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Do mining activities foster regional development? Evidence from Latin America in a spatial econometric framework

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Abstract

Against the backdrop of steadily increasing global raw material demand, the socio-economic implications of metal ore extraction in developing countries are of major interest in academic and policy debates. This work investigates whether mining activities relate to the economic performance of mining regions and their surrounding areas. Usually, sub-national impact assessments of mining activities are conducted in the form of qualitative in-field case studies and focus on a smaller sample of mining properties and regions. In contrast, we exploit a panel of 32 Mexican, 24 Peruvian and 16 Chilean regions over the period 2008 – 2015 and, in doing so, relate mine-specific data on extraction intensity to regional economic impacts. The study employs a Spatial Durbin Model (SDM) with heteroskedastic errors to provide a flexible econometric framework to measure the impact of natural resource extraction. The results suggest that mining intensity does not significantly affect regional economic growth in both short-run and medium-run growth models. Popular arguments of the mining industry that the extractive sector would trigger positive impulses for regional economic development cannot be verified. Rather, the findings support narratives that mining regions do not benefit from their wealth in natural resources due to low labour intensity, loose links to local suppliers and profit outflows.

1 Introduction

The economic importance of natural resources is a recurring theme throughout the history of almost any Latin American country. In the 2000s, many countries reoriented and intensified their economic strategies geared towards the export of primary commodities. This process of *re-primarization* (Svampa 2012) is closely related to the debate on *extractivist* development strategies, which are characterised by a type of resource extraction which is large-scale, oriented primarily towards export as well as entailing little or no industrial processing (Andreucci and Radhuber 2017). In the light of the *resource curse* concept, which has been extensively debated since the early 1990s, this regained focus on resource exploitation appears paradoxical. Today there is a firm academic consensus that the exploitation of natural resources must be rather associated with low economic growth rates (Arellano-Yanguas 2019; Arellano-Yanguas 2011; Nylandsted Larsen et al. 2009). Moreover, the negative impacts on water quality and quantity, forest cover, livelihood assets, and social relationships (Sonter et al. 2018; Arellano-Yanguas 2017; Northey et al. 2017; Sonter et al. 2017; Preston

2011; Bebbington and Bury 2009; Bebbington and Williams 2008) as well as local political conflicts that emerge from extractive practice (Arellano-Yanguas 2011) are well documented.

This applies in particular for metal ores. According to UN IRP (2017) data, global metal ore extraction doubled within the last twenty years to 9.1 billion tonnes in 2017, largely due to China and other emerging economies becoming international economic players in the early 21st century. In addition to these shifting geographies of global material use, the patterns of resource extraction increasingly concentrated (Schaffartzik et al. 2016). Developing countries were integrated into the world economy as raw material providers and, in doing so, negative environmental and social effects of international consumption were peripheralised (Liu et al. 2018; Bridge 2004). Furthermore, there is no evidence that mining would lose global economic importance, but rather that it will most likely be a major factor of production in future decades (see UN IRP 2019; OECD 2019).

This paper draws the attention to the mining economies of the Global South, more specifically to Mexico, Peru and Chile. Together, these three countries contributed 14% to global metal ore extraction in 2017. Moreover, they were selected for an empirical analysis because they show similar and typical patterns of re-primarization, have relatively stable economies and represent major Global South actors with regard to metal ore extraction and trade.

Previous contributions predominantly shed light on overall dynamics of mining economies at a country level (see e.g. Humphreys et al. 2007a), but also conduct sub-national impact assessments of mining activities. The latter are usually carried out in the form of qualitative in-field case studies (e.g. Arias et al. 2014; Zhang et al. 2012; Preston 2011) and/or focus on a smaller sample of mining properties and regions (Sonter et al. 2017; Delgado and Romero 2016). However, in contrast to work regarding environmental and social pressures of mining, little work was conducted providing a granular economic perspective on the issue.

Most prominently, it is the mining industry claiming that the extraction of metal ores directly and indirectly stimulates the economic performance of mining regions and their surrounding areas (ICMM 2015; ICMM 2006). This opinion is closely tied to the concept of *mining clusters*, which is centred on the idea that linkages between multinational corporations and local firms, local employment creation and knowledge spillovers are drivers of regional development (Arias et al. 2014). This paper investigates whether the mining industry's claim holds.

Mistakenly assuming independence and homogeneity among the regions in the sample, standard linear models lead to biased and inconsistent estimates, calling for a spatial econometric approach (Piribauer 2016; Crespo Cuaresma et al. 2014; LeSage and Pace 2009). Adding to that, violating the assumptions of standard linear models would be especially problematic in small samples. Being capable of interconnecting socio-economic and regional science, spatial econometric modelling is a powerful tool for quantifying causal relationships with particular regard to spatial relations. Other than standard linear models, this approach overcomes the simplification of assuming independence of observations. Not only have several studies found strong evidence that there is spatial autocorrelation in regional economic growth (Piribauer 2016; Piribauer and Fischer 2015; Crespo Cuaresma et al. 2014), also the spatial structure of dependency may be a subject of interest or provide key insights in regional growth processes. Spillover effects, for example, contribute to understanding how impacts spread over space and are of major importance when it comes to the evaluation of total impacts. Therefore, a spatial econometric model is very suitable for a spatial analysis of raw material extraction and related economic impacts. To our best knowledge, the intensity of mining activities within regions has not been considered yet as a determinant of growth in the econometric literature. But not only spatial dependence demands to be accounted for in the modelling. While heteroskedasticity is typically not addressed in regional models that investigate economic growth, an analysis of the Global South demands further adjustments. It is reasonable to assume that data may vary country-wise in volatility due to substantial differences in development paths and thus a credible regional growth model has to address this issue.

This article contributes to the literature along three dimensions. First, we assess whether mining indeed positively affects both mining regions and, via spillover effects, their neighbours in terms of economic development. For that, we employ spatial econometric modelling in order to provide unbiased and consistent estimates. Second, we provide an empirical framework that exploits detailed mine-specific data on extraction intensity and relates it to regional economic impacts. This is a more general contribution to the empirical literature on natural resource extraction than relating mining only to economic growth, because it can be applied to other economic, social and environmental topics in a very similar way. Given the availability of data, it will be either possible to adapt the model in order to allow relating mining activities to, for example, income distribution or poverty rates on a sub-national level, or to exchange metal ore extraction with other types of natural resources. Third, the econometric approach suggested in this paper introduces a setting that deals not only with spatial dependence, but also with heterogeneity on a country level. In doing so, patterns of varying volatility in the data due to country-specific characteristics such as institutional factors are incorporated in the model.

The empirical exercise of this article is geographically narrowed down to Mexico, Peru and Chile. It examines 2008 – 2015 panel data for 72 regions and extends the conventional growth model (Mankiw et al. 1992; Barro 1991) by including extraction intensity as an additional explanatory variable. Further, we use an SDM framework in order to control for spatial autocorrelation in the observations. The results suggest that mining intensity cannot be found to robustly serve as a determinant for regional economic growth in both short-run and medium-run growth models. Popular arguments of the mining industry that the extractive sector would foster regional economic development hence cannot be verified.

The remainder of the paper will be structured as follows: In Section 2, we provide a theoretical overview on how mining has been related to economic growth. Section 3 outlines the methodological framework, followed by Section 4 introducing the data that we have used for the empirical analysis. Subsequently, Section 5 presents and discusses the results. In Section 6, we conclude.

2 The link between mining and development

Mining was often related to development as a constitutional starting point of a series of economic and social changes. The assessment of its economic effects is crucial for answering urgent questions such as where and how resources are accessed and mineral revenues distributed (Bridge 2004). Therefore, this article refers to development as the growth of the regional gross domestic product (GDP).[1]

[1]We are well aware that there is no undisputed understanding of *development*. Rather, a variety of theories exist today, all of them shaped under specific historic and geographic contexts. Initially, development was equated with *modernization*, assuming a linear economic catching-up process of the world's poorest regions based on (foreign) capital investment and the achievements of technological innovation. This perspective on development, however, was (a) ignoring the historical

The question how mining affects GDP is a crucial topic for both economists and policy makers. When the World Bank and other international financial institutions promoted a beneficial environment for foreign investments in extractive economies in the 1980s and 1990s, this was argued in a narrative that put forward a win-win situation, where "host" countries and mining corporations would mutually gain from extractive practices. Corporations would make profits, while the mining industry would create local employment, and host governments would gain vital revenues through royalties and taxes (Emel and Huber 2008). Extractive industry growth as a development strategy has been continuously advised by political parties, company owners and representatives of international organisations, although social conflict and political debates around the relations among mining, human rights, environmental integrity and development became known phenomena (Bebbington et al. 2008; Martinez-Alier 2001).

Turning to Latin America, the idea of resource-based economic development is widespread in regimes that follow a free-market agenda (such as Chile, Peru and Colombia) as well as governments seen as progressive and centred towards state activity (Bolivia, Equador, Venezuela) (Burchardt and Dietz 2014; Acosta 2013; Svampa 2012). Unsurprisingly, also the mining industry pushed to promote a positive perception of mining. By using the same narrative as discussed above, the International Council on Mining and Metals (ICMM) speaks of direct and indirect positive macroeconomic effects induced by mining projects (ICMM 2015; ICMM 2006) and blames "general political and other forces" (ICMM 2006, p. 18) for potentially weak economic effects. The council argues that mining would be "economically critical for millions", since it would "drive economic growth and reduce poverty nationally and locally" (ICMM 2015, p. 4).

