted at actively developing different sectors of the economy and by no means abandoned.

Bibliography

Agosin, M. R., Alvarez, R., & Bravo-Ortega, C. (2012). Determinants of Export Diversification Around the World: 1962-2000. *World Economy*, *35*(3), 295–315. https://doi.org/10.1111/j.1467-9701.2011.01395.x

Atienza, M., Lufin, M., & Soto, J. (2018). Mining linkages in the Chilean copper supply network and regional economic development. *Resources Policy*. https://doi.org/10.1016/J.RESOURPOL.2018.02.013

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. https://doi.org/10.1016/J.RESOURPOL.2016.10.015

Castaño, A., Lufin, M., & Atienza, M. (2019). A structural path analysis of Chilean mining linkages between 1995 and 2011. What are the channels through which extractive activity affects the economy? *Resources Policy*. https://doi.org/10.1016/j.resourpol.2018.12.007

Corden, W. M., & Neary, J. P. (1982). Booming Sector and De-Industrialisation in a Small Open Economy. *The Economic Journal*, *92*(368), 825. https://doi.org/10.2307/2232670

Figueiredo, P. N., & Piana, J. (2016). When "one thing (almost) leads to another": A micro-level exploration of learning linkages in Brazil's mining industry. *Resources Policy*, *49*, 405–414. https://doi.org/10.1016/J.RESOURPOL.2016.07.008

Gerelmaa, L., & Kotani, K. (2016). Further investigation of natural resources and economic growth: Do natural resources depress economic growth? *Resources Policy*, *50*, 312–321. https://doi.org/10.1016/j.resourpol.2016.10.004

Hausmann, R., & Rodrik, D. (2003). Economic development as self-discovery. *Journal of Development Economics*, *72*(2), 603–633. https://doi.org/10.1016/S0304-3878(03)00124-X

Hund, K., Porta, D. La, Fabregas, T. P., Laing, T., & Drexhage, J. (2020). *Minerals for Climate Action: The Mineral Intensity of the Clean Energy Transition. Climate-Smart Mining Facility*. www.worldbank.org

Korinek, J. (2020). The mining global value chain. In *OECD Trade Policy Papers* (Issue 235). https://doi.org/10.1787/2827283e-en

Lederman, D., & Maloney, W. F. (Eds.). (2007). *Natural Resources Neither Curse nor Destiny*. Stanford University Press and The World Bank. http://siteresources.worldbank.org/INTTRADERESEARCH/Resources/D.Lederman_W.Maloney_Natural_Resources_book.pdf

McKinsey. (2013). *Reverse the curse: Maximizing the potential of resource-driven economies McKinsey Global Institute*. www.mckinsey.com/mgi.

Molina, O. (2018). Innovation in an unfavorable context: Local mining suppliers in Peru. *Resources Policy*, *58*(2018), 34–48. https://doi.org/10.1016/j.resourpol.2017.10.011

Owusu, S., Szirmai, A., & Foster-McGregor, N. (2021). The Rise of the Service Sector in the Global Economy. In L. Alcorta, N. Foster-McGregor, B. Verspagen, & A. Szirmai (Eds.), *New Perspectives on Structural Change: Causes and Consequences of Structural Change in the Global Economy* (pp. 270–297). Oxford University Press. https://doi.org/10.1093/OSO/9780198850113.003.0013

Perez, C. (2010). A Vision for Latin America : A resource-based strategy for technological dynamism and social inclusion. *Globelics. The Global Network for Economics of Learning, Innovation, and Competence Building System*, 1–32.

Pietrobelli, C., Marin, A., & Olivari, J. (2018). Innovation in mining value chains: New evidence from Latin America. *Resources Policy*, *58*. https://doi.org/10.1016/J.RESOURPOL.2018.05.010

Szirmai, A., & Verspagen, B. (2015). Manufacturing and economic growth in developing countries, 1950–2005. *Structural Change and Economic Dynamics*, *34*, 46–59. https://doi.org/10.1016/j.strueco.2015.06.002

Tilton, J. E. (2014). Cyclical and secular determinants of productivity in the copper, aluminum, iron ore, and coal industries. *Mineral Economics*, *27*(1). https://doi.org/10.1007/s13563-014-0045-9

UNCTAD. (2019). *The State of Commodity Dependence 2019*.

Wiig, A., & Kolstad, I. (2012). If diversification is good, why don't countries diversify more? The political economy of diversification in resource-rich countries. *Energy Policy*, *40*(1), 196–203. https://doi.org/10.1016/j.enpol.2011.09.041

World Bank. (2018). *Systematic Country Diagnostic (SCD): Priorities for ending poverty and boosting shared prosperity* (Issue 132010).

Impact addendum

This dissertation relates to social and economic impacts on different fronts. Using the Sustainable Development Goals framework as a reference, some considerations in this regard are presented. Firstly, this thesis explores how long-term growth is related to extractive resource exploitation in recent decades (Chapter 3). It also provides an assessment of how host countries, i.e., where the extraction of resources takes place, have been able (or not) to take advantage of high commodity prices. Namely, I explore this by measuring the integration of domestic firms along the extractive value chain (Chapters 2), and the export performance of firms in non-extractive sectors (Chapter 4). Developing entrepreneurial efforts within and outside the extractive sector represents an essential step toward securing a stable economic track and generating jobs for educated and non-educated workers. Moreover, domestic mining suppliers can often contribute largely to innovative solutions to increase the sustainability of extractive processes – their impact is, thus, beyond job generation. Likewise, I investigate how the expansion of mining sector activities affects directly employment in the manufacturing sector (Chapter 5). The latter is essential to ensure learning-by-doing opportunities for workers; the loss of such opportunities could mean hindering long-term economic growth. Considering the above, the present thesis has a strong link to SDG 8 ("Promote sustained, inclusive, and sustainable economic growth, full and productive employment, and decent work for all"), and SDG 9 ("Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation"). Secondly, an important share of the extraction of natural resources takes place in developing countries – mostly in Africa and Latin America – where sustained growth is fundamental to improving the livelihoods of millions and guaranteeing the provision of health and education services as well as social protection. Therefore, this thesis also is linked to SDG 1 ("End poverty in all of its forms everywhere").

The dissertation concludes that some of the mechanisms that previously linked extractive sectors with low long-term growth and high economic vulnerability are no longer empirically observed. Yet, this does not mean that the expansion of extractive sectors on its own is conducive to reaching any of the SDGs mentioned above. This thesis instead warns that transforming extractive sectors into inclusive economic growth requires specific policy interventions both on the supply and demand side (though, a specific prescription of how to achieve this is not within the scope of the thesis). Moreover, it finds that high commodity prices could still be 'be a curse in disguise' as it distorts incentives across the economy to develop domestic suppliers and diversify exports away from commodities.

