The Impact of Mining Activities on Regional Development – Evidence from Latin America in a Spatial Econometric Framework

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The overriding economic importance of natural resources is a recurring theme throughout the history of almost any Latin American country. In the 2000s, many countries have reoriented and intensified their economic strategies geared towards the export of primary commodities (Svampa 2012). While it is broadly acknowledged that the export of primary goods can, under beneficial market conditions, contribute to short-term national GDP growth, the intense exploitation of natural resources is also associated with harmful social and ecological impacts and thus may be related to long-term economic backlashes. This paper aims to investigate the implications of these extractivist development strategies using the example of mining activities and raises the question to which extent mining activities relate to the economic performance of mining regions and their surrounding areas.

While impact assessments of mining activities are usually conducted in the form of qualitative in-field case studies and focus on a smaller sample of mining properties and regions, we follow an econometric approach.

The modelling applied in the paper requires the availability of an extensive data foundation regarding the extraction of natural resources in the form of metals and minerals as well as further explanatory quantities for economic growth. Also, since mining is unequally spatially distributed over countries, the question of development calls for a regional, i.e. sub-national, analysis. 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. In fact, it is a novelty that the paper models the impacts of mining properties over three entire countries. It considers Mexico, Peru and Chile, since all of them are characterised by a substantial and for the most part institutionalised mining sector.

Many disciplines, from social sciences over geology to remote sensing, contribute a rich literature on the impacts of mining, each of them having its respective strengths and applying its tools. Both, environmental and social transformations have been and still are related to mining. This paper, however, turns the spotlight on another prominently discussed facet of mining, “development” in an economic sense. The assessment of economic effects is a crucial component when it comes to finding answers for the most urgent questions raised by mining, i.e. where and how resources will be accessed, mineral revenues distributed, and processing wastes disposed (Bridge 2004, p. 206).

We refer to the question how mining relates to the economy in terms of GDP growth. This is reasonable to discuss against the backdrop of a development discourse to the extent that high GDP rates, for example, usually correlate with many other indicators of living conditions that are typically regarded as worth striving for. Economic growth has been prominently analysed in the context of convergence across countries (see Barro 1991), where regional economic growth rates are
explained by \( k \) exogenous country characteristics in the initial period, including most importantly initial income. What is typically found in these kind of growth regressions is a negative coefficient for initial income, indicating that countries with high initial income grow slower than low initial income economies. Our growth model is inspired by the basic idea of the concept, while implementing twofold extensions. First, we expand it by moving to a sub-national level. Thereby, we explicitly model spatial dependence. Second, 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.

Being capable of interconnecting socio-economic and regional science, spatial econometric modelling is a powerful tool for quantifying causal relationships with special regard to spatial relations. Other than standard linear models, it overcomes the simplification of assuming independence of observations, which would lead to biased and inconsistent estimates. 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), but also may the spatial structure of this dependence be a subject of interest or provide a key insight. Spillover effects, for example, 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.

Acknowledging spatially dependent growth rates as well as spatial dependence in explanatory regional characteristics (LeSage and Fischer 2008), we employ the following panel-structure Spatial Durbin Model (SDM):

\[
\Delta y_t = \rho W \Delta y_t + X_t \beta + WX_t \theta + \mu + \xi_t + \epsilon_t, \quad \epsilon_t \sim N(0, \Sigma)
\]