This logic of natural resource extraction strengthening national economic development became, however, fragile and controversial. In fact, countries that were well endowed with natural resources turned out to perform economically worse than countries with fewer resources. This phenomenon became well known as the *resource curse* (Auty 1993). Since this theory gained momentum in the early 1990s, a sizeable literature has emerged discussing numerous transmission channels. These include undesirable exchange rate dynamics, mineral price volatility, economic mismanagement, political rent seeking of powerful elites and corrosive effects on the quality of institutions (see, for a review, Badeeb et al. 2017). One of the most popular arguments is the so-called dutch disease (see e.g. Humphreys et al. 2007b), when times of export booms are accompanied by the appreciation of real exchange rates. This, in turn, puts pressure on the domestic non-extractive sectors such as manufacturing because, on the one hand, exporting non-natural resource commodities becomes less attractive and, on the other hand, competing with imported goods becomes almost impossible.

experience of colonialism and neocolonialism and more generally imbalances between the "developed" countries of the Global North and the "underdeveloped" Global South (Peet and Hartwick 2015) and (b) turning out not to be yielding the expected beneficial economic effects, but in many cases even being associated with economic setbacks (Humphreys et al. 2007b). Since then, critical concepts have emerged, such as the perception that "underdevelopment" was not the state of origin of a development process, but the consequence of development itself, caused by uneven relationships of dependence between and within societies (Frank 1966). Later, socioeconomic questions such as the fulfilment of basic needs were increasingly addressed and targets such as reducing poverty were set that were often to be met by the means of "socioeconomic benefits of mineral-based development" (Bridge 2004, p. 226). While the neoliberal turnaround of the 1980s and 1990s brought back indicators like the emphasis on GDP, the value of foreign direct investment, or the trade balance as standard measures of development (Bridge 2004), other strings of literature began to challenge this position of development oriented towards economic growth. Most radical critique came from scholars of the post-development theory such as Escobar (1995) and Sachs (1992), who criticised the missing of pluriversality – the co-existence of cultures and localised forms of knowledge – in a discourse that was still dominated by Western epistemology and hermeneutics. This article's focus on GDP clearly accords to an economic notion and hence only a specific understanding of development.

Furthermore, resource economies are associated with unsustainable patterns of development and growth due to export dependence and postponed need for economic reform (Bebbington et al. 2008) as well as government overconsumption of resource revenues instead of financing public investment (Atkinson and Hamilton 2003). Also, resource dependency tends to result in enclave economies with relatively loose links to local suppliers, hence weakening multiplier effects in the economy (Arias et al. 2014). Adding to that, negative long-run effects on growth can be expected via undesirable societal developments associated with mining such as worsening labour conditions and unequal distributions of wealth (Bebbington et al. 2008). The foreign direct investment policy narrative was further challenged by the concepts of scholars who critically reflected the relationship between landowners (being host states, private owners or communal owners) and foreign investors, arguing that fiscal regimes clearly favoured foreign mining corporations, leading to an outflow of rents from the mining regions (Emel and Huber 2008).

When moving from the national to a regional level and discussing the impacts of mining on the regional GDP, a geographical mismatch of mining's costs and benefits becomes apparent (Bridge 2004). Whereas government revenue from taxes, royalties and export earnings can flow easily and may be distributed over the entire country (including non-mining regions), it is the social disruption and environmental impacts that are rigid, if not entirely bound to the location of extraction. Even if mineral-based development makes fractions of the population better-off, these flows are potentially unequal and come with costs that are unevenly distributed over space. Financial flows are registered in a few urban centres, whereas mining projects are often located in peripheral areas. Headquarters of large mining corporations, however, are strongly concentrated in the metropolitan regions, "where they can benefit from the technological externalities of large agglomerations and better access to international markets and suppliers" (Arias et al. 2014, p. 89). In recent years, there have been attempts in some countries to oppose these dynamics by introducing a "new localism in natural resources management" (Arellano-Yanguas 2011, 2019). Studies, however, show that the delegation of substantial revenues to sub-national governments (with a strong preference for mining areas) and the involvement of a range of local actors was disappointing, mostly because these policies in turn exacerbated local political conflicts. Furthermore, there is clear evidence for massive capital outflow to the non-domestic market originating from foreign investors being major shareholders or operators in the mining industry. Through this channel, regions within the host countries suffer from negative GDP effects (for example, lower multiplier effects due to less circulating capital), while at the same time mining centres have the additional burden of geographically rigid costs. The outflow of capital from extractive economies is discussed by Karl (2007). In that paper, it is noted that a very specific form of collective rent-seeking behaviour of dominant states and foreign private companies, accompanied by powerful local elites, applies, which strongly supports the outflow of rents. Primary reasons for the involvement of foreign actors are unequal expertise regarding the extraction of natural resources (Humphreys et al. 2007b) as well as the necessity for foreign capital to fund the projects (Emel and Huber 2008).

However, one can also find reasoning in favour of regional economic benefits related to mining activities. Not only is job creation a standard argument, but also transport and telecommunication infrastructure related to these frequently large-scale projects are claimed to positively affect the economy. Additionally, according to the ICMM, a substantial fraction of the expenditures of mining companies is local procurement, while admitting that the overall impact of mining on the economy would be more positive with a further increase of the percentage of procurement spent locally (ICMM 2015). Finally, the mining industry refers to the statements of local stakeholders. The ICMM states that, for example in a case study conducted in Ghana, "[m]ost community stakeholders hold the view that the large-scale mining companies have contributed noticeably to increasing overall economic benefits" (ibid.: p. 7).

While the mining industry obviously stresses job creation and regional economic impetus, there are two facts about mining that, in combination, challenge the argument. First, Emel and Huber (2008) note that the large-scale natural-resource development in the mining sector is highly capital-intensive, as it requires significant funds for exploration, energy infrastructure, machinery, transportation networks and construction. Second, mining increasingly becomes technologically intensive (Humphreys et al. 2007b). Therefore, it is likely that employment for low-skilled workers is only short-term during the construction phase, while mining in the long-run offers fewer positions, which are taken by high-skilled (and potentially foreign) employees (Arias et al. 2014). Further, the finding that capital-intensive resources are associated with a higher likelihood of civil conflict than labour-intensive resources (such as biomass) (Van der Ploeg 2011) must be added as a matter of concern. However, not only the local employment narrative, but also the argument that mining activities help establishing transport and telecommunication infrastructure and hence foster economic development in mining regions as well as in surrounding areas can be challenged. Here, the contentiousness regarding mining becomes obvious, as the construction of infrastructure almost always raises environmental concerns about pollution or deforestation, as well as social concerns, for example regarding land rights and expropriation (Conde 2017).

From these opposing positions one can draw to the relationship between mining and development being rather a question of representation of interest. Bebbington et al. (2008) call it not only a contentious but also ambiguous relationship: "Contentious because mining has so often delivered adverse social, environmental and economic effects for the many, but significant gains for the few; ambiguous because of the abiding sense, among local populations as much as development professionals, that *just maybe* mining could contribute much more" (p. 887). In the end, some fractions of the society are better-off due to mining. And in a majority of cases, this better-off translates into higher income. In some sense, therefore, these conflicts among different actors are seen as a Faustian pact between populations and the mining industries. Van der Ploeg (2011) stresses the dependence on the quality of institutions, associating "bad" institutions with volatility and lack of rule of law, corruption, nondemocratic regimes and underdeveloped financial systems. And on top of that, there is evidence that natural resource dependence may in turn undermine the quality of institutions (Van der Ploeg 2011). Similarly, Karl (2007) argues that the resource curse was rather a political than an economic phenomenon. Recent findings, however, show that addressing the institutional weaknesses by large-scale governance and transparency initiatives led by non-governmental organisations do not necessarily improve the situation (Sovacool et al. 2016).

3 Methodological framework

Advocated by Barro (1991) and Mankiw et al. (1992), economic growth has been prominently analysed in the context of convergence across countries. Characteristically, these types of growth regressions explain economic growth rates of countries or regions by k exogenous characteristics in the initial period, including most importantly initial income. What is typically found is so-called beta-convergence, a negative coefficient for initial income, indicating that countries with high initial income grow slower than low initial income economies. The growth model employed in this paper is inspired by the basic idea of the concept, while implementing three extensions. First, we use sub-national data. Second, we expand the original growth regressions by the use of econometrics that explicitly consider spatial autocorrelation in the observations. Third, we include the extent of mining as a region's characteristic in the set of explanatory variables, which is typically not considered, and evaluate the effect of mining activities on regional growth.