While oil and gas may be on their way out, demand for minerals and metals will keep growing as the climate change agenda pushes for the adoption of non-fossil-fuel technologies, such as electric vehicles. Therefore, a nuanced, and sober perspective of the risks associated with extractive activities is needed in the formulation of more comprehensive and coherent policies. This dissertation contributes to such perspective and raises further questions aimed at deepening our understanding of this controversial and, nonetheless, essential industry.

About the author

Beatriz Calzada Olvera was born and raised in Mexico. She joined UNU-MERIT as a Ph.D. fellow in 2015. Her doctoral dissertation examines the relationship between extractive industries and structural change. She also conducts research on issues of innovation, global value chains, international trade, and productivity. Besides these topics, her interests include broad issues related to economic development, such as economic resilience and inequality.

She holds a B.A. in International Trade from Universidad del Valle de Mexico and an M.A. in International Development and Economics from Hochschule für Technik und Wirtschaft Berlin. Her work experience includes consultancy projects for international organizations, such as the German Cooperation Agency (GIZ) and the Inter-American Development Bank. Since 2019 she is an economics researcher and lecturer at the Erasmus University Rotterdam - Institute for Housing and Urban Development.

UNU-MERIT/MGSoG Dissertation Series

2022

Beatriz Calzada Olvera
Extractive Industries and Structural Transformation
UNU-MERIT/Maastricht University Dissertation Series
Series № 274

Ngoc Quang Pham
Essays on Technical Change and Efficiency in a Transition Economy the Case of Vietnam
UNU-MERIT/Maastricht University Dissertation
Series № 273

Tamara A. Kool
Beyond the Right to Work:
Labour Market Engagement of Protracted Refugees Through a Social Exclusion Lens
UNU-MERIT/Maastricht University Dissertation
Series № 272

Atsuko Okuda
Towards E-Compliance:
Exploring the Role of Compliance and EGovernance Initiatives in the Case of Bhutan
UNU-MERIT/MGSoG Dissertation Series
№ 269

Rafael Lemaitre Carabias
Public Sector Innovation in the United Arab Emirates. How innovation occurs and the outcomes it delivers
UNU-MERIT/MGSoG Dissertation Series
№ 268

Maria Klara Kuss
The Negotiations of Zambia's Welfare Regime. The Transformative Potential of Social Cash Transfers
UNU-MERIT/MGSoG Dissertation Series
№ 267

2021

Yip Ching Yu
Immigrant Welfare Dynamics in the Netherlands
UNU-MERIT/MGSoG Dissertation Series
№ 271

Tatenda P. Zinyemba
Effects of hiv on children and youth's educational Attainment
UNU-MERIT/MGSoG Dissertation Series
№ 270

Michelle S. M. Momo
A Multidimensional Perspective on Education in Developing Countries
UNUMERIT/MGSoG Dissertation Series
№ 266

Gideon Onyewuchi Ndubuisi
Essays on International Trade: The Role of Institutions and Imported Intermediate Inputs
UNU-MERIT/MGSoG Dissertation Series
№ 265

Solomon Owusu
Powering Structural Transformation and Economic Development in Africa: The Role of Services, Manufacturing and Global Value Chains
UNU-MERIT/MGSoG Dissertation Series
№ 264

Halefom Yigzaw Nigus
Markets and Human Behavior: Evidence from Artefactual Field Experiments
UNU-MERIT/MGSoG Dissertation Series
№ 263

Iulia Falcan
Transition towards a renewable European electricity system. What are the implications for the power technology mix, pan-European power trade and the electricity market?
UNUMERIT/MGSoG Dissertation Series
№ 262

Gloria L. Bernal N.
On Improving Education Opportunities: Preferences and Performance of High School Students in Response to Scolarships, Information, and Coeducation
UNU-MERIT/MGSoG Dissertation Series
№ 262

Anne-Lore Fraikin
The effect of financial retirement incentives originating from the social security system on the retirement behavior of older Belgian workers
UNU-MERIT/MGSoG Dissertation
Series № 261

Philip Drauz
Who calls the shots and why?
The role of actors and instructions in the response to the sovereign debt crises in the euro area
UNU-MERIT/MGSoG Dissertation Series
№ 261

Bart Kleine Deters
A Quantitative approach to the right to education: Concept, Measurement, and Effects
UNU-MERIT/MGSoG Dissertation Series
№ 260

Eliana Rubiano-Matulevich
Essays on Conflict-Induced Displacement and Gender in Colombia
UNU-MERIT/MGSoG Dissertation Series
№ 259

Njagi Purity Muthoni
Financial Risk, Vulnerability and Equity of Access to Healthcare Services in Kenya
UNU-MERIT/MGSoG Dissertation Series
№ 258

María José Espinosa-Romero
The Shadow of Hierarchy in Marine Fisheries Governance
UNU-MERIT/MGSoG Dissertation Series
№ 257

Lorena Rivera León
Unveiling the Determinants of Scientific Productivity in Middle-Income Countries: An Economics of Science Perspective
UNU-MERIT/MGSoG Dissertation Series
№ 256

Racky Balde
Essays on Informal versus formal Economy Choices
UNU-MERIT/MGSoG Dissertation Series
№ 255

Caio Torres Mazzi
Learning, Capabilities and Governance in Global Value Chains
UNU-MERIT/MGSoG Dissertation Series
№ 254

Giulia Rossello
Social Transformations and Labour Market Entry
An Investigation into University Systems in Emerging Economies
UNU-MERIT/MGSoG Dissertation Series
№ 253

2020

Rose Camille Vincent
Essays in Public Economics
Multi-Layer Tax Structure and Implications
UNU-MERIT/MGSoG Dissertation Series
№ 252

Emmanuel Mensah
Structural change in developing countries: patterns, causes, and consequences
UNU-MERIT/MGSoG Dissertation Series
№ 251

Ornsaran Manuamorn
Governance of International Adaptation Finance for local Climate Change Adaptation: An Analysis of Adaptation Fund Projects
UNU-MERIT/MGSoG Dissertation Series
№ 250

Gillian McFarland
Doing policy in Further Education
An exploration of the enactment of the GCSE resits policy in Further Education colleges in England
UNU-MERIT/MGSoG Dissertation Series
№ 249

Omar Rodriguez Torres
Essays on Entrepreneurship in Colombia
UNU-MERIT/MGSoG Dissertation Series
№ 248

Elaine Lebon-McGregor
International Organizations and Global Migration Governance
UNU-MERIT/MGSoG Dissertation Series
№ 247

