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Volatile and spatially varied: The geographically differentiated economic outcomes of resource-based development in Peru, 2001–2015☆

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ABSTRACT

The macroeconomic impacts of resource-based development are diverse across national space. However, the more export dependent and geographically peripheral the region, the more susceptible it is to boom-and-bust cycles. We typify resource-based economic development in Peru in the period 2001–2015, analyzing regional export specialization, growth volatility, and de-industrialization, three resource curse symptoms. With the commodity cycle: (i) export specialization is not the same in all mineral regions; (ii) regional growth volatility is much higher at regional level than at national level; and (iii) there is no convincing case of de-industrialization and the Dutch disease, because a world economy surge does not operate as a national resource discovery. We say economic evolution within resource-rich Peru is volatile and spatially varied. At the national level, gold-and-copper-dependent Peru is not as vulnerable as other mineral dependent countries to external shocks. At the subnational level, growth volatility is very high for clusters of regions. Economic geography studies can contribute to challenging popular resource curse accounts of the development economics literature: we should be asking where, when, and why there is curse or blessing, and what type of it, rather than searching for a definitive universal answer on the developmental effects of mineral abundance.

1. Introduction

Do natural resources curse the economic development prospects of nations? Or if not the prospects of nations, those of their resource-rich regions? Adding to the new economic geography on resource-based development (Arias et al., 2014; Rehner et al., 2014; Phelps et al., 2015), our evidence shows that development based on natural resources is geographically uneven within countries. Similar claims have been made by economic geographers in relation to industrially sophisticated, non-resource-dependent economies (Martin, 2000; Hayter, 2004; Boschma and Frenken, 2009; MacKinnon et al., 2009), but we find them applicable to developing, resource-dependent ones as well. Mineral-abundant Peru, the Latin American economy with the best macroeconomic indicators during the last commodity supercycle, makes an appealing case to inform the resource curse debate; indeed, Peru has become a recurrent case study within a growing local resource curse literature (Cust and Poelhekke, 2015; Manzano and Gutierrez, 2019, Orihuela et al., 2019a). Studying the 2001–2015 commodity cycle, we contribute to the resource curse debate by documenting that economic development within emblematic resource-rich Peru is volatile and spatially diverse.

The resource-based development debate is commonly framed as a “curse or blessing” dichotomy, and sub-national variation was not previously explored (van der Ploeg, 2011; Frankel, 2012; Venables, 2016; Orihuela, 2018). This flaw can certainly be attributed to disciplinary paradigms and methods, as for the most part the economists who hape the debate have been searching for a general rule applicable to national economies (Sachs and Warner, 1997; Lederman and Mahoney, 2007; van der Ploeg, 2011; Orihuela, 2018). Recent economic literature has opted for a “local resource curse” line of research, given the wide availability of microdata that has recently opened up, yet we still observe little attention to sub-national *variation*. Thus, new quantitative methods-based approaches exploit national household survey data to find out whether mining districts or local communities—rather than mining countries—are cursed or blessed (Caselli and Michaels, 2013; Allcott and Keninston, 2014; Cust and Poelhekke, 2015; van der Ploeg and Poelhekke, 2017; Manzano and Gutierrez, 2019). Then, the evidence for local resource curse appears also inconclusive. In the case of Peru, some studies find mixed outcomes or scattered and disappointingly modest benefits, given the significance of

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the macroeconomic boom (Zegarra et al., 2007; Ticci and Escobal, 2015; Orihuela et al., 2019b). Others are more optimistic, but point out that positive outcomes appear to vary across space and over time (Aragón and Rudd, 2013; Loayza and Rigolini, 2015; Orihuela and Gamarra, 2019). Should mixed outcomes—within and across countries—not be the norm? How can quantitative research promote a more fruitful scholarly exchange? We contend that documenting within country spatial variation calls for a rethink of conventional analytical frameworks and the bold statements that often go with them. Going beyond curse or blessing, we call for complexity and variation to be embraced in the study of natural resource-based development: resource curse phenomena are contingent on time and place, to begin with.

To contribute to the field of resource curse studies with a more time-and-space sensitive approach, we analyze the macroeconomic performance of Peruvian regions. We do so by drawing on the empirical work of Rehner et al. (2014) and Jarreau and Poncet (2012), finding an economic geography approach that puts the hypothesis of uneven development at the center of the discussion. What we show statistically is a picture of diverse subnational macroeconomic dependence on more than a mining product. To begin with, Peru is not a mineral mono-export economy: the not only trades copper but also gold, zinc, and other metals, although gold and copper have a higher commercial volume. Moreover, as commodity prices do not always covariate and resources are not distributed uniformly throughout an intricate national territory made up of arid coastline, Andean mountains and the Amazon, it is problematic to expect subnational economic convergence. We find five clusters of regions when looking into the relationship between export dependence and variance in regional economic growth. And to add nuances to an already complex portrait, export specialization intensified along with price surges in one group of regions, but not in another. Finally, we find that in most—but not all—cases, and considering that the less dependent and wealthier regions are all coastal, the more export dependent and geographically peripheral the region, the more susceptible it is to boom-and-bust cycles as documented by the variance in regional economic growth rates.

The remainder of this article is organized as follows. First, we define the main features of resource-based development in Peru. Then, we present a basic analytical framework for the empirical study. Next, we set out our methods and data, followed by the results and a discussion based on the quantitative analysis. Finally, we conclude by highlighting lessons from the case study and their implications for advancing an evolutionary economic geography perspective of the resource curse.

2. The case of resource-dependent Peru

Peru is resource rich country, but one with a diversified resource-based economy. Natural resources are distributed unevenly across ecological (Pacific Ocean, arid coast, Andes, and Amazonia) and political (twenty-five) regions. Moreover, the modern economic history of Peru is characterized by numerous boom-and-bust cycles, sizeable illegal economies of coca in the Andes and gold and timber in the Andean Amazon, and a national political-economic system centralized in the coastal megacity of Lima. By "diversified resource-based economy" we mean, first, that mining exports are important, but their collective historical significance varies. Mining exports have fluctuated between 10% and 70% over the last 125 years (see Fig. 1). Second, mining exports mean different things at different points in history, from silver and nitrates in the 19th century to copper, gold, lead, oil and natural gas, silver and zinc in the 20th and 21 st centuries. Third, these resource economies are distributed throughout the national territory, in spatially differentiated ways. And while some early mining regions remain active, others die and new ones arise; gold cycles, in particular, have both killed off and restored life to a subset of mineral regions (Thorp and Bertram, 1978; Thorp et al., 2012; Dargent et al., 2017).[1]

Such historical and spatial complexities qualify "resource-abundance/dependence", to the extent that one may want to label mineral-

Fig. 1. Mining and Oil Exports in Chile and Peru (Percentages) 1900–2015.

rich Peru a historical case of diversified dependence, in contrast to mineral-rich Chile to the south, which is a historical case that more closely resembles mono-commodity dependence. For example, in Chile, mining meant copper in the mid-nineteenth century, nitrates in the 1870s to the 1920s, and since then copper again, almost all of which is located in the northern regions. In that country, and unlike Peru, Fig. 1 shows that mining exports have never accounted for less than 50% of all exports over the last 125 years. In turn, Table 1 presents the main commodities in the export basket and macroeconomic indicators. The structural reforms of the 1990s, which liberalized the mining and oil sectors, met with a new, positive international-economic outlook.[2] Put together, reforms, foreign capital and commodity prices led to a new export cycle in 1993–2015.