Acknowledging spatially dependent growth rates as well as spatial dependence in explanatory regional characteristics, we employ a panel-structure Spatial Durbin Model (SDM). The SDM specification, which nests a variety of popular econometric models used in regional growth studies, is shown to be most suitable and least biased for spatial growth regressions by LeSage and Fischer (2008). Hence, we consider a regression of the form

$$\boldsymbol{y}_t = \rho \boldsymbol{W}\boldsymbol{y}_t + \boldsymbol{X}_t\boldsymbol{\beta} + \boldsymbol{W}\boldsymbol{X}_t\boldsymbol{\theta} + \boldsymbol{\mu} + \xi_t + \boldsymbol{\epsilon}_t, \qquad \boldsymbol{\epsilon}_t \sim N(\boldsymbol{0}, \boldsymbol{\Sigma}), \tag{1}$$

for $t = 1, \ldots, T$ years, where $\boldsymbol{y}_t$ denotes the $n \times 1$ vector of regional economic growth rates with n being the total number of regions across all countries considered in the model. $\boldsymbol{X}_t$ is an $n \times k$ matrix of k exogenous country characteristics in the initial period. These include prominent determinants of economic growth such income, population density and indicators for industrial structure, but also regional extraction intensity, which is the most innovative component for this article. $\boldsymbol{W}$ is an $n \times n$, non-negative, row-standardised spatial weights matrix with $w_{ii} = 0$. Its elements are used to impose a structure of spatial dependence upon the observations, i.e. $w_{ij} > 0$ if region j is in a neighbourhood relationship with region i $(i, j = 1, \ldots, n)$. Note that the regression equation includes the spatially-lagged dependent variable (i.e. $\boldsymbol{W}\boldsymbol{y}_t$) as well as the spatially-lagged regional characteristics ($\boldsymbol{W}\boldsymbol{X}_t$) as explanatory variables. The $k \times 1$ vectors of unknown parameters $\boldsymbol{\beta}$ and $\boldsymbol{\theta}$ correspond to $\boldsymbol{X}_t$ and $\boldsymbol{W}\boldsymbol{X}_t$ respectively and $\rho \in (-1, 1)$ is a scalar parameter measuring the magnitude of spatial autocorrelation. For $\rho = 0$, the model collapses to a classical linear model. In all other cases ($\rho \neq 0$), the SDM specification allows for changes in the explanatory variable in one region effecting the dependent variables in other regions as well. The model is further extended with country-specific ($\boldsymbol{\mu}$) and time-period-specific (ξ_t) fixed effects. Additionally, heteroskedasticity may become an issue, especially since this framework is intended to be applied over a sample of resource-exporting countries of the Global South. Other than regions in the US or the European Union, the entities analysed in the context of this article may be significantly characterised by the development trajectories of their respective countries. Hence, they may very likely exhibit varying structural characteristics related to country-specific institutional and political economic conditions, including variations in growth-determinant volatility. Therefore, heteroskedasticity is dealt with by allowing for country-specific variance-covariance matrices: The n-element vector $\boldsymbol{\epsilon}_t$ follows a Normal distribution with zero mean and block diagonal variance-covariance matrix

$$\boldsymbol{\Sigma} = \begin{pmatrix} \sigma_1^2 \boldsymbol{I}_1 & & \\ & \ddots & \\ & & \sigma_R^2 \boldsymbol{I}_R \end{pmatrix} \tag{2}$$

for $1,\ldots,R$ countries, where $\boldsymbol{I}_1,\ldots,\boldsymbol{I}_R$ are identity matrices of dimension $\tilde{n}_r$ with $\tilde{n}_r$ being the respective number of regions per country and $\sum \tilde{n}_r = n$. Note that the model converts into a standard homoskedastic case for $\sigma_1^2,\ldots,\sigma_R^2 = \sigma^2$.

While parameter estimates of conventional (non-spatial) linear models can be straightforwardly computed as partial derivatives and interpreted as marginal changes in the dependent variable due to a change in one of the explanatory variables, the interpretation in spatial models becomes slightly more complicated. As a matter of fact, the interpretation as marginal changes becomes redundant, since the assumption of independence of observations does not hold and hence the partial derivatives of the dependent variable with respect to the explanatory variable are potentially non-zero (see LeSage and Pace 2009). For models that account for spatial dependence, a change in a single observation in one region will affect the region itself (direct impact), but all other regions indirectly via spillover effects are also affected (indirect impact), resulting in n^2 partial derivatives of a particular explanatory variable. LeSage and Pace (2009) provide computational approaches to calculating summary measures for this interconnected web of numerous impact links and feedback loops, i.e. average direct and average spillover (or indirect) effects. Average direct effects correspond to the average response of the dependent to independent variables over the sample of observations and hence may be understood in a way similar to the interpretation of typical regression coefficients. The average spillover effects correspond to the cumulative average response of a region's dependent variable to a marginal change in an explanatory characteristic in all other regions.

We make use of Bayesian Markov chain Monte Carlo (MCMC) estimation.[2] Standard specifications from the literature (LeSage and Pace 2009) are used as prior distributions for all relevant quantities: Weakly informative priors following a multivariate Gaussian distribution are used for β and θ. The disturbance parameter σ_r^2 is drawn from an inverse Gamma distribution

$$p(\sigma_r^2) \sim IG(\underline{a}, \underline{b}) \tag{3}$$

with the prior shape and scale parameters $\underline{a}$ and $\underline{b}$ being set weakly influential, i.e. $\underline{a} = \underline{b} = 0.01$. The conditional posterior distributions for β, θ and σ_r^2 follow known forms and thus can be directly sampled by Gibbs sampling steps.

For the spatial autocorrelation parameter, ρ, we follow LeSage and Parent (2007) and use a Beta (a_0, a_0) prior distribution defined on the interval $(-1, 1)$ and centred on zero:

$$p(\rho) \sim \frac{1}{Beta(a_0, a_0)} \frac{(1+\rho)^{a_0 - 1}(1-\rho)^{a_0 - 1}}{2^{2a_0 - 1}} \tag{4}$$

with hyperparameter value $a_0 = 1.01$. The conditional distribution of ρ, however, is not reducible to a well-known distribution, which is the reason for implementing a Griddy-Gibbs sampler as introduced by Ritter and Tanner (1992).

4 Data

The modelling approach employed in this paper requires the availability of an extensive data foundation regarding metal ore extraction as well as further control variables for economic growth. Adding

[2]For a comprehensive description of Bayesian Markov chain Monte Carlo (MCMC) estimation, see Koop (2003).

to that, demanding spatial disaggregation requires data other than national aggregates. Hence, data restrictions on the subject, which are especially challenging for analysing countries of the Global South, lead to a rare occurrence of broad econometric impact assessments. We consider Mexico, Peru and Chile, since all of them are characterised by considerable and for the most part institutionalised mining sectors. Together, they accounted for 14% of global metal ore extraction in 2017, with Chile (7%) being the primary extractor (Figure 1). The final dataset captures information on a panel of 32 Mexican, 24 Peruvian and 16 Chilean regions over the period 2008 – 2015 (for a full list of regions and descriptive statistics, see Appendix A). Regions are defined as first administrative tiers of sub-national government and match the OECD's definition of Tier Level 2 (TL2).

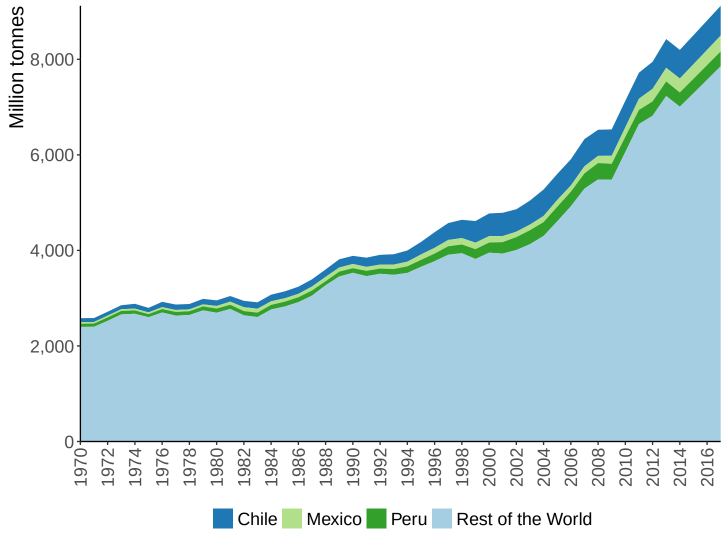
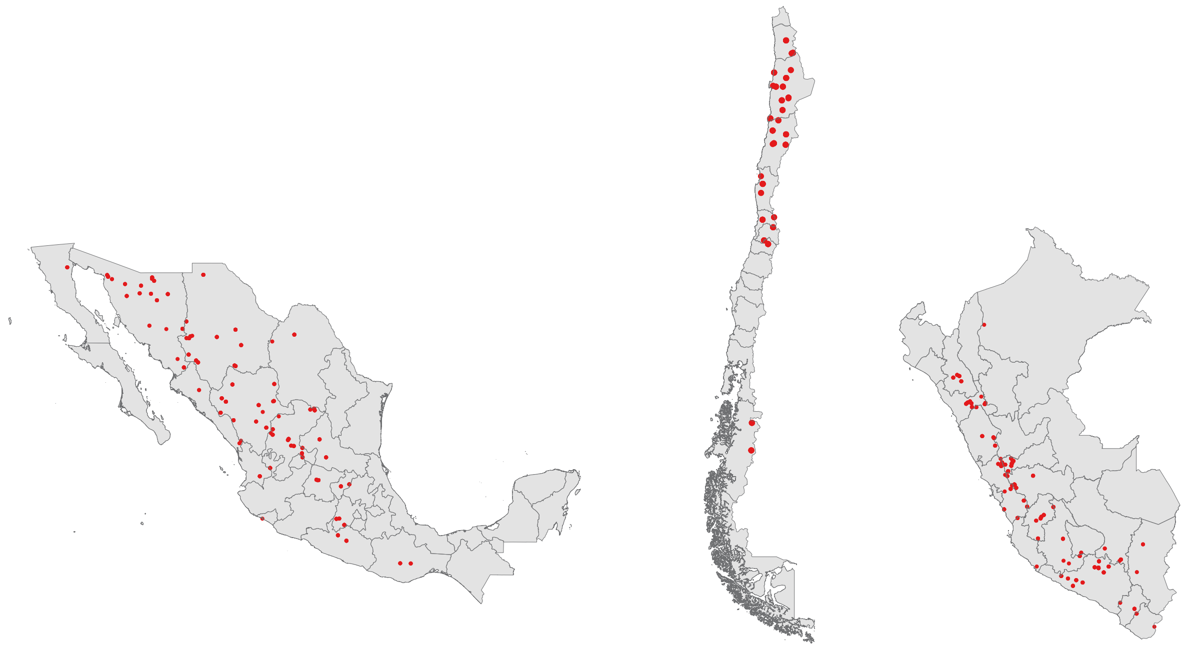