for \( t = 1, \ldots, T \), where \( \Delta y \) denotes the \( n \times 1 \) vector of regional economic growth rates, and \( X_t \) is an \( n \times k \) matrix of \( k \) exogenous country characteristics in the initial period. \( W \) is an \( n \times n \), non-negative, row-standardised spatial weights matrix with \( w_{ii} = 0 \). Its elements are used to specify the spatial dependence structure among the observations, i.e. \( w_{ij} > 0 \) if region \( j \) is in a neighbourhood relationship with region \( i \). Note that the regression equation includes the spatially-lagged dependent variable (i.e. \( W \Delta y_t \)) as well as the spatially-lagged regional characteristics (\( WX_t \)) as explanatory variables. The \( k \times 1 \) vectors of unknown parameters \( \beta \) and \( \theta \) correspond to \( X_t \) and \( WX_t \) respectively and \( \rho \in [-1, 1] \) is a scalar parameter measuring the magnitude of spatial autocorrelation. The model is further extended with country-specific (\( \mu \)) and time-period-specific (\( \xi_t \)) fixed effects. The \( n \)-element vector \( \epsilon_t \) follows a Normal distribution with zero mean and variance-covariance matrix \( \Sigma = \text{diag}(\sigma_r^2) \) for \( r = 1, \ldots, R \) countries.

We make use of Bayesian Markov Chain Monte Carlo (MCMC) estimation. Standard specifications from the literature are used as prior distributions for all relevant quantities: Weakly informative priors are used for \( \beta \) and \( \theta \), \( \sigma_r^2 \) follows an inverse Gamma and \( \rho \) a Beta distribution. For the estimation of \( \rho \), a Griddy-Gibbs step is implemented, whereas the quantities for the other parameters are sampled using Gibbs sampling. Additionally, heteroskedasticity due to varying structural characteristics is dealt with by allowing for country-specific variance-covariance matrices that are updated during estimation.
There are two aspects regarding model uncertainty. First, variable selection is of importance, since a too small subset of variables may give rise to omitted variable bias and a large number of potential regressors might make it difficult to identify important factors. Second, the choice of an appropriate spatial weights matrix, which imposes a structure on spatial dependence relations, is not trivial. Regarding the former, we rely on variable selection provided by recent literature, which uses Bayesian econometric approaches to deal with model uncertainty and variable selection. Regarding $W$, a k-nearest neighbours spatial weights matrix with $k = 5$ is applied, but for robustness a variation of matrices is tested. As an extension, it is intended to implement model uncertainty via Bayesian variable selection. Furthermore, the selection of $W$ need not be exogenous. It may be considered to estimate $k$ of the k-nearest neighbours spatial weights matrix within the model using Bayesian model averaging techniques.

The analysis takes 32 Mexican, 25 Peruvian and 15 Chilean regions into account. Regions are understood as first administrative tiers of sub-national government and match the OECD’s definition of Tier Level 2 (TL2). 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. It lists mining properties as point data with exact coordinates and includes information on various characteristics of the mines from which we selected the amount of gross ore processed as the indicator of extraction intensity and aggregated this quantity at the respective regional level. The dependent variable, which is the 4 years rolling average annual growth rate of regional GDP 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 innovation themes) for OECD member countries as well as other economies and serves as a source for our set of control variables. As discussed, we initially agree on a set of control variables that is suggested in regional growth literature. In addition to the OECD data and being a proxy for regional export infrastructure, information is taken from searoutes.com whether a large port is located within the respective region.

The paper finds evidence that on the one hand ore extraction is negatively related to economic growth rates within regions, while on the other hand positive spillover effects to neighbouring regions are registered. Variations in growth horizons further indicate that this pattern distinctively applies for 3 and 4 years average annual growth rates, while no negative direct effects can be found in the short-run. Popular arguments of the mining industry that the extractive sector would trigger positive impulse for regional economic development hence cannot be fully verified. Rather, it seems as if physical metals and minerals extraction and the realisation of rents in an economic sense are regionally decoupled. The findings of the paper therefore support the narrative that mining regions themselves do not directly benefit from their wealth in natural resources, because added value is transferred from mining peripheries to financial centers. This may be due to the fact that mining is considered as rather capital than labour intensive and hence does not intensively foster regional employment. Also, it may be taken into consideration that foreign investors could withdraw added values from the domestic economy at the first place. What definitely stays within the mining regions directly, however, are harmful forces concerning the environment and society, as it frequently becomes very evident at the examples of tailings dam failures, pollution and local political conflicts as well as long-term impacts such as deforestation and biodiversity loss due to mining activities.
Literature