We now turn to key contemporary features of economic geography, focusing on how export diversity benefits Peru and the spatial form this diversity takes. As we have noted, and as can be seen in Fig. 2, Peru exports a number of minerals but gold and copper are by far the most important ones, accounting for 24% and 19% of exports over the last five years, respectively.[3] During the 2008–2009 crisis, while gold prices kept escalating, copper prices fell drastically (see Figs. 2 and 3). The gold price trend changed after 2012, this time moving along with copper and greatly impacting Peru's exports (see Fig. 3). The following two maps (Fig. 4) show the geographical diversity of export specialization, and therefore mineral dependence, within Peru. Regional mineral exports vary in size and composition. From south to north, copper is prevalent in the southernmost regions of Moquegua and Tacna, which border Chile. Mineral deposits in Arequipa and Cusco are copper- and gold-rich.[4] The coastal regions south and north of Lima are mineral rich but diversified: Ica has large-scale iron mining and export agriculture;

[1] While most mining takes place in the Andes, most oil activity is located in Amazonia. Amazonia is also the site of (legal and illegal) gold mining, logging and, more recently, oil palm plantations. Finally, the Pacific Ocean yielded guano exports in the 19th century and fishmeal exports since the mid-20th century.

[2] Between World War II and the Debt Crisis, Peru's resource dependence moved from fisheries in the Pacific Ocean to oil in Amazonia and the northern continental shelf and copper in the southern regions of Moquegua and Tacna (the Peruvian side of the Atacama Desert, which also hosts copper in Chile). There was no foreign investment in mining throughout the 1980s.

[3] The country is ranked among the biggest mineral producers in the world: it is the third-largest producer of copper, the sixth of gold, and the second of silver.

[4] West of Cusco, small and poor Apurímac is silver dependent, an exceptional case. In turn, seated on a slightly different geology, the central Andes are lead rich, but copper and zinc are also significant. To the east, the peripheral Andean Amazonian regions of Puno and Madre de Dios are gold-rich and constitute extreme cases of export dependency. As these two frontier regions constitute the epicenter of illegal gold mining, exports figures are incomplete (illegal logging and coca are the other noticeable resource export-linked activities over there and elsewhere in the Eastern Andes or Andean Amazon).

Table 1
Growth, Exports Growth and Leading Exports in Peru 1945–2015.
Source: Authors' own calculation, based on BCRP, OXLAD y WDI.

	1945-72	1972-81	1981-93	1993-2015
Principal Exports (Main Location)	Sugar (northern Coast); fish flour (Pacific Ocean-Ancash); copper (Moquegua and Tacna)	Fish flour (Pacific Ocean-Ancash); copper (Moquegua and Tacna); petroleum (Amazon)	Copper (Moquegua and Tacna); petroleum (Amazon); lead and zinc (central Andes)	Copper, gold (all over the Andes); agricultural products (Coast)
Exports Rate Growth (annual average)	8.4	3.7	1.6	12.9
PIB Rate Growth (annual average)	5.3	4.0	0.1	4.27

Note: (a) 1961-72.

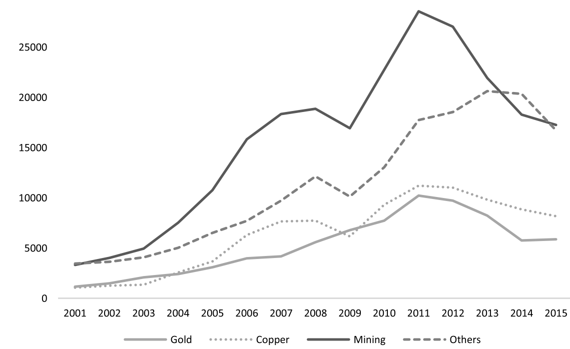

Fig. 2. Peru's Export Performance, 2001–2015.

copper-rich Ancash, in turn, is more diversified because of its fishmeal industry. In the northern Andes, gold-rich Cajamarca and La Libertad constitute another geological cluster, this time gold-based.[5] Piura has not welcomed new mining (in its large-scale form, but illegal activity takes place regardless), but benefits from oil. Finally the northern coastal regions are more diversified because of their sea access and irrigation infrastructure.[6] In short, few regions are not mineral dependent, but dependence means quite different things, across space and over time.

Between 2001 and 2015, see Fig. 4, the pie charts showing export structures changed in size and composition. The most significant increases took place in Arequipa, Puno, La Libertad and Madre de Dios, each of which became important gold exporters; and the central regions of Huánuco, Pasco and Junín, as well as Ancash, which became more copper-dependent. In turn, more drastic changes in composition took place in Ayacucho and Apurímac, which went from not exporting any metals in 2001 to exporting gold and silver by 2015. Clearly, Peru's economic geography appears to be even more complex than that of resource-rich Chile, a country subject to various case studies in the recent literature, including those from which we draw our methods (Arias et al., 2014; Rehner et al., 2014; Phelps et al., 2015). With a larger territory (1.275 million km2), 60% of which pertains to the Amazon basin, and a larger number of political regions, Peru has greater diversity in terms of ecological and political regions and a more varied pool of natural resources, minerals in particular.

3. Analytical framework

Though countries are not flat, the economic geography of Peru in particular, most of the resource curse literature approaches them as if they were space-free entities. While the term "resource curse" is commonly attributed to geographer Richard Auty (1994 and 2001), who argued that the underperformance of resource-rich countries is due to weak domestic linkages of mining, there is very little economic geography research on the "curse". However, the case of Chile has attracted some attention (Arias et al., 2014; Rehner et al., 2014; Phelps et al., 2015). As Hayter et al. (2003, 17) put it, economic geography "has no interest in what is perceived as 'old fashioned' economic geography". Thus, contemporary research on the so-called global commodity chain, global value change, and global production change overlooks extractive industries. In particular, resource peripheries feature nominally or are ignored altogether in the burgeoning evolutionary economic geography (Barnes et al., 2001; Hayter et al., 2003; Bridge, 2008; Patchell and

[5] Unlike small-scale gold mining in the south of the country, both legal and illegal, there are large open-pit developments in the northern Andes.

[6] Of the remaining regions, some have neither mineral nor oil endowments, but are subject nonetheless to other kinds of resource-curse phenomena—notably San Martin with coca. Amazonian Loreto and Ucayali are wood and fish exporters, and the coastal Tumbes exports fish and shellfish.

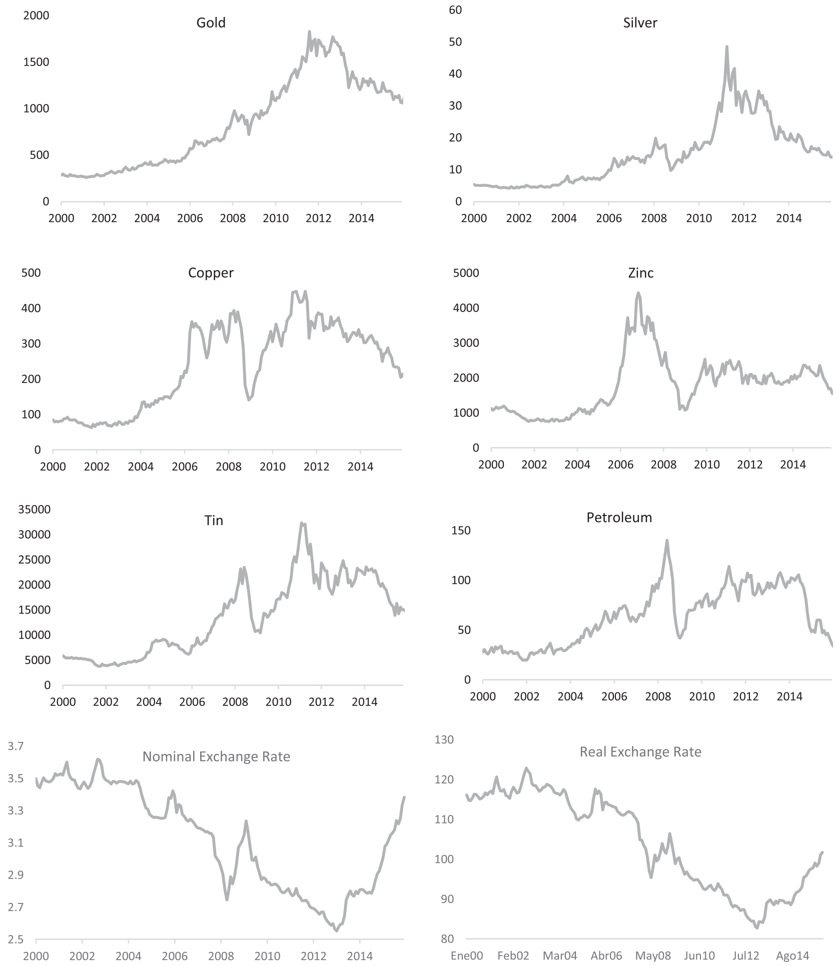

Fig. 3. Prices of Principal Mining Products and Exchange Rate, 2000-2015.