Figure 1: Global metal ore extraction; 1970-2017; Source: UN IRP (2017)

Regarding mining activities, the key component of the model, we make use of S&P's Global Market Intelligence Metals & Mining (also known as SNL) database (SNL 2018). This database lists mining properties as point data with exact coordinates, shown in Figure 2, and includes information on various characteristics of the mines. From these, we selected the amount of gross ore processed as the indicator of extraction intensity and aggregated data from 77 Mexican, 31 Chilean and 76 Peruvian mining properties at the respective regional level. As thoroughly discussed in Section 2, there is considerable ambivalence with regard to the direction of the actual effect on economic growth. The amount of gross ore processed as an indicator for mining intensity was chosen to deliberately capture mining activities' links to labour and capital input. Gross ore includes all raw material that is extracted and used in further processing levels. This approach differs from e.g. using the production of commodities as metal content, the final output of the production process, which would rather capture commodity price developments instead of being an indicator for the transformation of nature and its economic, social and environmental consequences.[3]

The dependent variable, a rolling average of annual regional GDP growth rates between 2008 and 2015, is calculated from data of the OECD regional database. This database encompasses yearly time series for around 40 indicators (demography, economic accounts, labour market, social and

[3]Ideally, one would want the model to consider which metals are actually mined in the respective mines, e.g. by the use of interaction dummy variables. Facing insufficient data availability, we have refrained from this idea because the existence of by-products would result in a very high-dimensional model.



(a) Mexico (b) Chile (c) Peru

Figure 2: Mining properties considered in this study; Source: SNL (2018)

innovation themes) for OECD member countries as well as other economies and serves as the main source for our set of control variables. Recent advances in (spatial) Bayesian econometric modelling inform on key economic determinants. For example, Bayesian Model Averaging (BMA) techniques, introduced by Hoeting et al. (1999), are exploited in the spatial growth models of LeSage and Fischer (2008), Crespo Cuaresma et al. (2014) and Crespo Cuaresma et al. (2018). They find by far the highest inclusion probabilities for initial income. Further, but not robustly over all models, high probability models include population density, area, proxies for human capital and infrastructure as well as the employment in certain industry sectors capturing region specific structural characteristics. Finding similar explanatory variables, Piribauer (2016) deals with the issue of model uncertainty making use of stochastic search variable selection (SSVS) priors (as introduced by George and McCulloch (1993)). Differently from studies conducted for European regions or the US, deficient data availability motivates a classical model comparison approach for the Global South.

Most obviously mattering with regard to the existing growth literature, we cover the aspect of initial income by including the log-transformed regional GDP of the respective starting period. An inverse relationship between the starting level of income and economic growth is advocated by neoclassical growth models, such as Solow (1956), identifying diminishing returns to reproduce capital as the main element behind this convergence. Next, differentials in economic growth are traced to the underlying productive structures of economic entities (Teixeira and Queirós 2016). In order to control for this industrial mix, we draw to the BMA results of LeSage and Fischer (2008) and con-

Variable	Description
Initial income	Regional gross domestic product (USD mn, current prices, current PPP, log). *Source:* OECD (2018)
Ore extraction	Gross ore processed (kilotonnes, log). *Source:* SNL (2018)
Population density	Population per square km (log). *Source:* OECD (2018)
GVA agriculture	Gross value added in agriculture, forestry and fishing (USD mn, current prices, current PPP, log). *Source:* OECD (2018)
GVA financial	Gross value added in financial and insurance activities (USD mn, current prices, current PPP, log). *Source:* OECD (2018)
Large port	Dummy variable, 1 denotes region with large port, 0 otherwise. *Source:* Searoutes (2019)

Table 1: Explanatory variables used in the analysis (measured at the beginning of the respective growth horizon)

sider (a) agriculture, forestry and fishing and (b) financial and insurance activities.[4] To proxy the sectoral mix, we include the (logged) levels of gross value added in the respective industries.

Studies on regional economic growth are typically constrained by scarcity of sub-national data. This specifically applies for the Global South. Innovation and technological change are regarded as driving components for the process of growth (Barro 1991) and human capital is another widely considered variable in the literature (Crespo Cuaresma et al. 2018). Due to the lack of observations on human capital in the selected regions, we proxy this variable by (logged) population density. Regions with higher population density represent urban agglomerations, which differ significantly from rural regions with regard to human capital stocks and hence innovation, technological progress and economic growth (LeSage and Fischer 2008).

Furthermore, it is argued that transport infrastructure decreases the cost of trade and hence by fostering trade activities positively affects income levels (Donaldson 2018). Since all three countries considered in this analysis are predominantly export economies, we introduce a proxy for regional export infrastructure. In doing so, information is taken from Searoutes (2019) whether a large port is located within the respective region. This is sufficient for export economies, because other, terrestrial, transport infrastructure is designed for supplying facilities related to international trade, which are most importantly ports.

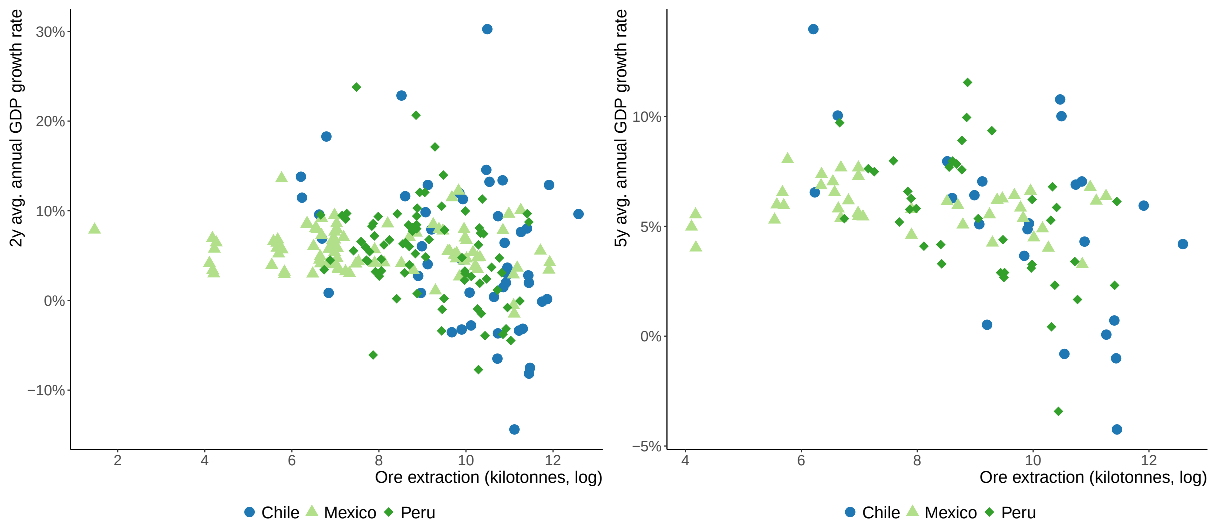
All variables are measured at the respective initial period of the rolling average growth horizon in order to mitigate endogeneity between regional growth and potential determinants. The entire set of used variables and their respective data sources are summarised in Table 1.

5 Results and discussion

Figure 3 shows the relationship between annualised growth rates (2 years average left panel, 5 years right panel) and the amounts of ore extraction for Chile, Mexico and Peru, respectively. From these descriptive charts, two aspects become evident. First, the panels for both growth periods indicate that, on the one hand, the variation in growth rates is larger for Chile (between -14% and 30% for 2 year and -4% and 14% 5 year average annual growth rates) and Peru (-8% to 24% 2 year, -3% to 12% 5 year), whereas this variation is more moderate for Mexico (-1% to 14% 2 year, 3% to 8% 5 year). The distribution of extraction intensity, on the other hand, appears to be equally skewed (note the log-scale) for all countries. Second, there are different dynamics throughout the selection

[4]Replacing agriculture, forestry and fishing by the manufacturing sector does not affect the results significantly, see Appendix B.

of countries regarding the correlation between economic growth and extraction intensity. While no clear correlation is evident for Mexico, there appears to be a negative relationship for the two Andean countries. Further, note that the number of observations decreases with the length of the period, over which the growth rates are annualised.