Janyl Moldalieva
Playing the 'Game'of Transparency and Accountability in Kyrgyzstan's Resource Governance
UNU-MERIT/MGSoG Dissertation Series
№ 246

Kaleab Kebede Haile
Essays on Rural Household Decision-Making under Climate Risk
UNU-MERIT/MGSoG Dissertation Series
№ 245

Nora Jasmin Ragab
Diaspora Mobilisation in a Conflict Setting
UNU-MERIT/MGSoG Dissertation Series
№ 244

Mary Kaltenberg
From Micro to Macro: Essays on Technological Change and Income Divergence
UNU-MERIT/MGSoG Dissertation Series
№ 243

Ayla E. Bonfiglio
Student migrant, refugee or both? Exploring Refugee Agency and Mobility through Tertiary Education in Kenya, South Africa and Uganda
UNU-MERIT/MGSoG Dissertation Series
№ 242

Danilo Sartorello Spinola
Cycles, Economic Structures and External Constraints.
A Structuralist study on the causes of economic volatility in Latin America
UNU-MERIT/MGSoG Dissertation Series
№ 241

2019

Jemal Adem
Livelihood Vulnerability to Shocks, Behaviour and Investment in Education: Essays in Behavioural Development Economics
UNU-MERIT/MGSoG Dissertation Series
№ 240

Davina Osei
Corrupt or corrupted networks?
An empirical enquiry
UNU-MERIT/MGSoG Dissertation Series
№ 239

Patima Chongcharoentanawat
Beyond Static Inequality
Public policies and economic mobility in Thailand
UNU-MERIT/MGSoG Dissertation Series
№ 238

Charlotte Guillard
Rethinking economic growth and structural change.
The role of boundaries and linkages between industries
UNU-MERIT/MGSoG Dissertation Series
№ 237

Nicolas Echarti
Employment Effects or Vocational Rehabilitation in Germany:
A quantitative analysis
UNU-MERIT/MGSoG Dissertation Series
№ 236

Shellie E. Solomon
Neighborhoods Matter:
Crime, collective efficacy and foreclosures in Miami
UNU-MERIT/MGSoG Dissertation Series
№ 235

Michał Kazimierczak
Regional Innovation and Entrepreneurship
Patents, trade marks, entry and entrants' growth in European manufacturing industries
UNU-MERIT/MGSoG Dissertation Series
№ 234

Fernanda Soares
The Influence of Within School and Across Schools' Collaborative Practices on Student Learning and Teaching Outcomes in West Africa
UNU-MERIT/MGSoG Dissertation Series
№ 233

Mira Bierbaum
New Mindsets to Innovate Activation
UNU-MERIT/MGSoG Dissertation Series
№ 232

Norman Dytianquin
Technology in the Asian Miracle and Crisis Debates: Applications of and Insights from the Field of Influence Approach to Input-Output Analysis
UNU-MERIT/MGSoG Dissertation Series
№ 231

Nga Le
The implications of health insurance for the labour market and patient satisfaction with medical care in Vietnam
UNU-MERIT/MGSoG Dissertation Series
№ 230

Jinhyuck Park
Intellectual Property right protection and cross-border R&D investments by multinational enterprises
UNU-MERIT/MGSoG Dissertation Series
№ 229

Richard de Groot
Show me the Money:
Essays on the Impact of Cash Transfers on Child Nutrition and the Role of Intra-Household Dynamics
UNU-MERIT/MGSoG Dissertation Series
№ 228

Catie Lott
Diamonds are a Women's Best Friend
Broadening Measures of Women's Access to Formal Political Decision-Making
UNU-MERIT/MGSoG Dissertation Series
№ 227

Ana Cristina Calderon Ramirez
Public Management Reforms
Three stories about public procurement agencification in Latin America
UNU-MERIT/MGSoG Dissertation Series
№ 226

Camilo Nicanor Carrillo Purin
Teachers' in-service training and student achievement:
The effect of in-service training of Peruvian teachers on student achievement
UNU-MERIT/MGSoG Dissertation Series
№ 225

Hugo Confraria
Developing scientific capacity in the Global South
UNU-MERIT/MGSoG Dissertation Series № 224

Alison Cathles
Educational Pathways and Skills:
Past, Present, and Future
UNU-MERIT/MGSoG Dissertation Series
№ 223

Ibrahima Sory Kaba
Aggregate Fluctuations and Development:
Essays on Macroeconomic Volatility and Economic Growth
UNU-MERIT/MGSoG Dissertation Series
№ 222

Charlotte Keijser
Firm Participation, Learning and Innovation in Heterogenous Value Chains of IT-enabled Services
UNU-MERIT/MGSoG Dissertation Series
№ 221

Salih Çevikarslan
Innovation Strategies and Their Implications for Technological Change and Market Outcomes:
An Evolutionary Multi-Agent Based Modelling Approach
UNU-MERIT/MGSoG Dissertation Series
№ 220

Wondimagegn Mesfin Tesfaye
Essays on the Impacts of Climate-Smart Agricultural Innovations on Household Welfare
UNU-MERIT/MGSoG Dissertation Series
№ 219

Tatevik Poghosyan
How Board Networks Affect Firm Performance and Innovation Incentives in Transition Economies: The Case of Armenia
UNU-MERIT/MGSoG Dissertation Series
№ 218

Arip Muttaqien
Essays on Inequality and Polarization:
Empirical Studies in Developing Asia
UNU-MERIT/MGSoG Dissertation Series
№ 217

2018

Katrin Marchand
Essays on Forced Migration and Labour Market Participation in Developing Countries
UNU-MERIT/MGSoG Dissertation Series
№ 216

Ortrun Merkle
The Myth of Gender Neutral Power:
Corruption and Gender Norms
UNU-MERIT/MGSoG Dissertation Series
№ 215

Biljana Meshkovska
Life after Trafficking:
(re)integration processes of women that have been trafficked for the purpose of sexual exploitation in Europe
UNU-MERIT/MGSoG Dissertation Series
№ 214

Vincenzo Vinci
The Relevance of Institutions and People's Preferences for Social Protection
UNU-MERIT/MGSoG Dissertation Series № 213

Silke Heuser
The Effectiveness of Environmental Policies on Reducing Deforestation in the Brazilian Amazon
UNU-MERIT/MGSoG Dissertation Series № 212

Jennifer Waidler
Social Assistance and Remittances and Their Role in the Fight Against Poverty
UNU-MERIT/MGSoG Dissertation Series № 211

Choolwe Muzyamba
The role of community mobilization in the promotion of maternal health of women living with HIV in Zambia
UNU-MERIT/MGSoG Dissertation Series № 210