Hayter, 2013; Martin and Sunley, 2015).

Turning to development economics, resource-curse postulations can be traced back to Adam Smith, who singled out mining as an economic activity that reduced the wealth of nations (The Wealth of Nations, Book IV). The resource curse thesis per se gained popularity following Sachs and Warner's (1995) cross-country econometric analysis, which linked dependency on resource exports to poor economic growth rates. The association between natural resource abundance (dependence) and poor economic development became highly contested, however. Conclusions differ subject to sampled data, variable definitions, and model specification (Lederman and Maloney, 2007; Brunnschweiler and Bulte, 2008; Wick and Bulte, 2009; van der Ploeg, 2011).

Partly as a response to these problems with the cross-country econometric literature, and partly as result of the microdata that is now available, a local or subnational resource curse literature is currently emerging among economists and political scientists (van der Ploeg, 2011; Ross, 2015). Within-country economic studies, however, also point to both curses and blessings related to natural resource abundance and/or dependence. The empirical assessment of resource curse hypotheses is subject to dependent variable choice as well as the temporal and spatial scope of analysis (van der Ploeg, 2011; Cust and Poelhekke, 2015; Orihuela, 2018). The same applies to resource curse economic studies on Peru: the relationship between natural resources and economic development is neither simple nor universal (Aragón and Rudd, 2013; Ticci and Escobal, 2015; Loayza and Rigolini, 2016; Orihuela et al., 2019b); besides, there is also conflict (Bebbington et al., 2008; Arellano-Yaguas, 2011; Paredes, 2016; Gruber and Orihuela, 2017; Orihuela et al., 2019a).

While empirically disputed, in theory there is more than one possible type of "resource curse". There are various possible classifications, including those of Van der Ploeg (2011), Aragón et al. (2015), Cust and Poelhekke (2015), Gilberthorpe and Papyrakis (2015), Van der Ploeg and Poelhekke (2017) and Orihuela (2018). Resource curse varieties include economic, political and environmental phenomena, which can certainly be subject to interplay. Our research deals fundamentally with the harmful volatility and the Dutch disease hypotheses, two of the most popular types of resource curse and postulated to be behind low national growth rates and political turmoil.

Volatility arguments are diverse. Van der Ploeg (2011) and Aragón et al. (2015) explain that commodity price volatility could lead to uncertainty and therefore reduce investment in physical or human capital as well as expenditure on other kinds of learning and technological innovation, which in turn may reduce productivity and economic growth in the long run. There is also the argument that it leads to poor financial market development. As regards the short run, price volatility can produce balance of payments crises and/or may fuel political conflict through various effects and mechanisms (Frankel, 2010; Van de Ploeg, 2011; Orihuela, 2018). Cross-country research indicates that it is foreign debt rather than resource abundance what causes low economic growth rates, debt exposure being related to commodity price volatility (Manzano and Rigobón, 2001; Hausmann and Rigobón, 2003; Van der Ploeg, 2011). In turn, economic historians point to the centrality of volatility in shaping the political economy of development in Latin America (Prebisch, 1950; Thorp, 1998; Bértola and Ocampo, 2012). Looking into the subnational level, in the context of poor and developing national economies, regional specialization is key for subnational

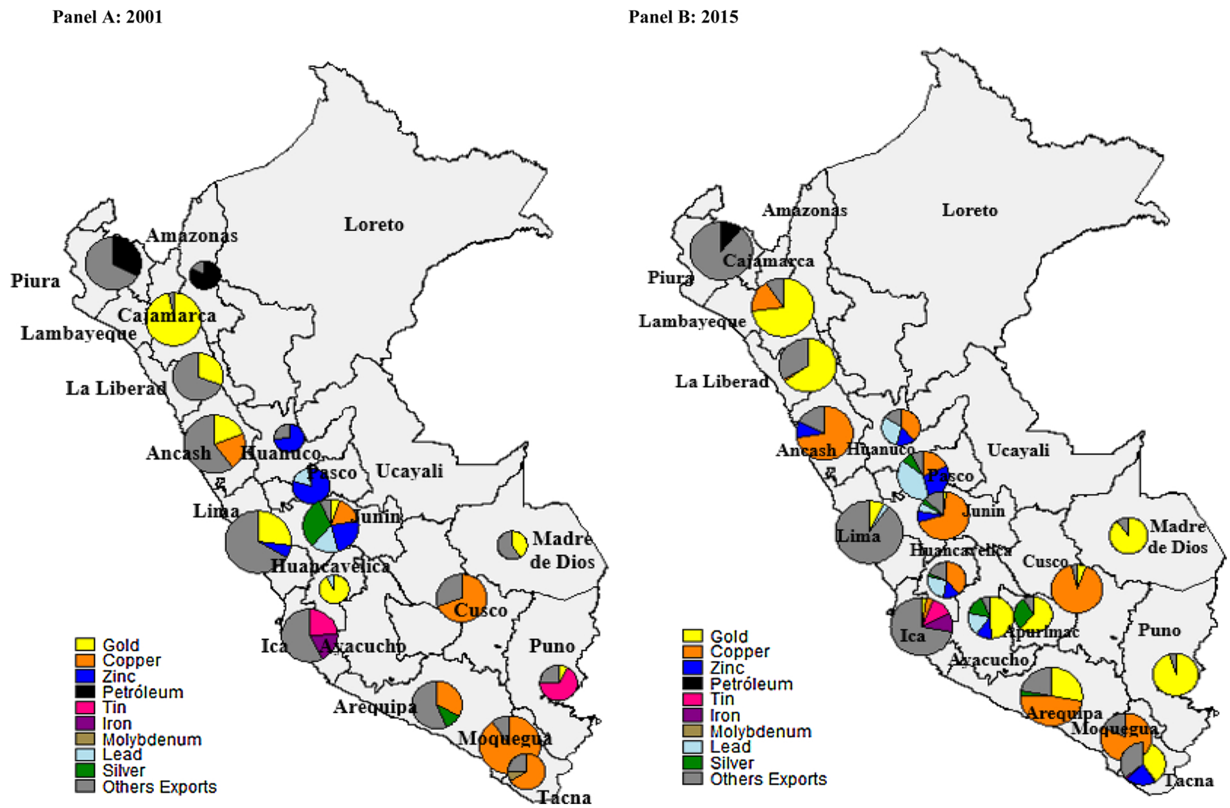

Fig. 4. Regional Exports Structure of Peru.

growth volatility (Auty, 2001; Arias et al., 2014; Rehner et al., 2014).