(a) 2 year average annual growth rates

(b) 5 year average annual growth rates

Figure 3: Sub-national aggregated ore extraction versus average annual regional GDP growth rates; Sources: SNL (2018), OECD (2018)

This section presents MCMC results of four models using 20,000 iterations and discarding the first 10,000 (burn-ins) respectively.[5] For the spatial weights matrix **W**, we use a k-nearest neighbours specification with $k = 5$.[6] Spatial dependence has been tested for by the use of Moran's I statistics, confirming the necessity of addressing the autocorrelation.

Average direct and indirect impact estimates are summarised in Table 2. We distinguish between short-run growth models with 2 year annual average growth rates as the dependent variables and medium-run 5 year average annual growth rates. In addition to both of these baseline approaches [part (1) and (3) in Table 2], we introduce interaction terms between ore extraction and the country dummy variables in order to allow for different slopes depending on the respective country [part (2) and (4)].

The results suggest significant spatial dependence with the posterior mean estimate of the spatial autocorrelation parameter ρ being between 0.250 and 0.289 in all considered models. Therefore, it is evident that economic growth rates of neighbouring regions influence each other via unobserved channels. It is a strength of this study's econometric approach to take the spatial dependence into account when calculating impact estimates. There is, however, no evidence that changes in any of the covariates specifically lead to spillover effects. This finding may be related to the rather large size of TL2 regional entities. Further investigations at the level of smaller regions (including the compilation of the respective datasets) are highly encouraged, because finer granularity of spatial observations

[5]Convergence of the MCMC sampler has been checked using convergence diagnostics introduced by Geweke (1992) and Raftery and Lewis (1992). The convergence diagnostics have been calculated using the R package `coda`.

[6]We follow an exploratory approach yielding that variations in k between k=3 and k=6 do not qualitatively affect the results, see Appendix B.

	2y horizon								5y horizon							
	(1)				(2)				(3)				(4)			
	Avg. Direct		Avg. Spillover		Avg. Direct		Avg. Spillover		Avg. Direct		Avg. Spillover		Avg. Direct		Avg. Spillover	
Variables	PM	SD	PM	SD	PM	SD	PM	SD	PM	SD	PM	SD	PM	SD	PM	SD
Initial income	**-3.164**	0.599	2.085	1.547	**-2.947**	0.633	2.215	2.068	**-2.989**	0.470	1.358	1.297	**-2.849**	0.493	1.014	1.748
Ore extraction	0.033	0.054	0.175	0.129					0.022	0.043	0.083	0.103				
Ore extraction × Chile					-0.131	0.141	0.012	0.346					-0.181	0.116	0.005	0.292
Ore extraction × Mexico					**0.167**	0.074	0.142	0.214					**0.153**	0.057	-0.006	0.185
Ore extraction × Peru					-0.101	0.094	0.353	0.319					-0.098	0.074	0.413	0.243
Population density	0.274	0.277	0.221	0.616	0.400	0.288	0.184	0.639	0.202	0.229	-0.185	0.469	0.342	0.235	-0.206	0.498
GVA agriculture	**1.093**	0.267	0.205	0.815	**0.904**	0.288	-0.253	0.995	**0.988**	0.228	0.096	0.657	**0.848**	0.231	-0.195	0.789
GVA financial	**1.654**	0.489	-2.136	1.204	**1.581**	0.509	-1.832	1.466	**1.688**	0.397	-1.032	1.009	**1.645**	0.398	-0.615	1.267
Large port	-1.084	0.790	-4.041	3.314	-0.540	0.886	-1.288	3.668	-1.053	0.633	-4.840	2.705	-0.634	0.706	-2.196	3.125
ρ	**0.274**	0.070			**0.279**	0.069			**0.250**	0.104			**0.289**	0.104		
σ^2_{CHL}	**30.384**	5.048			**31.290**	5.152			**9.718**	2.984			**10.544**	3.193		
σ^2_{MEX}	**12.487**	1.453			**12.129**	1.399			**3.732**	1.148			**3.338**	1.057		
σ^2_{PER}	**19.616**	2.592			**19.277**	2.539			**5.899**	1.946			**5.399**	1.811		
R^2	0.302				0.303				0.324				0.342			
Obs.	432				432				216				216			

Table 2: Panel SDM impact estimates (considering time and country fixed effects). Estimates printed in bold type are statistically different from zero based on the 95 percent posterior credible interval. PM and SD denote posterior mean and standard deviation, respectively.

could give more specific insights on how the covariates, such as mining activities, indirectly influence neighbouring communities. In this study, these insights are blurred by the scale effect. Importantly, the finding on ρ strongly supports the use of spatial econometric techniques in order to avoid biased results.

In accordance with non-spatial growth literature (Barro 1991), the results persistently over all models suggest negative direct impacts of initial income on economic growth. Compared to spatial econometric growth studies, convergence via direct impacts for Mexican, Peruvian and Chilean regions can be shown, however, to be substantially larger than previously found in studies on the Global North (Piribauer 2016; Crespo Cuaresma et al. 2014).

Drawing to the main interest of this article, the direct and indirect impact assessment of ore extraction intensity on regional economic growth, the results do not support the existence of major causal relationships. However, against the backdrop of stakeholders continuously emphasising mining projects' supposedly positive stimulus on regional economies, the insights given by this study are surprising. Obtaining mainly insignificant average posterior impact estimates, neither the short, nor the medium-run models depict clear evidence that mining intensity would serve as a determinant for regional economic growth. The only cases where significant positive effects are found are the short and medium-run Mexican interaction terms [part (2) and (4)]. Interacting ore extraction with being located in either Chile or Peru, in contrast, yields negative but insignificant direct impacts. No statements can be made regarding the average mining intensity over all three countries [part (1) and (3)], which is most likely due to different country characteristics and impact directions cancelling each other out. Popular arguments raised by the mining industry that the extractive sector would trigger positive impulse for regional economic development (ICMM 2015; ICMM 2006) hence cannot be verified. The findings rather support narratives that mining regions themselves do not benefit from their wealth in natural resources. These include, first, mining being considered as rather capital- than labour-intensive and hence not intensively fostering regional employment. Therefore, the creation of additional economic multipliers fails to come in (Arias et al. 2014; Emel and Huber 2008; Humphreys et al. 2007b). Second, it is argued that (mostly) foreign investors withdraw added values from the regional economy (Karl 2007).

Population density, which ought to proxy the dynamics of an urban-rural divide with special regard to innovation capacity and other human capital endowments, cannot be identified to exhibit significant impacts on GDP growth. Likewise, large ports being a proxy for export infrastructure are not detected as prominent impact factors for regional economic growth. Besides initial income, however, a region's sectoral structure very well matters. Both gross value added (GVA) in the agriculture, forestry and fishing industries as well as GVA in financial and insurance activities show positive average direct impact estimates with the latter being larger in magnitude across all four models. The findings on agricultural orientation oppose LeSage and Fischer (2008), who find negative impacts, while they are in line with direct impact estimates for low-income regimes in Piribauer (2016). Intuitively, it is reasonable to argue that both agricultural and financial hotspots grow faster: the former correlate with low-income regions that, according to neoclassical theory, promise higher returns to capital. Adding to that, it still makes a difference whether the regional agricultural sector is highly industrialised and oriented towards exports (this kind of economic activity is most likely covered by GVA accounting) or whether small-scale domestic supply dominates the local agricultural structures.

Financial hotspots obviously refer to economic centres that incorporate growth dynamics due to their openness to global financial markets and large-scale financial investment.

Another contribution of this article is to explore the need for country-specific treatment of uncertainty incorporated in the data. Mexico, Peru and Chile have in common that they are among the largest Latin American economies and oriented towards the export of natural resources. And yet they differ substantially in size and population, absolute and per capita income and political economic environment in general. This heterogeneity reflects in heteroskedastic data, which becomes of concern in the application of regression analysis, yielding inefficient results. Figure 4 depicts the posterior distributions of the country-specific variances. The left panels indicate that particularly the short-run models (both interaction and no interaction specification) incorporate country-wise variations in variance with Chile showing the largest volatility, reflecting most substantial inequality among regions. Regarding medium-run growth rates, the differences are smaller (and variances lower in magnitude). Mexico, however, still significantly differs in the structure of data. Therefore, it is evident that heteroskedasticity is an issue in cross-country regional growth comparisons and thus shall be accounted for in the modelling.