Juan Carlos A. Castillo Sánchez
Assessing the Role of the Export Sector in Mexican Economic Development,1965-2014
UNU-MERIT/MGSoG Dissertation Series № 209

Tareq Abuelhaj
Food Security Policy Impact Analysis: The Econometrics of Cash and Food Assistance Cost Effectiveness
UNU-MERIT/MGSoG Dissertation Series № 208

Marta Férnandez de Arroyabe Arranz
Essays on M&AS and Innovation
UNU-MERIT/MGSoG Dissertation Series № 207

Clotilde Mahé
Essays on Migration and Occupational Choice
UNU-MERIT/MGSoG Dissertation Series № 206

Simone Sasso
Talent on the move. Essays on Human Capital, Graduate Mobility and Economic Development
UNU-MERIT/MGSoG Dissertation Series № 205

Khaled Walid Rajab
Strategic Planning under Fragility
UNU-MERIT/MGSoG Dissertation Series № 204

Mutinta Hambayi Nseluke
A Tall Order: Improving Child Linear Growth
UNU-MERIT/MGSoG Dissertation Series № 203

Elvis Korku Avenyo
Innovations and Firm Performance in sub-Saharan Africa: Empirical Analyses
UNU-MERIT/MGSoG Dissertation Series № 202

Ni Zhen
Employment Dynamics, Firm Performance and Innovation Persistence in the Context of Differentiated Innovation Types: Evidence from Luxembourg
UNU-MERIT/MGSoG Dissertation Series № 201

Caroline Wehner
Too Scared to Achieve: The Relation Between Neuroticism, Conscientiousness and Socioeconomic Outcomes
UNU-MERIT/MGSoG Dissertation Series № 200

Stefania Innocenti
On Institutional Persistence
UNU-MERIT/MGSoG Dissertation Series № 199

Hassen Abda Wako
Economic Globalization, Institutions and Development: Essays on Aid, Foreign Direct Investment and Trade
UNU-MERIT/MGSoG Dissertation Series № 198

2017

Hans-Erik Edsand
Winds of Change
UNU-MERIT/MGSoG Dissertation Series № 197

Ana Patricia Silva Vara
Redressing the Gender Gap
UNU-MERIT/MGSoG Dissertation Series № 196

Andrés Iván Mideros Mora
Essays on the Economic Effects of Non-contributory Social Protection
UNU-MERIT/MGSoG Dissertation Series № 195

Tobias Broich
New Actors in the Global Economy
UNU-MERIT/MGSoG Dissertation Series № 194

Bernard Nikaj
From No-government to E-government
UNU-MERIT/MGSoG Dissertation Series № 193

Ali Safarnejad
Prioritizing the HIV Response
UNU-MERIT/MGSoG Dissertation Series № 192

Clovis Freire
Diversification and Structural Economic Dynamics
UNU-MERIT/MGSoG Dissertation Series № 191

Michael Verba
Innovation and Knowledge Dynamics: Essays on the Knowledge Economy
UNU-MERIT/MGSoG Dissertation Series № 190

Pui Hang Wong
The Hearts and Minds in Conflict and Peace: The Economics of Counterinsurgency and the Psychology of Reconstruction
UNU-MERIT/MGSoG Dissertation Series № 189

Brenda Yamba
Schooling Despite All Odds: Evidence from Lesotho on Female Child Carers who Stayed in School
UNU-MERIT/MGSoG Dissertation Series № 188

Sheng Zhong
Moving towards An Energy Efficient Future: Essays on Energy Efficiency, Technology and Development
UNU-MERIT/MGSoG Dissertation Series № 187

Julieta Marotta
Access to Justice and Legal Empowerment of Victims of Domestic Violence through Legal Organizations in the City of Buenos Aires: A Qualitative Empirical Legal Study
UNU-MERIT/MGSoG Dissertation Series, № 186

Andrea Franco-Correa
On the Measurement of Multidimensional Poverty as a Policy Tool: Empirical Applications to Chile, Colombia, Ecuador and Peru
UNU-MERIT/MGSoG Dissertation Series, № 185

2016

Yesuf Awel
Insurance for Growth: Empirical Essays on Insurance Demand and Impacts in Africa
UNU-MERIT Dissertation Series, № 108

Tigist Mekonnen Melesse
Grow More Food using Fewer Resources: Agricultural Technology Adoption and Innovation Practices for Inclusive and Sustainable Development
UNU-MERIT Dissertation Series, № 107

Eleni Yitbarek
Getting Ahead or left Behind? Essays on Poverty Dynamics and Social Mobility in Africa
UNU-MERIT Dissertation Series, № 106

Thuy Dieu Nguyen
Firm-Level Theory and Evidence of Corruption
UNU-MERIT Dissertation Series, № 105

Raquel Tsukada Lehman
Essays on Household Production with Labor-Saving Technology
UNU-MERIT Dissertation Series, № 104

Eva Barteková
Multi-Problem Challenges for a Renewable Future: Empirical Studies on Competitive Disadvantages from Electricity Price Differentials and Mineral Supply Risk in an Open Economy
UNU-MERIT Dissertation Series, № 103

Jocelyn Olivari
Entrepreneurial Traits and Innovation: Evidence from Chile
UNU-MERIT Dissertation Series, № 102

Muhammad Shafique
Essays on the role of knowledge, R&D, and Technology-based Firms in the Evolution of Socio-techno-economic System
UNU-MERIT Dissertation Series, № 101

Serdar Türkeli
Governance of Innovation Policy: Empirical Studies on Applied Political Economy by Multi-Methods Analysis
UNU-MERIT Dissertation Series, № 100

Ayokunu Adedokun
Pathways to Sustainable Peace building in Divided Societies: Lessons and Experiences from Mozambique
MGSoG Dissertation Series, № 75

Luiz Rothier Bautzer
Organizing Concurrent Engineering through ICT Platforms
Blueprinting Product Lifecycle Management Platforms across Disciplinary Agencies
MGSoG Dissertation Series, № 74

Natalia Popova
Migration in the Periphery of the European Union:
Determinants of Successful and Sustainable Labour Market Integration of Return Migrants in Albania, Egypt, Moldova and Tunisia
MGSoG Dissertations Series, № 73

Richard A. Martina
Uncertainty and Resource Constraint in the Small Island Developing States:
Essays in Entrepreneurial Cognition
MGSoG Dissertations Series, № 72

Cécile Cherrier
The Expansion of Basic Social Protection in Low-income Countries:
An Analysis of Foreign Aid Actors' Role in the Emergence of Social Transfers in Sub-Saharan Africa
MGSoG Dissertations series, № 71

Paul Caldron
The Tacit Bargain in Short-Term Medical Missions: Why U.S. physicians go and what it costs
MGSoG Dissertation Series, № 70