Dutch disease theories, the most popular of the resource curse theses, link resource abundance to bad economic performance: exchange rate appreciation crowds out alternative export sectors, manufacturing in particular (Corden and Neary, 1982; Corden, 1984; Krugman, 1987). More widely, Dutch disease theories expect resource booms to generate a rise in demand of non-tradable goods, which in turn leads to a reduction in the allocation of labor and capital to the manufacturing sector. In short, when a national economy experiences a resource boom, either because of terms of trade improvement or resource discovery, the manufacturing sector, or any other traded sectors such as agriculture, will likely shrink and the non-trade sector will expand (Sachs and Warner, 1995; Van der Ploeg, 2011). According to Sachs and Warner (1995), within a competitive markets perspective, a shrinkage in manufactures is only a problem when manufactures create externalities in production, which the authors call a speculative and yet unproven claim. Theoretical disputes aside, the empirical evidence on the Dutch disease is mixed (Sala-i-Martin and Subramanian, 2003; Van der Ploeg, 2011; Aragón et al., 2015).

Acknowledging the complexity of potential resource curse mechanisms and equilibria, our research assesses export specialization, volatility and de-industrialization symptoms across political regions in Peru. Our general hypothesis is that these phenomena are likely to be present, yet in diverse forms because commodity dependence is not uniform and economic geography matters. On commodity dependence, mineral economies can be very different, beginning with the minerals that are involved: mono-dependence and basket-dependence are not the same thing. On economic geography, mining regions can be highly diverse in terms of resource endowments and ecological conditions (as discussed in the previous section), integration with global value chains, domestic agglomeration and learning economies, as well as institutional context, to name the usual factors of economic development. In particular, the institutional dimension, which we believe goes beyond conventional corruption and political resource curse accounts (Robinson et al., 2006; Brollo et al., 2010; Casselli and Michaels, 2013; Boutilier, 2017), is commonly called upon to explain why some resource abundant economies succeed while others fail (van der Ploeg, 2011; Orihuela, 2018). Because resource curse effects take place conditional to temporal and place-related political-economic phenomena, mixed outcomes and uneven subnational development are likely to prevail.

4. Methods and data

To assess the hypothesis of spatially differentiated resource-based economic development in Peru, we draw on the methodologies of Rehner et al. (2014) and Jarreau and Poncet (2012). Throughout the discussion, by "the case of Chile" we refer to Rehner et al. (2014). We explore three resource-curse related phenomena, using a set of quantitative approximations. Specifically, we test three hypotheses: (a) the specialization hypothesis, through an analysis of regional export specialization of mineral-rich regions and their recent evolution; (b) the macroeconomic volatility hypothesis, through an analysis of the relationship between export specialization and GDP growth on a regional basis; and (c) the Dutch disease or de-industrialization hypothesis, through an analysis of regional export sectors, their growth and growth variability. As such, we proceed as follows:

(a) Regional export specialization and its recent evolution: using the methodology of Rehner et al. (2014), we estimate the Herfindahl-Hirschmann Index (HHI), which is an index that is within the range of 1/n and 1.0, where 'n' is the number of products in the Peruvian export basket. Because of the high export specialization of some of the regions, some in this HHI are close to 1 (Rhoades, 1993; Calkins, 1983), while other regions are close to 0 (such as the region of Lima, which is the most diversified of all).

(b) Export specialization and regional economic growth volatility: in this case, we relate the export specialization of Peru's regions (using the HHI) and the regional GDP growth rate, taking averages from both indicators for the period 2001–2015.[7] We classify the regions in clusters, using the non-hierarchical cluster technique, the 'k-means' methodology, and classifying the variables mentioned above using their own value and their standardized value (z-score[8] standardization).[9] In addition, drawing on Jarreau and Poncet (2012), we carry out regression analysis for alternative robustness checks. Regressions assess the yearly growth rate of each region and the volatility of growth (average). We use panel data fixed effects for the first variable and pooled regression for the second one.[10]

(c) Export growth and exploratory Dutch disease analysis: for this purpose, we look at the export growth rates of the main resource products, the volatility of the international prices of those products, the relationship between these variables at different time periods for 2001–2015, and finally, some stylized facts about mining and manufacture GDP and exports. We focus on gold and copper exports due to their greater significance for the national economy. We do so by comparing export growth rates between sectors and years using T-tests.[11]

We obtained our database from the Ministry of Trade and Tourism's Integrated Foreign Trade Information System (*Sistema Integrado de Información de Comercio Exterior*, SIICEX), which compiles data on regional exports in FOB prices for the period of 2001–2015.[12] In turn, we obtained the information about the international prices of the resources from Bloomberg. Finally, we obtained the information on regional GDP and the US dollar-Peruvian sol conversion from the National Institute of Statistics (INEI) and the Central Bank of Peru (BCRP), respectively. The series on regional GDP is in real terms, with 2007 as the base year. All such series were calculated using the same methodology (INEI, 2015).

5. Results and discussion: macroeconomic effects are spatially diverse

(a) Growing export specialization in some cases, diminishing in others

At first sight, we can see that coastal regions have the lowest HHI (see Table 2). Lima (which has some mining) and the port city of Callao (which today, along with Lima, constitutes a single megacity of ten million people) have the lowest export-specialization indicators, followed by other coastal and non-mining regions. Taking the group of mining regions alone, the average HHI value for non-landlocked mining regions excluding Lima was 0.298 in 2001 and 0.290 in 2015;[13] while the average HHI value for landlocked mining regions was 0.573 in 2001 and 0.485 in 2015.[14] Some of the coastal regions, however, have a relatively high HHI value, as they are highly dependent on resource exports.

Export specialization does not always increase along with mineral prices. In particular, mineral-rich Tacna and Moquegua (southern regions next to Chile and rich in cooper deposits) defy the export-specialization hypothesis. The mining boom cycle brought about a decrease in HHI values, much more substantial in the case of the less dependent Tacna[15] . The dry coastal region of Ica is another case of high complexity. Compared to Moquegua and Tacna, mining is less important. Instead of copper, Ica has one large iron mine in the hands of a single Chinese enterprise, which of course exports the iron to China, in addition to small-scale informal gold mining. In common with non-mining, coastal Piura in the north, Ica has one of the lowest HHI scores, after Lima and Callao[16] . Meanwhile, in contrast with the likes of Ica and Piura (or Moquegua and Tacna), southern landlocked mining regions have become more export specialized.

- Variety of region types and regional growth volatility higher than Chile's

We address the relationship between export specialization and economic growth volatility through cluster analysis, using average HHI and variance of economic growth as inputs. We document two important differences compared with regional economic growth in Chile: (i) a more complex typology is needed to depict the relationship between export specialization and variance of regional economic growth; and (ii) regions in Peru have undergone much greater economic growth volatility, three times more on average, with a sub-set of cases of extreme dependence/volatility. While the basic economic geography of Chile is composed of the mineral-rich northern regions, the agricultural- and manufacturing-based Central Valley, and the water- and forest-rich southern regions, Peru has mining all over the Andes, some on the coast and some in the Amazon, while export agriculture takes place fundamentally along the dry, irrigated coast. However, it is important to say that regions with high growth volatility are not directly linked to the specialization and dependence on exports of basic products. Extreme volatility is presented in mining regions as well as non-mining regions. Also, some regions that are resource-dependent may not have much volatility of growth as other non-dependent ones (specifically those that are gold dependent).

International trade dependence has both pros and cons. Amid a good international context, exports and therefore aggregate income increase. However, those regions that are highly specialized in the export of raw materials are more susceptible to external shocks, which makes economic growth for such regions highly volatile and ultimately unsustainable. There have been no visible efforts to cope with this developmental challenge. Regional governments now administer larger budgets than ever. In the last two decades, fiscal decentralization and the implementation of a scheme for fiscal mining-rent transfers to

[7] Although we use the average HHI, and that a few regions have HHI that varies considerably, we consider the average as a central measure to carry out our analysis. The use of the initial HHI and the final HHI in the cluster analysis does not significantly change the composition of these.

[8] This value is obtained by subtracting the mean of the observations and dividing by the standard deviation, so the mean and the standard deviation of the resulting variables are 0 and 1, respectively.