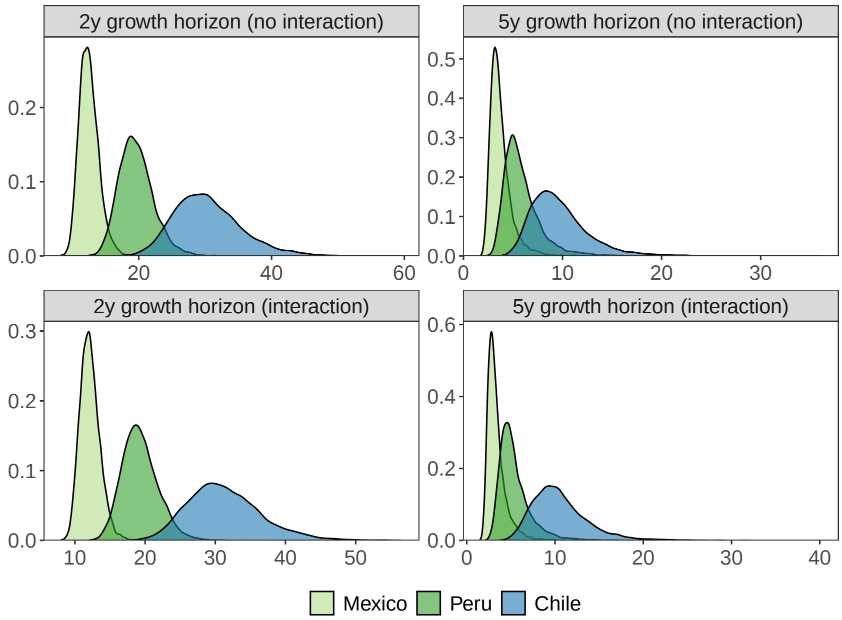


Figure 4: Posterior distributions of country-specific variances

But why do mining activities, which prove highly financially profitable for some multinational corporations, do not translate into regional economic growth? What we usually observe is that mining regions are characterised by the presence of large, mostly multinational, corporations. Emphasising the work of Arias et al. (2014), the direction and extent of economic development in mining regions depends on the structure of export-oriented agglomerations that are created around large-scale mining projects. These structures can be either closer to what is called a mining enclave or to a cluster. While mining clusters are characterised by a broad range of local supplier firms, strong regional linkages and the development of new local industries as well as a substantial labour market and knowledge spillovers from multinational corporations to regional firms, opposite characteristics apply for mining enclaves. Ideally, mining clusters would develop since they promoted regional economic development. The results of this study suggest that only Mexico tends to have managed creating clusters, while no significant dynamics of mining regions with regard to economic growth are found for Peru and Chile. Arias et al. (2014) conducted a case study for Chile's Antofagasta Region, a global mining hotspot endowed with vast deposits of copper, iodine and lithium, as well as major reserves of silver and molybdenum. Their findings support the results of this study regarding Chile, i.e. no beneficial effects of mining intensity as they find (a) weak linkages of local supplier firms with the mining sector and limited productive diversification, (b) the highest rate of regional commuting in the country and jobs that require rather low-skilled workers, indicating a labour market that lacks thickness and (c) no evidence of knowledge spillovers, but rather a monopsonistic structure of corporations with little incentives to transfer their knowledge and technological innovations developed in their headquarters to local firms in the Antofagasta Region. Certainly, this study does not entail enough evidence to fully claim that Mexico manages to establish mining clusters generating endogenous development, while Peru and Chile are stuck with mining enclaves. For that, further individual studies on Mexican, Peruvian and Chilean mining regions needed to be conducted. However, the theory of clusters and enclaves serves as a first indication why we do not generally find positive causal relationships between mining and regional economic growth.

One main instrument to generate regional income under the circumstance that large multinational corporations dominate the mining industry is a tax policy that intervenes in the distribution of mining profits and prevents companies from exporting all profits to international headquarters. Analyses by the Economic Commission for Latin America and the Caribbean (CEPAL) show that mainly corporate income tax is used as a means for capturing revenues generated from mining throughout all Latin American metals- and minerals-exporting countries (CEPAL 2013). However, the report also states that the largest share of revenue from the mining sector was retained by the national treasury at the central level. This fact that tax revenues are predominantly collected by central instead of sub-national governments, again, supports the outcome of the paper's empirical analysis that no clear pattern of mining fostering regional development can be found.

Mining profits may on the one hand be equally distributed across the entire country via imposing taxes on mining corporations and adequate government spending, and on the other hand be siphoned off abroad. The major economic benefits of metals and minerals extraction concern a small amount of globally acting players. What stays within the mining regions directly, however, are harmful forces concerning the environment and society, as it frequently becomes evident at the examples of tailings dam failures (Agurto-Detzel et al. 2016), pollution (Northey et al. 2017; Zhang et al. 2012) and local political conflicts (Arellano-Yanguas 2011) as well as long-term impacts such as deforestation (Bebbington et al. 2018; Sonter et al. 2017) and biodiversity loss (Sonter et al. 2018) due to mining activities. Furthermore, Edwards (2016) finds a negative relationship between a country's mining sector size and health and education outcomes. All these implications must, in turn, be related to economic backlashes, eventually cancelling out potentially positive effects on regional economic growth. As stated in CEPAL (2010) and adding another argument in favour of the paper's empirical results, it is Mexico that reports significant progress in promoting clean production in the mining sector.

CEPAL (2010) moreover puts forward the difference between small-scale and large-scale mining. Their report identifies its informal nature, environmental degradation and health issues due to pollution as the main issues of small-scale mining, but also stresses its economic value to the local population as it offers local employment. Although labour intensity is extremely high and conditions of security and hygiene are precarious, small-scale mining serves as an important source of employment especially for the poor and may possibly create local production clusters. Large-scale mining, in contrast, poses major challenges to sustainable and local economic growth because non-renewable resources are exploited and exported "with little (or no) value added through processing" (ibid.: p. 32). Further, energy and water resources are used intensively with potentially significant environmental consequences, "while there are limited mechanisms to ensure that the profits created remain in the producing regions" (ibid.). From the data on all mining projects covered in this study, it becomes evident that rather large-scale mining applies: Figure 5 indicates that the mining sectors in Mexico, Peru and Chile are highly concentrated and biased towards a few mining projects. For example, 50% of all ore extracted in 2017 was mined in only 12, 80% in only 30 out of 156 mining facilities. This indicates that most metal ore extraction is conducted by a small number of large-scale projects, while many small projects extract insignificant numbers of ore. Therefore, it is more likely that only a small fraction of mining profits eventually remains in the producing regions.

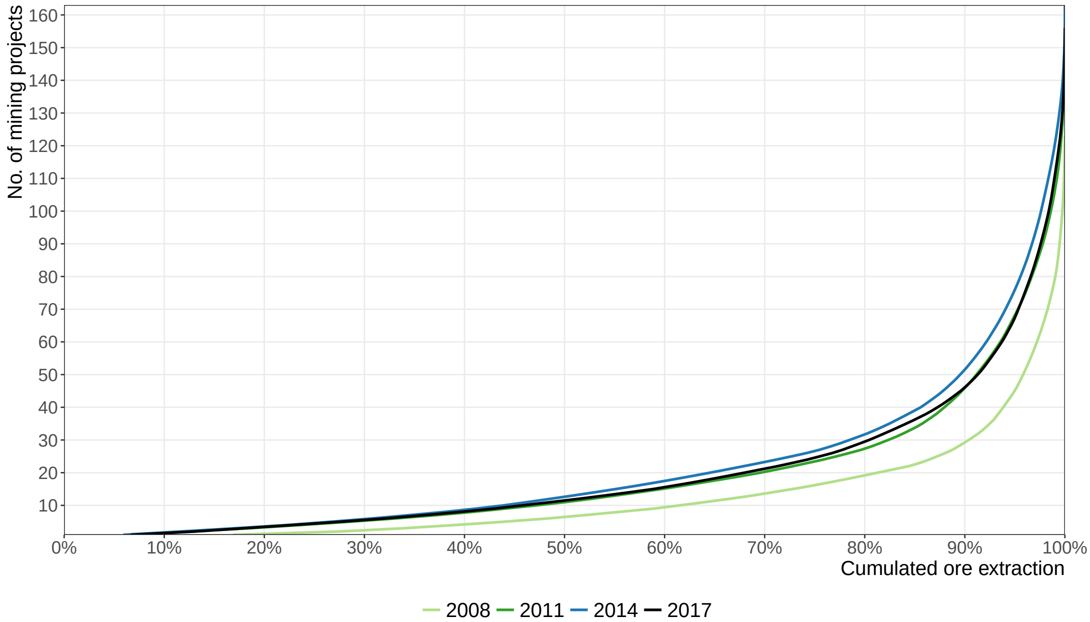


Figure 5: Cumulated ore extraction of mining projects in Mexico, Peru and Chile; ordered from largest to smallest; 2008, 2011, 2014 and 2017; Source: SNL (2018)

Lastly, we want to stress the need for an integrated view on economic, environmental and social spheres. The global trend of rising consumption of products and services not only increasingly drives the extraction of raw materials, including that of metals and minerals, but also relates to impacts that are potentially hazardous such as environmental and social concerns. Further, there is no doubt that the extraction and export of metals and minerals, a major economic activity in resource-rich countries, relates to the economic sphere. However, this study finds that no clear patterns arise that link ore extraction to regional economic development. What this empirical model does not incorporate yet is endogeneity between economic activity, environmental impacts and social dynamics. Mining activity can, for example, affect society or natural systems, which in turn has economic implications, which again may shape societal and environmental conditions. A closer assessment of these links is a topic for future research.

6 Concluding remarks

Previous literature on the relationship between mining and economic development predominantly investigated country-wide dynamics, whereas regional or spatially explicit studies remained mainly analysing environmental and social impacts of mining activities. Claims that mining would foster regional development remained empirically unchecked on a broader scope than for specific cases. The purpose of this paper was to examine whether the claim holds. Conventional growth regressions neither take into account spatial autocorrelation nor do they address the issue of heteroskedasticity. Therefore, we employed a panel-structure Spatial Durbin Model (SDM) incorporating spatial dependence as well as heteroskedastic errors. We considered a total of 72 regions in Mexico, Peru and Chile over the period 2008 – 2015 and regressed average annual growth rates on a range of potential growth determinants, including extraction intensity.