Mahmut Kobal
Customs & Excellence: A Comparative Approach on Administrative and Regulatory Compliance Perspectives of the EU-Turkey Customs Union
MGSoG Dissertation Series, № 69

Craig Loschmann
Essays on Conflict-related Migration and Development in the Case of Afghanistan
MGSoG Dissertations Series, № 68

Andrea Milan
Rural Livelihoods, Location and Vulnerable Environments: Approaches to Migration in Mountain areas of Latin America
MGSoG Dissertation Series, № 67

Farida Lada
On Guarding the Welfare of Clinical Trial Subjects While Promoting Novel Drug Innovation
A Game Theoretical Approach
MGSoG Dissertation Series, № 66

2015

Hibret Belete Maemir
Dissecting Aggregate Productivity: International Integration and Growth with Heterogeneous Firms
UNU-MERIT Dissertation Series, № 96

Giorgio Triulzi
Looking for the Right Path: Technology Dynamics, Inventive Strategies and Catching-up in the Semiconductor Industry
UNU-MERIT Dissertation Series, № 95

Abdul Baseer Qazi
Knowledge flows and networks in the ICT sector: The case of Pakistan
UNU-MERIT Dissertation Series, № 94

Ajay Thutupalli
Technology Paradigm Shifts in Agriculture: Drivers of Sustainability and Catch up
UNU-MERIT Dissertation Series, № 93

Eduardo Urias
Improving access to HIV/AIDS treatment in Brazil: When are Compulsory Licenses effective in Price Negotiations?
UNU-MERIT Dissertation Series, № 92

Francesca Guadagno
Why have so few Countries Industrialised?
UNU-MERIT Dissertation Series, № 91

Daniel Opolot
The Evolution of Beliefs and Strategic Behaviour
UNU-MERIT Dissertation Series, № 90

Alejandro Lavopa
Structural Transformation and Economic Development: Can Development Traps be Avoided
UNU-MERIT Dissertation Series, № 89

Jinjin Zhao
Urban water management reform: The Case of China
UNU-MERIT Dissertation Series, № 88

Simona Vezzoli
Borders, Independence and Post-colonial Ties: the Role of the State in Caribbean Migration
MGSoG Dissertation Series, № 65

Silvia Consuelo Gómez Soler
Civil Conflict and Education: How Does Exposure to Civil Conflict Affect Human Capital Accumulation? Evidence from Standardized Exit Exams in Colombia
MGSoG Dissertation Series, № 64

Paula Nagler
Occupational Choice in the Developing World
MGSoG Dissertation Series, № 63

Jasmin Kientzel
Determinants of Professional Commitment to Environmental Sustainability
MGSoG Dissertation Series, № 62

Mehmet Güney Celbiş
Regional Policies: Convergence, Trade, and the Allocation of Public Capital
MGSoG Dissertation Series, № 61

Florian Henning
Living Up to Standard: Interoperability Governance and Standards Adoption in Government Information Networks
MGSoG Dissertation Series, № 60

Niels P. Groen
The Never-Ending Project
Understanding E-Government Project Escalation
MGSoG Dissertation Series, № 59

Derek Copp
Teacher-Based Reactivity to Provincial Large-scale Assessment in Canada
MGSoG Dissertation Series, № 58

Michaella Vanore
Family-Member Migration and the Psychosocial Health Outcomes of Children in Moldova and Georgia
MGSoG Dissertation Series, № 57

Sonja Fransen
The Economic and Social Effects of Remittances and Return Migration in Conflict-Affected Areas: The Case of Burundi
MGSoG Dissertation Series, № 56

Ibrahim Khalil Conteh
The Impact of Floods on Primary School Education in Zambia
MGSoG Dissertation Series, № 55

Richard Bluhm
Growth Dynamics and Development
Essays in Applied Econometrics and Political Economy
MGSoG Dissertation Series, № 54

Nevena P. Zhelyazkova
Work-Family Reconciliation and Use of Parental Leave in Luxembourg: Empirical Analysis of Administrative Records
MGSoG Dissertation Series, № 53

2014

Dirk Crass
The Impact of Brands on Innovation and Firm Performance: Empirical Evidence from Germany
UNU-MERIT Dissertation Series, № 87

Samyukta Bhupatiraju
The Geographic Dimensions of Growth and Development
UNU-MERIT Dissertation Series, № 86

François Lafond
The Evolution of Knowledge Systems
UNU-MERIT Dissertation Series, № 85

Annalisa Primi
Promoting Innovation in Latin America: What Countries Have Learned (and What They Have Not) in Designing and Implementing Innovation and Intellectual Property Policies
UNU-MERIT Dissertation Series, № 84

Fatoumata Lamarana Diallo
Evaluation of Meal and Deworming Programs for Primary Schools in Rural Senegal
UNU-MERIT Dissertation Series, № 83

Sachin Kumar Badkas
Metachoice and Metadata: Innovating with Environmental Policy Analysis in Europe
MGSoG Dissertation Series, № 52

Irina S. Burlacu
An Evaluation of Tax-Benefit Systems Impact on the Welfare of Frontier Worker: The Case of Luxembourg and Belgium
MGSoG Dissertation Series, № 51

Özge **Bilgili**
Simultaneity in Transnational Migration Research: Links Between Migrants' Host and Home Country Orientation
MGSoG Dissertation Series, № 50

Yulia Privalova Krieger
Reshaping the Big Agenda: Transnational Politics and Domestic Resistance Financial crisis and social protection reform in Bosnia and Herzegovina
MGSoG Dissertation Series, № 49

Marieke van Houte
Moving Back or Moving Forward? Return migration after Conflict
MGSoG Dissertation Series, № 48

Oxana Slobozhan
Global Governance in the Management of Natural Resources: The Case of the Extractive Industries Transparency Initiative (EITI)
MGSoG Dissertation Series, № 47

Luis Bernardo Mejia Guinand
The Changing Role of the Central Planning Offices in Latin America: A Comparative Historical Analysis Perspective (1950-2013)
MGSoG Dissertation Series, № 46

Cheng Boon Ong
Ethnic Segregation in Housing, Schools and Neighbourhoods in the Netherlands
MGSoG Dissertation Series, № 45

Luciana V. Cingolani
Bureaucracies for Development: Oxymoron or Reality? Studies on State Capacity in Challenging Governance Contexts
MGSoG Dissertation Series, № 44

Carlos Cadena Gaitán
Green Politics in Latin American Cities - Sustainable Transport Agendas
MGSoG Dissertation Series, № 43

Katie Kuschminder
Female Return Migration and Reintegration Strategies in Ethiopia
MGSoG Dissertation Series, № 42