[9] To determine the optimal number of clusters, we use the stopping-rule value methodology (Calinski and Harabasz, 1974). This methodology computes an index for each cluster solution, where larger (or smaller values) indicate more distinguished clustering. The technique assures number of clusters that provides best similar intra-cluster characteristics and best different characteristics between clusters.

[10] We use panel data for growth rates because our main dependent variable, regional growth rate, is available for each year of analysis. In the case of the volatility of growth, we use as main dependent variable the variance of economic growth (2001-2010), thus we have same values for each region in all years.

[11] Specifically, we compare gold, copper and overall mining sector export growth rates, individually, with the non-mining exports, at different intervals of time. This allows us to explore whether mining sectors have better export performance during boom, crisis and overall time period, based on economic growth performance.

[12] Although the database had a very small level of disaggregation, the removal of 'extreme values' did not affect the indices. We eliminated all items that had an export value of less than USD 1,000.

[13] Non-landlocked regions are Ancash, Arequipa, Ica, La Libertad, Lambayeque, Moquegua, Piura, Tacna and Tumbes (see Table 2).

[14] Landlocked regions are Amazonas, Apurímac, Ayacucho, Cajamarca, Cusco, Huancavelica, Huánuco, Junín, Loreto, Madre de Dios, Pasco, Puno, San Martín and Ucayali.

[15] Their proximity to both Chile and Bolivia are features that characterize the regional development of these two regions. For a future historical analysis, it has also to be considered that large-scale mining started in Moquegua and Tacna decades before the post-1980s mining cycle (see Table 1 above).

[16] It's important to mention that Ica has a long tradition of grape and pisco production (agroindustry), which was increase in recent years to meet the upturn in world demand.

Table 2
Export Specialization – HHI differentiated by Region.
Source: Authors' own calculation, based on SIICEX data.

Region	Average HHI	Estándar Dev.	HHI 2001	HHI 2015	Landlocked
Amazonas	0.665	0.185	0.716	0.856	Yes
Ancash	0.357	0.101	0.252	0.539	No
Apurímac	0.820	0.216	1.000	0.470	Yes
Arequipa	0.275	0.075	0.142	0.269	No
Ayacucho	0.356	0.147	0.653	0.304	Yes
Cajamarca	0.787	0.175	0.951	0.569	Yes
Callao	0.071	0.013	0.053	0.086	No
Cusco	0.523	0.183	0.557	0.824	Yes
Huancavelica	0.477	0.140	0.856	0.245	Yes
Huánuco	0.332	0.126	0.616	0.277	Yes
Ica	0.153	0.034	0.145	0.099	No
Junín	0.219	0.080	0.178	0.493	Yes
La Libertad	0.393	0.124	0.220	0.434	No
Lambayeque	0.306	0.102	0.406	0.134	No
Lima	0.063	0.026	0.084	0.018	No
Loreto	0.187	0.079	0.207	0.169	Yes
Madre De Dios	0.481	0.169	0.310	0.822	Yes
Moquegua	0.552	0.079	0.677	0.596	No
Pasco	0.431	0.111	0.667	0.274	Yes
Piura	0.134	0.047	0.201	0.068	No
Puno	0.663	0.197	0.484	0.878	Yes
San Martin	0.590	0.148	0.608	0.358	Yes
Tacna	0.318	0.109	0.445	0.212	No
Tumbes	0.232	0.046	0.206	0.270	No
Ucayali	0.240	0.085	0.207	0.257	Yes

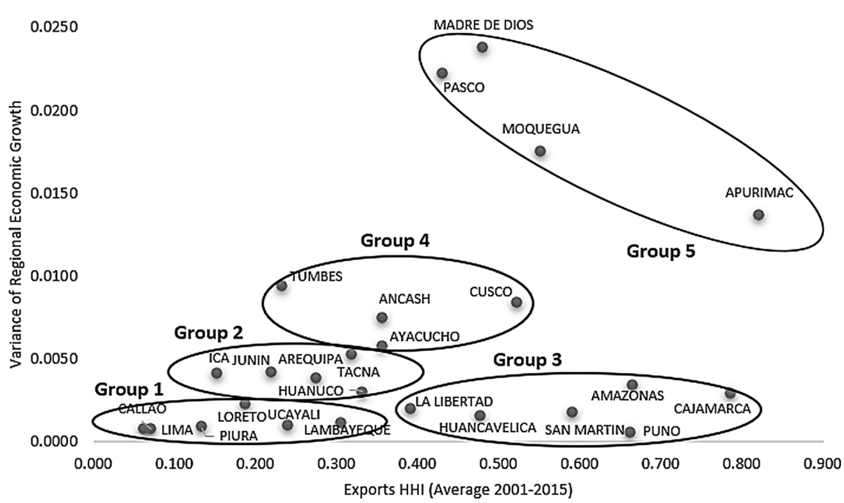

Fig. 5. Exports Specialization and GDP Growth Stability, 2001–2015.

regional governments and municipalities, the so-called "*canon minero*" (Arellano-Yaguas, 2011; Gruber and Orihuela, 2017), have increased the input of subnational politics in regional development. A remedy for ameliorating high regional growth volatility would thus be counter-cyclical fiscal policy carried out by regional governments. There have been no such institutional developments, however; quite the contrary, regional government expenditure is pro-cyclical. At the national level, a stabilization fund was implemented a decade ago, although much smaller than that established by Ministry of Finance economists in Chile (Frankel, et al., 2013; Orihuela, 2013).

The analysis of export specialization (average HHI) and the variation of regional GDP growth rates are presented based on the standard deviation of the regional GDP, see Fig. 5. Compared to the Chilean case, Peruvian regions appear hyper-volatile. Unlike the Chilean case (which only made three clusters), k = 5 clusters had the best performance.[17] Cluster 1 regions have low HHI and relatively lower variation in economic growth. In this cluster are the coastal regions of Lima and Callao, Piura, and Lambayeque, as well as Amazonian Loreto and Ucayali. As Fig. 6 shows, no Andes-centered regions are located in this cluster. The average HHI ranges from values close to 0.050 to mean values of 0.350, where the mean is 0.167. What these political regions have in common is that they are not eminently mining regions. This is evidence that

[17] Cluster-analysis stopping rules are used to determine the number of clusters. A stopping rule value (also called an index) is computed for each cluster solution. Larger values (or smaller, depending on the particular stopping rule) indicate more distinct clustering. We use Calinski and Harabasz's (1974) stopping rule, which consists of a pseudo-F index, where larger values indicate more distinct clustering.