The results indicate that there is no general positive stimulus of mining activities on economic growth. Only Mexico shows extraction-induced regional growth, while no patterns emerge for Chile, Peru, and over the full dataset. Therefore, the findings rather support the view that mining regions themselves do not universally benefit from their wealth in natural resources. First, because mining is considered as rather capital- than labour-intensive and hence does not intensively foster regional employment and thereby does not create additional economic multipliers. Second, because there is a tendency for multinational corporations to withdraw added values from the regional economies.

While the analysis is in accordance with claims that mining profits are mostly divided into central government tax revenue and company shares (CEPAL 2013), it is the environmental and social consequences that take effect regionally. The vast amount of analyses relating mining to societal and ecological concerns underpins the urgent need for dealing with the implications of increased global resource demand in a way that integrates environmental, social and economic spheres while also taking into consideration sub-national patterns.

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A List of regions and descriptive statistics

Country	Region	2 y growth (%)	5 y growth (%)	GDP (USD mn, log)	Ore extraction (kilotonnes, log)	GVA Agr. (USD mn, log)	GVA Fin. (USD mn, log)	Pop. Den. (Pop./km^2, log)	Large port
Chile	Aisén del General Carlos Ibáñez del Campo	10.14	10.18	7.23	6.36	5.19	3.47	-0.06	No
Chile	Antofagasta	3.66	3.04	10.42	11.98	4.01	6.48	1.50	Yes
Chile	Araucanía	7.83	8.38	8.77	0.00	6.44	6.27	3.40	No
Chile	Arica y Parinacota	8.17	9.17	7.50	0.00	4.42	3.99	2.54	Yes
Chile	Atacama	6.26	6.66	8.81	10.50	5.31	5.12	1.34	No
Chile	Bío-Bío	5.51	5.86	10.00	0.00	7.39	7.35	4.00	Yes
Chile	Coquimbo	5.47	4.92	9.08	8.78	6.22	5.94	2.85	Yes
Chile	Libertador General Bernardo O'Higgins	6.29	6.08	9.50	10.82	7.42	6.88	3.97	No
Chile	Los Lagos	8.05	8.43	8.96	0.00	6.78	6.59	2.80	No
Chile	Los Ríos	8.39	8.66	8.13	0.00	6.01	5.32	3.04	No
Chile	Magallanes y Antártica Chilena	8.51	9.69	7.82	0.00	4.37	4.81	0.31	No
Chile	Maule	5.92	6.33	9.14	0.00	7.01	6.13	3.49	No
Chile	Ñuble	5.51	5.86	10.00	0.00	7.39	7.35	4.00	Yes
Chile	Región Metropolitana de Santiago	4.41	4.55	11.80	9.89	6.95	10.64	6.09	No
Chile	Tarapacá	-0.20	-1.15	9.17	11.37	4.58	5.52	1.93	No
Chile	Valparaíso	6.06	6.18	10.10	9.06	6.60	7.31	4.65	Yes
Mexico	Aguascalientes	6.90	6.80	9.80	6.99	6.54	5.94	5.34	No
Mexico	Baja California	4.20	4.28	10.88	5.27	7.27	7.13	3.79	No
Mexico	Baja California Sur	3.88	3.79	9.49	0.00	6.06	5.68	2.14	No
Mexico	Campeche	-3.74	-2.19	11.37	0.00	6.11	5.42	2.66	No
Mexico	Chiapas	4.02	4.05	10.35	0.00	7.80	6.40	4.18	No
Mexico	Chihuahua	5.37	5.57	10.84	9.68	8.01	6.99	2.64	No
Mexico	Coahuila	6.25	6.24	10.91	7.18	7.27	6.91	2.90	No
Mexico	Colima	5.45	5.67	9.15	1.77	6.32	5.28	4.74	Yes
Mexico	Distrito Federal	4.12	4.31	12.59	0.00	4.98	10.08	8.71	No
Mexico	Durango	5.48	5.88	9.86	8.82	7.54	6.01	2.59	No
Mexico	Guanajuato	6.94	7.07	10.99	6.62	7.82	7.44	5.19	No
Mexico	Guerrero	4.49	4.46	10.09	10.15	7.12	6.23	3.98	No
Mexico	Hidalgo	6.37	6.40	10.08	0.00	6.97	6.08	4.84	No
Mexico	Jalisco	5.88	5.94	11.57	5.60	8.60	8.10	4.53	No
Mexico	México	5.72	5.91	11.85	6.63	7.73	8.17	6.53	No
Mexico	Michoacán	5.37	5.52	10.55	0.00	8.34	6.88	4.31	No
Mexico	Morelos	3.71	3.79	9.92	0.00	6.46	6.13	5.90	No
Mexico	Nayarit	4.94	4.84	9.35	4.17	6.77	5.55	3.66	No
Mexico	Nuevo León	4.89	4.89	11.72	0.00	6.67	8.43	4.28	No
Mexico	Oaxaca	4.67	4.62	10.21	0.00	7.37	6.26	3.72	No
Mexico	Puebla	5.09	5.34	10.90	0.00	7.73	7.08	5.13	No
Mexico	Querétaro	6.66	6.61	10.40	6.20	6.52	6.46	5.05	No
Mexico	Quintana Roo	5.20	5.43	10.09	0.00	5.20	6.45	3.42	No
Mexico	San Luis Potosí	5.79	5.96	10.37	8.64	7.03	6.43	3.74	No
Mexico	Sinaloa	4.22	4.42	10.51	0.56	8.28	7.03	3.90	Yes
Mexico	Sonora	5.96	6.44	10.83	11.11	8.08	6.94	2.70	Yes
Mexico	Tabasco	2.90	3.51	10.95	0.00	6.59	6.15	4.50	No
Mexico	Tamaulipas	2.58	2.87	10.94	0.00	7.53	7.05	3.71	Yes
Mexico	Tlaxcala	4.71	4.31	9.20	0.00	5.97	5.06	5.68	No
Mexico	Veracruz	4.57	4.80	11.32	0.00	8.32	7.29	4.67	Yes
Mexico	Yucatán	5.28	5.39	10.04	0.00	6.73	6.40	3.90	No
Mexico	Zacatecas	5.52	5.02	9.66	10.12	7.15	5.67	2.99	No
Peru	Amazonas	7.92	7.98	7.47	0.00	6.42	2.38	2.35	No
Peru	Ancash	2.09	2.65	9.37	10.31	6.74	5.04	3.43	No
Peru	Apurímac	9.52	10.19	7.26	3.44	5.53	2.72	3.06	No
Peru	Arequipa	5.12	5.03	9.66	7.93	7.24	5.60	2.95	No
Peru	Ayacucho	7.89	8.27	8.04	7.03	6.29	3.44	2.69	No
Peru	Cajamarca	3.79	3.91	9.04	10.42	7.00	4.53	3.80	No
Peru	Cusco	7.94	8.95	9.24	8.93	6.80	4.91	2.87	No
Peru	Huancavelica	5.59	5.79	7.69	7.50	5.35	2.07	3.06	No
Peru	Huánuco	7.70	8.05	8.00	2.11	6.48	3.47	3.10	No
Peru	Ica	7.73	7.97	9.11	8.24	7.11	4.79	3.55	No
Peru	Junín	7.01	6.97	8.91	8.62	6.82	4.82	3.37	No
Peru	La Libertad	5.89	5.98	9.53	10.35	7.58	5.53	4.21	No
Peru	Lambayeque	6.84	6.96	8.81	0.00	6.65	4.94	4.43	No
Peru	Lima	7.52	7.74	11.76	8.64	8.00	9.01	5.55	Yes
Peru	Loreto	3.40	3.75	8.69	0.00	6.21	4.21	0.97	No
Peru	Madre de Dios	2.27	1.91	7.55	0.00	4.49	2.48	0.32	No
Peru	Moquegua	-0.14	-0.23	8.64	10.38	4.96	3.78	2.38	No
Peru	Pasco	3.07	3.32	8.06	9.49	5.38	2.57	2.45	No
Peru	Piura	7.33	7.87	9.35	0.00	7.13	5.36	3.89	No
Peru	Puno	7.28	7.38	8.68	2.49	7.01	4.45	2.92	No
Peru	San Martín	8.33	8.43	8.05	0.00	6.65	3.98	2.71	No
Peru	Tacna	4.33	4.19	8.21	9.98	5.30	4.27	2.98	No
Peru	Tumbes	5.44	5.48	7.43	0.00	5.35	3.11	3.84	No
Peru	Ucayali	5.53	5.90	7.90	0.00	5.65	3.46	1.50	No

Table 3: Summary of variables; numeric variables indicate 2008 – 2013 mean (exceptions: GDP 2008 – 2015, 5 y growth 2008 – 2010)); GDP and GVA in current prices and current PPP