Metka Hercog
Highly-Skilled Migration and New Destination Countries
MGSoG Dissertation Series, № 41

Margaret Agaba Rugadya
Can Remittances Influence the Tenure and Quality of Housing in Uganda?
MGSoG Dissertation Series, № 40

Ilire Agimi
New Governance Under Limited Statehood: The Case of Local Government Reform in Kosovo
MGSoG Dissertation Series, № 39

2013

Anant Kamath
Information Sharing through Informal Interaction in Low-Tech Clusters
UNU-MERIT Dissertation Series, № 82

Flavia Pereira de Carvalho
What we talk about when we talk about Brazilian Multinationals: An Investigation on Brazilian FDI, Economic Structure, Innovation and the Relationship between them
UNU-MERIT Dissertation Series, № 81

Jun Hou
Complementarity in Innovation and Development: A Cross-country Comparison
UNU-MERIT Dissertation Series, № 80

Rufin Baghana
Impacts of Government Incentives to R&D, Innovation and Productivity: A Microeconometric Analysis of the Québec Case
UNU-MERIT Dissertation Series, № 79

Lilia I. Stubrin
High-Tech Activities in Emerging Countries: A Network perspective on the Argentinean Biotech Activity
UNU-MERIT/MGSoG Dissertation Series, № 78

Kristine Farla
Empirical Studies on Institutions, Policies and Economic Development
MGSoG Dissertation Series, № 38

Marina Petrovic
Social Assistance and Activation in the Pursuit of Happiness: Shedding New Light on Old Policy Solutions to Social Exclusion
MGSoG Dissertation Series, № 37

Laura Torvinen
Assessing Governance Assessments: The Case of Mozambique: Governance Assessments in the Context of Aid Effectiveness Discourse
MGSoG Dissertation Series, № 36

Biniam Egu Bedasso
Institutional Change in the Long Shadow of Elite: Essays on Institutions, Human Capital and Ethnicity in Developing Countries
MGSoG Dissertation Series, № 35

Sepideh Yousefzadeh Faal Deghati
Childhoods Embargoed: Constructing and Reconstructing Multidimensional Child Poverty in Iran 1984-2009
MGSoG Dissertation Series, № 34

Robert Bauchmüller
Investing in Early Childhood Care and Education: The Impact of Quality on Inequality
MGSoG Dissertation Series, № 33

Martin Rehm
Unified Yet Separated: Empirical Study on the Impact of Hierarchical Positions within Communities of Learning
MGSoG Dissertation Series, № 32

2012

Abdul Waheed
Innovation Determinants and Innovation as a Determinant: Evidence from Developing Countries
UNU-MERIT Dissertation Series, № 77

Bilal Mirza
Energy Poverty and Rural Energy Markets in Pakistan
UNU-MERIT Dissertation Series, № 76

Benjamin Engelstätter
Enterprise Software and Video Games: An Empirical Analysis
UNU-MERIT Dissertation Series, № 75

Fulvia Farinelli
Natural Resources, Innovation and Export Growth: The Wine Industry in Chili and Argentina
UNU-MERIT Dissertation Series

Rodolfo Lauterbach
Innovation in Manufacturing: From Product Variety and Labor Productivity Growth to Economic Development in Chile
UNU-MERIT Dissertation Series

Kirsten Wiebe
Quantitative Assessment of Sustainable Development and Growth in Sub-Saharan Africa
UNU-MERIT Dissertation Series, № 74

Julio Miguel Rosa
Organizational Strategies, Firms' Performance and Spatial Spillovers: The Canadian Case in Research and Development.
UNU-MERIT Dissertation Series, № 73

Johannes Wilhelmus Marie Boels
Joseph Schumpeter, Honderd Jaar Economische Ontwikkeling: Een Historisch-theoretische Beschouwing.
UNU-MERIT Dissertation Series

Dorcas Mbuvi
Utility Reforms and Performance of the Urban Water Sector in Africa
MGSoG Dissertation Series, № 31

Lina Salanauskaite
Distributional Impacts of Public Policies: Essays in Ex-Ante and Ex-Post Evaluation
MGSoG Dissertation Series, № 30

Esther Schüring
To Condition or not – is that the Question? An Analysis of the Effectiveness of Ex-Ante and Ex-Post Conditionality in Social Cash Transfer Programs
MGSoG Dissertation Series, № 29

Joe Abah
Strong Organisations in Weak States: Atypical Public Sector Performance in Dysfunctional Environments
MGSoG Dissertation Series, № 28

Zina Samih Nimeh
Social Citizenship Rights: Inequality and Exclusion
MGSoG Dissertation Series, № 27

2011

Daniel Vertesy
Interrupted Innovation: Emerging Economies in the Structure of the Global Aerospace Industry
UNU-MERIT Dissertation Series, № 72

Tina Saebi
Successfully Managing Alliance Portfolios: An Alliance Capability View
UNU-MERIT Dissertation Series, № 71

Nora Engel
Tuberculosis in India: A Case of Innovation and Control
UNU-MERIT/MGSoG Dissertation Series, № 70

Evans Mupela
Connectivity and growth in Sub-Saharan Africa: The Role of Communication Satellites
UNU-MERIT Dissertation Series, № 69

Nantawan Kwanjai
Cross Cultural Intelligence amid Intricate Cultural Webs: A Tale of the UnDutchables in the Land of 1002 Smiles
UNU-MERIT Dissertation Series, № 68

Lina Sonne
Innovation in Finance to Finance Innovation: Supporting Pro-poor Entrepreneur-based Innovation
UNU-MERIT Dissertation Series, № 67

Lenka Eisenhamerová
Legitimacy of 'Humanitarian Military Intervention'
MGSoG Dissertation Series, № 26

Sonila Tomini
Informal Payments for Health Care Services in Albania
MGSoG Dissertation Series, № 25

Jinjing Li
Dynamic Microsimulation in Public Policy Evaluation
MGSoG Dissertation Series, № 24

Aziz Atamanov
Rural Nonfarm Employment and International Migration as Alternatives to Agricultural Employment: The Case of Kyrgyzstan
MGSoG Dissertation Series, № 23

Frieda Vandeninden
Poverty Alleviation: Aid and Social Pensions
MGSoG Dissertation Series, № 22

Juliana Nyasha Tirivayi
The Welfare Effects of Integrating AIDS Treatment with Food Transfers: Evidence from Zambia
MGSoG Dissertation Series, № 21

Agnieska Ewa Sowa
Who's Left Behind? Social Dimensions of Health Transition and Utilization of Medical Care in Poland
MGSoG Dissertation Series, № 20