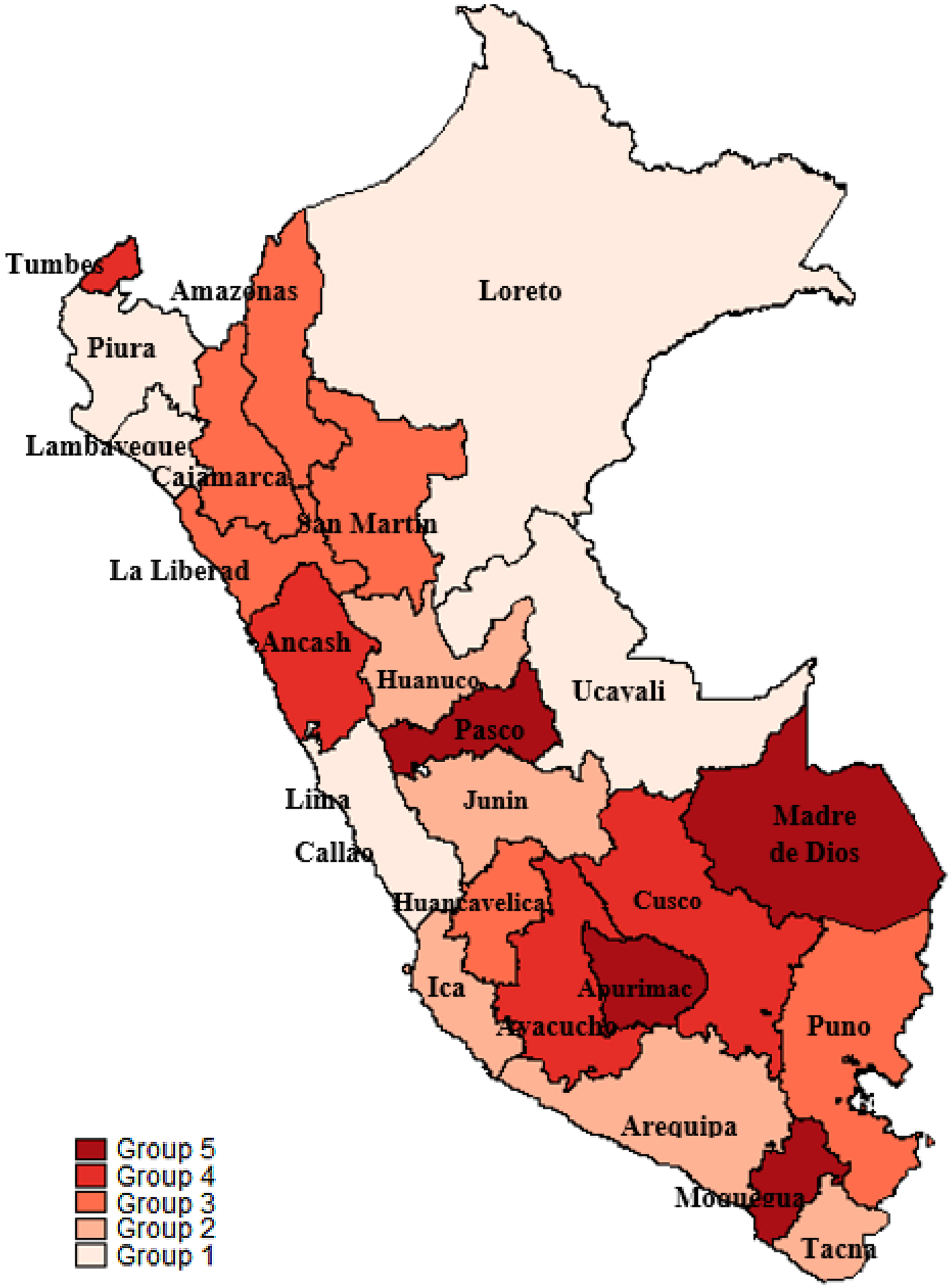

Fig. 6. Spatial Distribution of Exports Clusters in Peru, 2016.

regions of low export specialization and without many mining exports tend to have a more stable and less volatile economic growth. In turn, Cluster 2 presents low HHI but higher GDP volatility than Cluster 1. Here we have the mining regions of Junín, Huánuco, Ica, Arequipa and Tacna. Junín, Arequipa and Huánuco have a diversified export basket, yet are dependent on mining resources: gold, silver, copper, lead and zinc. In the case of Tacna and Ica, mining has a relatively lower significance among regional exports.

Table 3
Descriptive Statistics of Clusters.
Source: Authors' own calculation, based on SIICEX and INEI data. Exports and Real GDP measured in millions of dollars.

	Average HHI	Var. of growth	Exports	Real GDP	Export/GDP
Cluster 1	0.167	0.0011	1,851.2	11,591	16.0%
Cluster 2	0.259	0.0041	1,144.8	2,797	40.9%
Cluster 3	0.582	0.0020	643.0	2,188	29.4%
Cluster 4	0.367	0.0077	932.4	2,483	37.5%
Cluster 5	0.571	0.0193	662.5	1,094	60.5%

Cluster 3 is a subset with slightly more volatility of GDP than Cluster 1 (but not as much as Cluster 2) and much higher export specialization. Within this cluster are the gold export regions of Cajamarca, La Libertad and Puno, in addition to Huancavelica, Amazonas and San Martin. While deprived Huancavelica is a region that exports several metals, Amazonas and San Martín have no mining. Thus, in the period of analysis, there was relatively stable economic growth when the region's main export product was gold, as well as non-mining products. In other words, gold looks less likely to become a curse for short-term regional economic growth (for long term growth, curse/blessing will depend on where gold rents are being invested). Gold prices are not as volatile as those of copper. Fig. 3 shows that gold prices continued to increase even during the world crisis in 2009, but alike the others metals the price started falling in 2012.

The next two clusters are those with high GDP volatility; the regions involved are quite diverse. Cluster 4 groups together HHI values of between 0.200 and 0.600, medium-level export specialization, along with high regional economic growth variance. The regions in this cluster are Ancash, Cusco and Ayacucho in the Andes, and coastal Tumbes, on the border with Ecuador. It is noteworthy that Ancash and Cusco exports are both highly dependent on copper (75 and 85 percent, respectively) while the Cusco economy is quite dependent on tourism. In turn, Ayacucho constitutes an exceptional case. At the beginning of the period, the region was not dependent on any mineral resource; its basket of metals was subject to variation over the years. Finally, Tumbes' story is completely different because its exports come from fisheries. In turn, Cluster 5 is made up of cases with extremely high growth volatility along with high export specialization: Apurímac, Madre de Dios, Pasco, and Moquegua. Although their exports are concentrated on mining products, this constitutes a rather heterogenous set of regions in terms of natural resource endowments. There is one case of a copper-dependent region, Moquegua, and one gold dependent region, Madre de Dios. The other two regions have diversified baskets.

As Fig. 6 shows, there is no clear spatial pattern of clusters. In turn, Table 3 presents descriptive statistics of the clusters. As we can see, the contribution of exports to GDP may also be a key factor in its volatility, particularly for cluster 5, the most volatile. The extreme dependence on exports (60%) makes the GDP highly dependent on international prices.

As robustness checks, we carry out regression analysis, drawing on Jarreau and Poncet (2012). The baseline specification consists in linking growth rates (or their volatility) and exports concentration/sophistication by using a growth determinants regression, controlling for human capital, initial real GDP per capita, and regional investment rate. The results are shown in Table 4. First, we show that, on average, regions with more concentrated export baskets (high HHI) are associated with higher growth rates volatility (columns 4, 5 and 6). This is because the relationship is positive in Fig. 5 (if we trace a linear relation, the scope will be positive). Thus, being located in the coastal region, the most diversified, reduces significantly the volatility of growth, consistent with our cluster analysis. Moreover, a higher investment rate may be associated with lower volatility, but the relationship is not as strong as the aforementioned determinants. The results indicate that geographical characteristics predict growth volatility; in turn, the growth rate seems not to be affected by the HHI, but by human capital formation (positively) and initial GDP per-capita (negatively, as in a conventional Solow growth model).

- Volatile mineral exports and no evidence on Dutch disease

In Table 5, we compare exports growth rate of gold, copper and total mining versus the average of other sectors (non-mining sectors). While Fig. 2 shows that other exports kept growing along with copper and gold exports in 2001–2015, Table 5 breaks the information down by relevant time periods: 2001–2008 (expansion), 2008-9 (crisis), 2009–2012 (recovery) and 2012–2015 (end of cycle). The 2008-9 crisis, in particular, had different outcomes for different export sectors. This, fundamentally, is because while the prices of copper, zinc and petroleum fell sharply as global demand shrunk, gold prices continued increasing (see Fig. 3 above). Copper (like oil) is much more volatile than gold, as the latter works as an asset of last resort. Thus, the 2008-9 change in international conditions had a different impact on mono-dependent Chile than it did on basket-dependent Peru. However, deterioration in international conditions does not always take the same form. While the gold price kept climbing during the crisis of 2008–2009, the 2012–2015 downturn meant the same for copper and gold prices, and gold exports fell more sharply (see Table 5).