B Alternative models

	2y horizon								5y horizon							
	(1)				(2)				(3)				(4)			
	Avg. Direct		Avg. Spillover		Avg. Direct		Avg. Spillover		Avg. Direct		Avg. Spillover		Avg. Direct		Avg. Spillover	
Variables	PM	SD	PM	SD	PM	SD	PM	SD	PM	SD	PM	SD	PM	SD	PM	SD
Initial income	-3.575	0.602	2.015	1.543	-3.238	0.655	2.182	2.035	-3.379	0.447	0.578	1.208	-3.146	0.516	0.383	1.700
Ore extraction	0.049	0.053	0.125	0.131					0.040	0.042	0.019	0.095				
Ore extraction × Chile					-0.130	0.137	0.049	0.347					-0.171	0.107	0.047	0.276
Ore extraction × Mexico					0.186	0.073	0.097	0.218					0.152	0.055	-0.043	0.177
Ore extraction × Peru					-0.092	0.092	0.304	0.301					-0.085	0.078	0.360	0.241
Population density	0.016	0.270	0.283	0.541	0.178	0.280	0.404	0.649	-0.116	0.210	-0.082	0.387	0.020	0.219	-0.006	0.497
GVA agriculture	0.828	0.255	0.581	0.983	0.626	0.276	0.326	1.090	0.753	0.191	-0.062	0.730	0.581	0.209	-0.203	0.824
GVA manufacturing	1.634	0.505	-2.118	1.347	1.574	0.515	-2.007	1.604	1.725	0.381	-0.122	1.005	1.724	0.398	0.114	1.361
Large port	-0.225	0.795	-1.682	3.279	0.137	0.821	0.427	3.429	-0.438	0.601	-3.208	2.493	-0.187	0.650	-1.389	2.744
ρ	0.268	0.069			0.272	0.069			0.217	0.102			0.257	0.102		
σ^2_{CHL}	29.959	4.954			31.160	5.247			8.227	2.541			8.946	2.790		
σ^2_{MEX}	11.987	1.390			11.828	1.369			3.200	1.016			3.010	1.027		
σ^2_{PER}	21.761	2.835			20.961	2.730			8.409	2.139			7.413	2.057		
R^2	0.286				0.290				0.288				0.320			
Obs.	432				432				216				216			

Table 4: Panel SDM impact estimates, GVA agriculture replaced by GVA manufacturing, 2 and 5 y avg. annual growth rates, time FE, country FE

	2y horizon								5y horizon							
	(1)				(2)				(3)				(4)			
	Avg. Direct		Avg. Spillover		Avg. Direct		Avg. Spillover		Avg. Direct		Avg. Spillover		Avg. Direct		Avg. Spillover	
Variables	PM	SD	PM	SD	PM	SD	PM	SD	PM	SD	PM	SD	PM	SD	PM	SD
Initial income	-3.303	0.581	1.174	1.022	-3.122	0.608	0.750	1.237	-3.095	0.443	0.556	0.824	-2.976	0.442	0.012	0.997
Ore extraction	0.018	0.053	0.200	0.100					0.014	0.043	0.128	0.077				
Ore extraction × Chile					-0.106	0.149	0.181	0.238					-0.160	0.119	0.157	0.189
Ore extraction × Mexico					0.179	0.074	0.024	0.164					0.174	0.055	-0.076	0.126
Ore extraction × Peru					-0.133	0.092	0.364	0.192					-0.118	0.067	0.339	0.143
Population density	0.397	0.277	0.346	0.406	0.616	0.297	0.061	0.422	0.342	0.217	0.011	0.296	0.556	0.230	-0.244	0.305
GVA agriculture	0.980	0.263	0.152	0.455	0.863	0.264	0.001	0.538	0.930	0.213	0.131	0.364	0.822	0.205	0.060	0.397
GVA financial	1.624	0.482	-1.854	0.822	1.496	0.497	-1.482	0.911	1.614	0.367	-0.959	0.617	1.547	0.374	-0.590	0.727
Large port	-0.709	0.673	-1.743	1.593	-0.512	0.698	-0.617	1.689	-0.757	0.511	-2.342	1.182	-0.599	0.509	-1.234	1.313
ρ	0.222	0.055			0.230	0.055			0.175	0.079			0.236	0.079		
σ^2_{CHL}	29.033	4.693			30.160	4.955			8.964	2.374			9.457	2.613		
σ^2_{MEX}	12.414	1.386			11.980	1.346			3.478	0.809			2.984	0.728		
σ^2_{PER}	18.933	2.474			18.435	2.353			5.177	1.364			4.749	1.263		
R^2	0.320				0.324				0.367				0.398			
Obs.	432				432				216				216			

Table 5: Panel SDM impact estimates, k-nearest **W** with $k = 3$, 2 and 5 y avg. annual growth rates, time FE, country FE

	2y horizon								5y horizon							
	(1)				(2)				(3)				(4)			
	Avg. Direct		Avg. Spillover		Avg. Direct		Avg. Spillover		Avg. Direct		Avg. Spillover		Avg. Direct		Avg. Spillover	
Variables	PM	SD	PM	SD	PM	SD	PM	SD	PM	SD	PM	SD	PM	SD	PM	SD
Initial income	-3.171	0.587	1.426	1.319	-2.900	0.610	1.806	1.594	-3.002	0.446	0.904	1.087	-2.827	0.476	0.781	1.327
Ore extraction	0.029	0.056	0.167	0.117					0.022	0.044	0.091	0.093				
Ore extraction × Chile					-0.122	0.147	0.031	0.291					-0.174	0.119	0.028	0.243
Ore extraction × Mexico					0.167	0.074	0.125	0.189					0.155	0.055	-0.021	0.155
Ore extraction × Peru					-0.108	0.096	0.223	0.257					-0.091	0.074	0.311	0.199
Population density	0.344	0.279	0.098	0.520	0.480	0.290	-0.032	0.531	0.247	0.225	-0.208	0.393	0.375	0.230	-0.337	0.414
GVA agriculture	1.035	0.272	0.210	0.704	0.869	0.285	-0.256	0.803	0.945	0.226	0.220	0.572	0.804	0.221	-0.022	0.660
GVA financial	1.620	0.494	-1.508	1.033	1.502	0.508	-1.454	1.184	1.675	0.389	-0.629	0.839	1.632	0.400	-0.354	0.990
Large port	-0.802	0.721	-2.634	2.381	-0.428	0.771	-1.107	2.541	-0.800	0.552	-3.482	1.909	-0.558	0.579	-2.062	2.093
ρ	0.289	0.062			0.291	0.063			0.275	0.093			0.309	0.091		
σ^2_{CHL}	28.875	4.801			29.750	4.967			9.130	2.623			9.725	2.804		
σ^2_{MEX}	12.382	1.380			12.046	1.363			3.535	0.942			3.170	0.895		
σ^2_{PER}	19.603	2.510			19.359	2.485			5.788	1.670			5.352	1.586		
R^2	0.314				0.315				0.344				0.367			
Obs.	432				432				216				216			

Table 6: Panel SDM impact estimates, k-nearest **W** with $k = 4$, 2 and 5 y avg. annual growth rates, time FE, country FE

	2y horizon								5y horizon							
	(1)				(2)				(3)				(4)			
	Avg. Direct		Avg. Spillover		Avg. Direct		Avg. Spillover		Avg. Direct		Avg. Spillover		Avg. Direct		Avg. Spillover	
Variables	PM	SD	PM	SD	PM	SD	PM	SD	PM	SD	PM	SD	PM	SD	PM	SD
Initial income	-3.243	0.604	2.878	1.957	-2.902	0.649	4.149	2.787	-3.035	0.486	2.005	1.731	-2.816	0.520	2.171	2.408
Ore extraction	0.036	0.053	0.158	0.145					0.026	0.042	0.087	0.115				
Ore extraction × Chile					-0.155	0.144	-0.172	0.441					-0.176	0.125	-0.208	0.397
Ore extraction × Mexico					0.184	0.076	0.250	0.257					0.162	0.060	0.070	0.220
Ore extraction × Peru					-0.127	0.093	0.090	0.360					-0.113	0.074	0.298	0.289
Population density	0.248	0.279	0.166	0.685	0.369	0.289	0.440	0.732	0.195	0.219	-0.326	0.534	0.334	0.225	-0.069	0.586
GVA agriculture	1.056	0.268	0.264	0.940	0.817	0.294	-0.698	1.208	0.965	0.230	-0.010	0.808	0.803	0.248	-0.533	1.039
GVA financial	1.747	0.502	-2.552	1.390	1.613	0.507	-3.017	1.749	1.756	0.397	-1.177	1.250	1.670	0.404	-1.234	1.560
Large port	-1.048	0.773	-5.359	4.100	-0.222	0.862	0.339	4.724	-1.081	0.623	-6.717	3.471	-0.385	0.684	-1.320	3.994
ρ	0.310	0.075			0.311	0.074			0.304	0.113			0.328	0.114		
σ^2_{CHL}	30.646	5.122			31.229	5.182			10.553	3.130			11.563	3.402		
σ^2_{MEX}	12.537	1.488			12.201	1.436			3.686	1.295			3.365	1.256		
σ^2_{PER}	19.354	2.537			19.301	2.535			5.931	2.142			5.505	2.090		
R^2	0.302				0.303				0.312				0.320			
Obs.	432				432				216				216			

Table 7: Panel SDM impact estimates, k-nearest **W** with $k = 6$, 2 and 5 y avg. annual growth rates, time FE, country FE

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