Emmanaouil Sfakianakis
The Role of Private Actors in the Provision of Public Goods with Applications to Infrastructure and Financial Stability
MGSoG Dissertation Series, № 19

Siu Hing Lo
White Collars Green Sleeves: An Inter-organizational Comparison of Determinants of Energy-Related Behaviors among Office Workers
MGSoG Dissertation Series, № 18

Treena Wu
Constraints to Human Capital Investment in Developing Countries: Using the Asian Financial Crisis in Indonesia as a Natural Experiment
MGSoG Dissertation Series, № 17

Henry Espinoza Peña
Impact Evaluation of a Job-Training Programme for Disadvantaged Youths: The Case of Projoven
MGSoG Dissertation Series, № 16

2010

Fernando Santiago
Human Resources Management Practices and Learning for Innovation in Developing Countries: Pharmaceutical Firms in Mexico
UNU-MERIT Dissertation Series, № 66

Zakaria Babutsidze
Essays on Economies with Heterogeneous Interacting Consumers
UNU-MERIT Dissertation Series, № 65

Bertha Vallejo
Learning and Innovation Under Changing Market Conditions: The Auto Parts Industry in Mexico
UNU-MERIT Dissertation Series, № 64

Donatus Ayitey
Technical Change, Competitiveness and Poverty Reduction: A Study of the Ghanaian Apparel Industry
UNU-MERIT Dissertation Series, № 63

Sergey Filippov
Multinational Subsidiary Evolution: Corporate Change in New EU Member States
UNU-MERIT Dissertation Series, № 62

Asel Doranova
Technology Transfer and Learning under the Kyoto Regime: Exploring the Technological Impact of CDM Projects in Developing Countries
UNU-MERIT Dissertation Series, № 61

Florian Tomini
Between Family and Friend: Understanding the Interdependency of Private Transfers
MGSoG Dissertation Series, № 15

Michał Polalowski
The Institutional Transformation of Social Policy in East Central Europe: Poland and Hungary in Comparative and Historical Perspective
MGSoG Dissertation Series, № 14

Maha Ahmed
Defining, Measuring and Addressing Vulnerability: The Case of Post Conflict Environments
MGSoG Dissertation Series, № 13

Pascal Beckers
Local Space and Economic Success: The Role of Spatial Segregation of Migrants in the Netherlands
MGSoG Dissertation Series, № 12

Victor Cebotari
Conflicting Demands in Ethnically Diverse Societies: Ethno political Contention and Identity Values in Europe
MGSoG Dissertation Series, № 11

Dennis Gyllensporre
Competing and Complementary Perspectives on the EU as a Crisis Management Actor: An Examination of the Common Security and Defence Policy through the Lenses of Idealism and Realism
MGSoG Dissertation Series, № 10

Judit Vall Castello
Business Cycle and Policy Effects on Labour Market Transitions of Older and Disabled Workers in Spain
MGSoG Dissertation Series, № 9

Keetie Roelen
False Positives or Hidden Dimensions: The Definition and Measurement of Child Poverty
MGSoG Dissertation Series, № 8

Denisa Maria Sologon
Earning Dynamics in Europe
MGSoG Dissertation Series, № 7

Melissa Siegel
Money and Mobility: Migration and Remittances
MGSoG Dissertation Series, № 6

Jessica S. Hagen-Zanker
Modest Expectations: Causes and Effects of Migration on Migrant Households inSource Countries
MGSoG Dissertation Series, № 5

2009

Alexis Habiyaremye
From Primary Commodity Dependence to Diversification and Growth: Absorptive Capacity and Technological Catch Up in Botswana and Mauritius.
UNU-MERIT Dissertation Series, № 60

Yoseph Getachew
The Role of Public Capital in Economic Development
UNU-MERIT Dissertation Series, № 59

Sandra Leitner
Embodied Technological Change and Patterns of Investment in Austrian Manufacturing
UNU-MERIT Dissertation Series, № 58

Semih Akçomak
The Impact of Social Capital on Economic and Social Outcomes
UNU-MERIT Dissertation Series, № 57

Abraham Garcia
The Role of Demand in Technical Change
UNU-MERIT Dissertation Series, № 56

Saurabh Arora
Coherence in Socio-technical Systems: A Network Perspective on the Innovation Process
UNU-MERIT Dissertation Series, № 55

Mirtha R. Muniz Castillo
Human Development and Autonomy in Project Aid: Experiences from four bilateral projects in Nicaragua and El Salvador
MGSoG Dissertation Series, № 4

Christiane Arndt
Governance Indicators
MGSoG Dissertation Series, № 3

Britta Augsburg
Microfinance: Greater Good or Lesser Evil?
MGSoG Dissertation Series, № 2

2008

Rutger Daems
Medicines for the Developing World
UNU-MERIT Dissertation Series, № 54

Johannes Hanel
Assessing Induced Technology: Sombart's Understanding of Technical Change in the History of Economics
UNU-MERIT Dissertation Series, № 53

Rifka Weehuizen
Mental Capital: the Economic Significance of Mental Health
UNU-MERIT Dissertation Series, № 52

Danielle Cloodt
The Relationship between R&D Partnership Formation, Social Embeddedness and Innovative Performance
UNU-MERIT Dissertation Series, № 51

Sabine Fuss
Sustainable Energy Development under Uncertainty
UNU-MERIT Dissertation Series, № 50

Geranda Notten
Measuring and Managing Poverty Risks
MGSoG Dissertation Series, № 1

2007

Tobias Kronenberg
Reconciling Environmental Conservation with Economic Prosperity: The Feasibility of Double Dividends in the Short and Long Run
UNU-MERIT Dissertation Series, № 49

Viktoria Kravtsova
Assessing the Impact of Foreign Direct Investment in Transition Economies
UNU-MERIT Dissertation Series, № 48

Suhail Sultan
The Competitive Advantage of Small and Medium Sized Enterprises: The Case of Jordan's Natural Stone Industry
UNU-MERIT Dissertation Series, № 47

2006

Bulat Sanditov
Essays on Social Learning and Imitation
UNU-MERIT Dissertation Series, № 46

Mamata Parhi
Dynamics of New Technology Diffusion: A Study of the Indian Automotive Industry
UNU-MERIT Dissertation Series, № 45

Andreas Reinstaller
Social Structures and the Innovation Process: Their Role in the Demand of Firms and Consumers
UNU-MERIT Dissertation Series, № 44

Rose Kiggundu
Innovation systems and Development: The Journey of a Beleaguered Nile Perch Fishery in Uganda
UNU-MERIT Dissertation Series, № 43

Thomas Pogue
The Evolution of Research Collaboration in South African Gold Mining: 1886-1933
UNU-MERIT Dissertation Series, № 42