Table 4
Growth Rate and Volatility of Growth Regressions, 2001–2015.

Dependent Variables	Growth Rate			Volatility of Growth		
	(1)	(2)	(3)	(4)	(5)	(6)
Initial real GDP per capita	−0.026***	−0.028***	−0.028***	0.057***	0.074***	0.088***
	(0.002)	(0.002)	(0.002)	(0.007)	(0.007)	(0.006)
Export HHI	0.005*	0.005*	0.005	0.062***	0.061***	0.040***
	(0.003)	(0.003)	(0.003)	(0.009)	(0.008)	(0.008)
Investment rate	−0.003***	−0.004***	−0.004***	−0.009***	−0.001	−0.004**
	(0.001)	(0.001)	(0.001)	(0.002)	(0.002)	(0.002)
Human capital	0.198***	0.207***	0.210***	0.036	−0.045	0.087*
	(0.018)	(0.018)	(0.019)	(0.054)	(0.053)	(0.049)
Lima dummy		0.010**	0.010**		−0.084***	−0.079***
		(0.005)	(0.005)		(0.013)	(0.012)
Coastal region dummy			−0.001			−0.047***
			(0.002)			(0.005)
Constant	0.316***	0.344***	0.343***	−0.285***	−0.535***	−0.609***
	(0.021)	(0.025)	(0.025)	(0.065)	(0.074)	(0.067)
Observations	360	360	360	360	360	360
R-squared	0.339	0.347	0.347	0.342	0.408	0.522

Notes: Columns 1, 2 and 3 are panel data fixed effects regressions, while columns 4, 5 and 6 are pooled regression. *** Significant at the 1 percent level. ** Significant at the 5 percent level. * Significant at the 10 percent level.

Table 5

Export Growth Rate - Differentiated by Period and Sector.

Source: Authors' own calculation based on data from SIICEX (2016). Column Significance show *t*-test of exports growth rates of Gold, Copper and Total Mining versus exports growth rates of Other Sectors. Other Sectors refers to non-mining exports. Ns. means no significant. *** means significant at 1%. ** means significant at 5%. * means significant at 10%.

Variable	Sectors	N	Standard dev.	Average	Significance
Export growth rate 2001-2015 (%)	Gold	166	0.64	17.43	0.0775*
	Copper	170	0.70	14.55	ns
	Total Mining	253	0.48	18.49	0.0301*
	Other Sectors	315	0.32	11.20	–
Export growth rate 2001-2011(%)	Gold	73	0.60	30.07	0.0015***
	Copper	70	0.58	34.44	0.0802*
	Total Mining	121	0.48	27.00	0.0724*
	Other Sectors	154	0.28	17.00	–
Export growth rate 2001-2008 (%)	Gold	112	0.56	32.79	0.0264**
	Copper	110	0.71	27.41	0.0029***
	Total Mining	176	0.47	24.68	0.0322**
	Other Sectors	221	0.30	17.67	–
Export growth rate 2008-2009 (%)	Gold	11	0.73	21.57	0.0161**
	Copper	13	0.98	−17.26	ns
	Total Mining	18	0.56	−10.18	ns
	Other Sectors	21	0.35	−16.59	–
Export growth rate 2009-2012 (%)	Gold	28	0.39	35.49	ns
	Copper	27	0.82	30.72	ns
	Total Mining	37	0.38	28.88	ns
	Other Sectors	46	0.25	29.91	–
Export growth rate 2012-2015 (%)	Gold	41	0.63	−24.22	0.0208**
	Copper	46	0.66	−11.32	ns
	Total Mining	57	0.46	−11.63	ns
	Other Sectors	71	0.34	−0.86	–

We find that gold, copper and the entire mining sector are subject to a higher export growth rate than other sectors in Peru, which is, in principle, conducive to the effects of Dutch disease. However, the rest of the evidence does not support a Dutch disease diagnosis: while manufacturing GDP expanded in all clusters at different rates, non-mining exports by regional clusters evolved in quite different ways (Figs. A1 and A2 in the Appendix). In addition and most importantly, export growth rates of non-mining regions were positive during boom and recovery periods. What else does our empirical evidence reveal? The more diversified regions (Clusters 1 and 2) show a sharp yet cyclical expansion of non-mining exports, while the more mining-dependent (Clusters 3, 4 and 5) show no increase in non-mining exports. Thus, mineral-abundant but diversified regions and extreme mineral dependent regions behave in marked contrast. On top of that, high sub-national volatility renders all means tests of export growth statistically insignificant (Table A1 in the Appendix). In short, the evidence supports a high-volatility type of resource curse, but not a Dutch disease per se.

In fact, it makes sense that the mining cycle did not stop other tradable sectors from growing, because this is not a stylized Dutch disease scenario. While Dutch disease theories assume a boom in the mining sector only, a super-cycle means growing demand for *all* tradable sectors. In principle, an expansion of world demand for all tradable goods will not produce the same effects as the discovery of a mineral. Thus, global demand effects will offset or surpass Dutch disease ones.

6. Conclusions

Peru is a case of diverse subnational economic dependence. We found that with the commodity supercycle, macroeconomic evolution within the country varied. Economic geography conditions are central to understanding uneven volatile outcomes: Peru not only has large copper deposits, but also gold and other natural resources; because commodity prices do not always covariate and resource endowments are not distributed uniformly throughout an ecologically diverse national territory, it is problematic to expect subnational economic convergence. We found five clusters of regions when looking into the relationship between export specialization and variance in regional economic growth. Export specialization intensified with price surges in one group of regions, but not in another. Finally, we find that in most—but not all—cases, the more export dependent and geographically peripheral the region, the more susceptible it is to boom-and-bust cycles. Growth volatility is very high for some regions. From the empirical evidence, we conclude that the resource curse should not be conceptualized as either a homogenous (the same underpinning mechanisms in all cases) or a universal (everywhere, all the time) phenomenon. The portrait is one of diversified resource dependency.

According to much of the literature, a greater degree of export specialization in minerals leads to higher vulnerability to external shocks, which is conducive to Dutch disease/resource curse phenomena. Our empirical analysis tells a more nuanced tale. Yes, there is very high sub-national volatility of export income; however, not all mineral-rich regions experienced higher export specialization, or high growth volatility, and there is no strong evidence for Dutch disease. In particular, the Dutch disease does not seem to have materialized across regions because a world trade surge in principle involves more effects on tradable sectors than a mineral discovery.

Regional trajectories are diverse; the results, mixed. By documenting uneven development in resource-dependent national economies, economic geography studies can contribute to challenging popular resource curse accounts of the development economics literature: we should be asking where, when, and why there is curse or blessing, rather than searching for a definitive universal answer on the developmental effects of mineral abundance. The diversity of resource endowments and related ecologies, the integration to the world economy and global value chains, the development of domestic agglomeration and learning economies, and the interplaying institutional environment condition the relationship between resource abundance and economic development. Under this analytical framework, sensitive to temporal and spatial variation, future case study research could aim to engage meaningfully with the study of production linkages and agglomeration dynamics, while questioning what "institutions matter" entails.