Geoffrey Gachino
Foreign Direct Investment, Spillovers and Innovation: The Case of Kenyan Manufacturing Industry
UNU-MERIT Dissertation Series, № 41

Önder **Nomaler**
Technological Change, International Trade and Growth: An Evolutionary, Multi-Agents-Based Modeling Approach
UNU-MERIT Dissertation Series, № 40

2005

Samia Satti Osman Mohamed-Nour
Change and Skill Development in the Arab Gulf Countries
UNU-MERIT Dissertation Series, № 39

Elad Harison
Intellectual Property Rights: Economics and Policy Analysis
UNU-MERIT Dissertation Series, № 38

Daniel Dalohoun
Learning to innovate: agricultural innovation and entrepreneurship: the case of Songhaï farmers in Benin
UNU-MERIT Dissertation Series, № 37

Müge Ozman
Networks, Organizations and Knowledge
UNU-MERIT Dissertation Series, № 36

Bas Straathof
Product Variety and Economic Growth: The Counteracting Effects of Scale and Idiosyncrasy
UNU-MERIT Dissertation Series, № 35

Wilfred Schoenmakers
Knowledge Flows between Multinational Companies: A Patent Data Analysis
UNU-MERIT Dissertation Series, № 34

Myriam Cloodt
Mergers and Acquisitions (M and As) in High-Tech Industries: Measuring the Post-M and A Innovative Performance of Companies
UNU-MERIT Dissertation Series, № 33

2004

Paola Criscuolo
R&D Internationalisation and Knowledge Transfer: Impact on MNEs and their Home Countries
UNU-MERIT Dissertation Series, № 32

Maarten Verkerk
Trust and Power on the Shop Floor
UNU-MERIT Dissertation Series, № 31

Gottfried Leibbrandt
Adoption, Harmonization and Succession of Network Technologies across Countries
UNU-MERIT Dissertation Series, № 30

Mark Sanders
Skill Biased Technical change: Its Origins, the Interaction with the Labour Market and Policy Implications
UNU-MERIT Dissertation Series, № 29

2003

Nadine Roijakkers
Inter-firm Cooperation in High-tech Industries: a Study of R&D Partnerships in Pharmaceutical Biotechnology
UNU-MERIT Dissertation Series, № 28

Viki Sonntag
Speed, Scale and Sustainability
UNU-MERIT Dissertation Series, № 27

Masaru Yarime
From End-of-Pipe Technology to Clean Technology
UNU-MERIT Dissertation Series, № 26

Stéphane Malo
The Combinatorial Chemistry Revolution: Sustaining a Superior Performance Position through Technological Learning
UNU-MERIT Dissertation Series, № 25

2002

Annelies Hogenbirk
Determinants of Inward Foreign Direct Investment: the Case of the Netherlands
UNU-MERIT Dissertation Series, № 24

Bastiaan Johan terWeel
The Computerization of the Labour Market
UNU-MERIT Dissertation Series

2001

John Adeoti
Technology Investment in Pollution Control in Sub-Saharan Africa: The Case of the Nigerian Manufacturing Industry
UNU-MERIT Dissertation Series, № 23

Edward Huizenga
Innovation Management: How Frontrunners Stay Ahead: An Empirical Study on Key Success Factors in the ICT sector
UNU-MERIT Dissertation Series, № 22

2000

Machiel van Dijk
Technological Change and the Dynamics of Industries: Theoretical Issues and Empirical evidence from Dutch Manufacturing
UNU-MERIT Dissertation Series, № 21

1999

Jan Cobbenhagen
Managing Innovation at the Company Level: A Study on Non-Sector-Specific Success Factors
UNU-MERIT Dissertation Series, № 20

Marjolein Caniëls
Regional Growth Differentials: The Impact of Locally Bounded Knowledge Spillovers
UNU-MERIT Dissertation Series, № 19

1998

Aldo Geuna
Resource Allocation and Knowledge production: Studies in the Economics of University Research
UNU-MERIT Dissertation Series, № 18

1996

Reinoud Joosten
Dynamics, Equilibria, and Values
UNU-MERIT Dissertation Series, № 17

Hugo Kruiniger
Investment, R&D, and the Financing Decisions of the Firm
UNU-MERIT Dissertation Series, № 16

1995

Hans van Meijl
Endogenous Technological Change: The Case of Information Technology, Theoretical Considerations and Empirical Results
UNU-MERIT Dissertation Series, № 15

René Kemp
Environmental Policy and Technical Change: A Comparison of the Technological Impact of Policy Instruments
UNU-MERIT Dissertation Series, № 14

Rohini Acharya
The Impact of New Technologies on Economic Growth and Trade: A Case Study of Biotechnology
UNU-MERIT Dissertation Series, № 13

Geert Duysters
The Evolution of Complex Industrial Systems: The Dynamics of Major IT Sectors
UNU-MERIT Dissertation Series, № 12

Marjan Groen
Technology, Work and Organisation: A Study of the Nursing Process in Intensive Care Units
UNU-MERIT Dissertation Series, № 11

1994

Huub Meijers
On the Diffusion of Technologies in a Vintage Framework: Theoretical Considerations and Empirical Results
UNU-MERIT Dissertation Series, № 10

Theon van Dijk
The Limits of Patent Protection: Essays on the Economics of Intellectual Property Rights
UNU-MERIT Dissertation Series, № 9

Hans Voordijk
Naar Integrale Logistiek in Bedrijfsketens: Ontwikkelingen in de Bouw
UNU-MERIT Dissertation Series, № 8

1993

Paul Diederen
Technological Progress in Enterprises and Diffusion of Innovation: Theoretical Reflections and Empirical Evidence
UNU-MERIT Dissertation Series, № 7

Ben Dankbaar
Economic Crisis and Institutional Change: The Crisis of Fordism from the Perspective of the Automobile Industry
UNU-MERIT Dissertation Series, № 6

Hanno Roberts
Accountability and Responsibility: The Influence of Organisation Design on Management Accounting
UNU-MERIT Dissertation Series, № 5

1992

Bart Verspagen
Uneven Growth between Interdependent Economies: An Evolutionary View on Technology Gaps, Trade and Growth
UNU-MERIT Dissertation Series, № 4

Sjoerd Romme
A Self-organization Perspective on Strategy Formation
UNU-MERIT Dissertation Series, № 3

1989

John Spangenberg
Economies of Scale, and Atmosphere in Research Organisations
UNU-MERIT Dissertation Series, № 2

1988

John Hagedoorn
Evolutionary and Heterodox Innovation Analysis: A Study of Industrial and Technological Development in Process Control and Information Technology
UNU-MERIT Dissertation Series, № 1