Appendix A

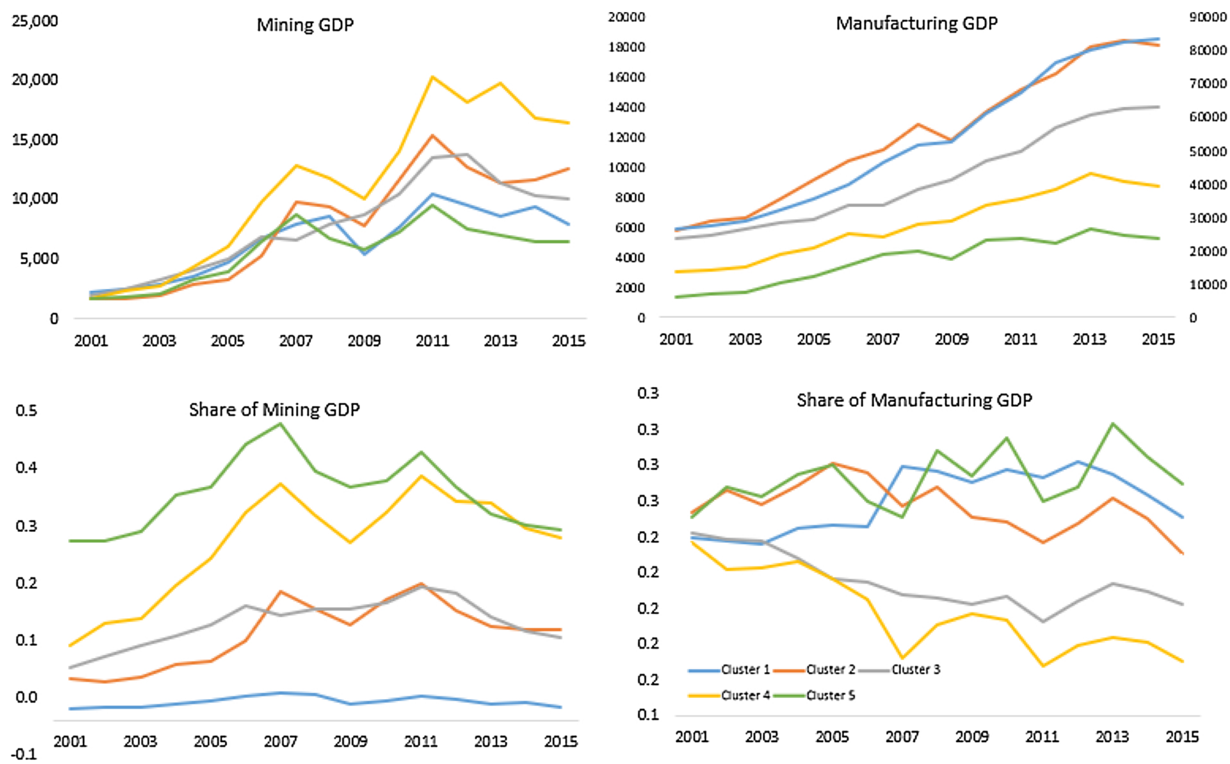

Fig. A1. Level and Share of Mining and Manufacturing GDP in Total GDP, by Group (2001–2015).

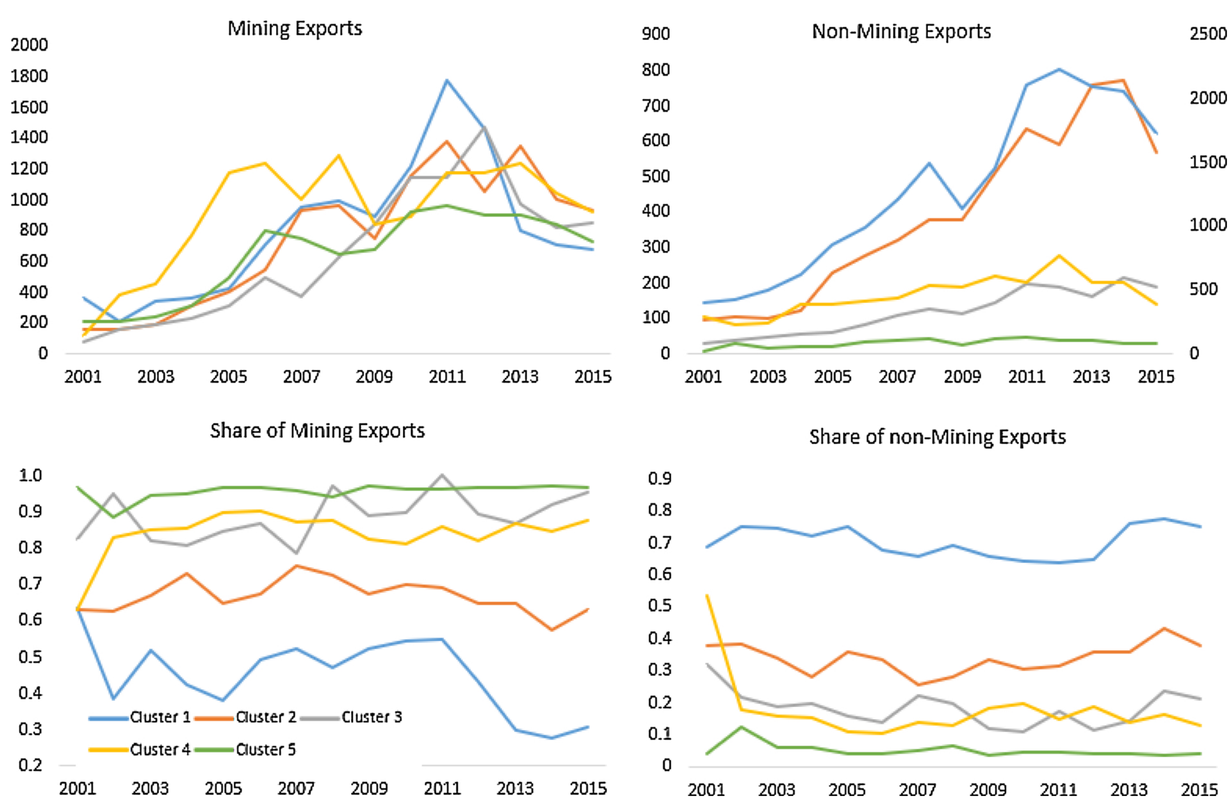

Fig. A2. Level and Participation of Mining and Manufacture Exports in Total Exports, by Group (2001–2015).

Table A1
Export Growth Rates - Differentiated by Period and Group of Region.
Source: Authors' own calculation based on data from SIICEX (2016). Other Sectors reffers to non-mining exports. N.S. means no significant. *** means significant at 1%. ** means significant at 5%. * means significant at 10%.

Variable	Groups of Regions	N	Std. dev.	Average	Significance
All Sectors					
Export growth rate 2001-2015 (%)	Group 1	75	0.19	9.22	ns
	Group 2	63	0.29	12.53	ns
	Group 3	75	0.34	13.63	ns
	Group 4	51	0.27	16.56	ns
	Group 5	51	0.49	21.09	ns
Export growth rate 2001-2011(%)	Group 1	52	0.17	14.39	ns
	Group 2	43	0.28	18.03	ns
	Group 3	52	0.28	23.26	ns
	Group 4	35	0.26	23.49	ns
	Group 5	35	0.48	25.88	ns
Export growth rate 2012-2015 (%)	Group 1	17	0.20	−5.23	ns
	Group 2	15	0.30	5.29	ns
	Group 3	17	0.41	−6.57	ns
	Group 4	12	0.26	−0.34	ns
	Group 5	12	0.45	2.41	ns
Non-Mining Sectors					
Export growth rate 2001-2015 (%)	Group 1	75	0.19	8.81	ns
	Group 2	63	0.27	10.55	ns
	Group 3	75	0.39	16.35	ns
	Group 4	51	0.31	6.90	ns
	Group 5	51	0.64	12.24	ns
Export growth rate 2001-2011(%)	Group 1	52	0.17	13.53	ns
	Group 2	44	0.22	16.79	ns
	Group 3	53	0.36	23.63	ns
	Group 4	35	0.24	14.75	ns
	Group 5	36	0.63	14.82	ns
Export growth rate 2012-2015 (%)	Group 1	17	0.19	−4.00	ns
	Group 2	14	0.35	−0.36	ns
	Group 3	16	0.43	2.52	ns
	Group 4	12	0.39	−13.15	ns
	Group 5	11	0.33	2.08	ns

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