Booming Sector, Multinationals, and Local Economic Development*

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Abstract

Can a resource boom induce long-term local economic development? Do multinational companies (MNCs) foster such equilibria or move away the economic gains from the booming sector? This study examines the heterogeneous economic impacts of MNCs and domestic firms on the characterization of the contemporaneous and long-term general equilibrium effects of resource booms in local labor markets. Consistent with the predictions of a spatial equilibrium model that features a pre- and post-booming economy with productive linkages and endogenous amenities, the evidence from a major emerging resource-oriented country suggests that spillovers from productive linkages of the booming sector can prevent productivity losses in the form of local Dutch-Disease, with higher productivity spillovers for MNCs in comparison to domestic firms. However, these spillovers are mediated by dis-amenities rising from externalities in production, and the propensity of firms to offshoring.

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1 Introduction

A common feature of many modern resource-rich economies is that production in the booming sector is dominated by large multinational corporations (MNCs).[1] Notwithstanding, the literature exploring the economic impacts of a resource boom usually overlooks this fact.[2] In this study, I show that the consideration of this feature has important implications for the understanding of the contemporaneous and long-term general equilibrium effects of a resource boom. Specifically, if MNCs have a propensity to outsource more productive activities to foreign locations, the productivity losses caused by the crowding-out effects of the resource boom are unlikely to be entirely offset by the positive spillovers from productive linkages generated during the boom, reinforcing the mechanisms of the *Dutch disease*. This idea implies that the resource sector tends to generate a pattern of development consistent with the *enclave* hypothesis. Questioning the long-term gains of a resource boom for local economic development.

In the seminal study by Corden and Neary (1982) and subsequent contributions, the *Dutch disease* is caused by a sector-specific boom in an *"enclave traded-good sector, which has no production links with the rest of the economy. (Natural resource sectors are an obvious example.)"* (Neary, 1988, *pp. 212*), leads to de-industrialization. It also induces a loss in productivity and, consequently, a decline in economic growth.[3] This de-industrialization is caused by the resource boom, which increases the marginal productivity in the booming sector and absorbs resources from other sectors. This *resource movement effect* causes an excess of demand in the non-tradable sector, which produces a real appreciation, known as *spending effect*. The real appreciation indirectly induces de-industrialization by reducing the revenue of exporting firms, while the *resource movement effect* directly decreases manufacturing employment and the subsequent output.

In the spirit of Moretti (2010), a within-country version of the *Dutch disease* was introduced by Allcott and Keniston (2018). In this framework, the key mechanisms that determine the

[1] Notably, nearly 90% of global mining production is undertaken by large-scale mining companies, and 75% of all mining companies are headquartered in Canada (Global Affairs Canada, 2022).

[2] For example, MNCs can easily adapt to negative economic shocks in the intensive margin. After closing plants in less productive places (Helpman et al., 2004), they gain more bargaining power to negotiate forward contracts with local suppliers (Antràs and Helpman, 2004) and avoid price fluctuations, access to cheaper intermediate inputs (Halpern et al., 2015), and have less incentives to enforce local law (Herkenhoff and Krautheim, 2022), among other differences attributed to ownership structure, such as management (Boom and Van Reenen, 2010; Bloom et al., 2013), and more generally efficiency (Chari et al., 2010; Bircan, 2019).

[3] Here, the resource boom is modeled in a two-sector Hecksher-Ohlin framework as a Hicks-neutral technological shock, which implies that as a direct consequence of the Rybczynski theorem (Rybczynski, 1955), the decrease in the output of the manufacturing sector result from the increase in the size of the sector that intensively uses the factor subject to the shock, i.e., the resource sector.

effects of the resource sector on the local economy are firm-productivity gains due to local population and sector-specific employment growth, defined as *agglomeration spillovers* and *learning-by-doing* respectively.[4] This higher local population and employment arise out of the resource boom that increases the revenue productivity of the booming sector. This generates higher local wages in this sector. Higher local wages induce a local version of the original *resource movement effect* by raising the cost of labor for firms in other sectors. Simultaneously, higher local wages also increase the demand for non-tradable goods and their price. A type of *spending effect* that might imply no relative local real wage gains arising from the resource boom.

The central argument in Allcott and Keniston (2018) proposes that these congestion effects of the resource boom causes a loss of externalities in the form of foregone *agglomeration economies* or/and *learning-by-doing*. This induces long-term productivity losses that might become evident during a bust period.[5] Nevertheless, there is no strong evidence in favor of "local" *Dutch disease*.[6] Empirically, this effect is complex to study because it requires the identification of between-sector spillover effects generated by the resource sector that follows the chain of events inducing the decline in the productivity of the local tradable or manufacturing sector—the local *resource movement* and *spending effects*. Scholars usually justify the positive effect of a resource boom in other sectors and the overall economy by arguing that productivity spillovers from backward linkages of the resource sector are a strong force offsetting the productivity decline induced by a crowding-out effect over other tradable industries.[7] In fact, based on this argument, a significant number of resources are allocated toward policies that

[4]Although Allcott and Keniston (2018) define the concepts modeled as *agglomeration effects* and *learning-by-doing*, these effects are equivalent to persistent *urbanization* and *localization economies* or simply between- and within- sector productivity spillovers. Previous studies incorporating *learning-by-doing* in *Dutch disease* models include van Wijnbergen (1984); Krugman (1987); Torvik (2001); Bjørnland and Thorsrud (2015).

[5]This connects with the idea of unsustainable development induced by the resource sector mentioned in Corden and Neary (1982), referring to the between-country version of the *Dutch disease*. Here, the concept of sustainable development refers to the contemporaneous growth induced by the resource sector that is consistent with long-term economic development (Corden and Neary, 1982). Here, the *Dutch disease* is generated only when the shrink in the tradable—manufacturing—sector induces a loss in productivity and negatively impacts economic growth. Without such productivity losses, the de-industrialization is merely a consequence of specialization induced by the increase in factor endowments on natural resources (Rybczynski, 1955). This might happen due to newly discovered natural resources or a more general increase in the revenue productivity of the sector. However, by itself, this effect does not generate a long-term decline in economic growth.

[6]Apart from the evidence provided in Allcott and Keniston (2018), which is based on the oil and gas sectors in the US, Aragon and Rud (2013) explore similar mechanisms for the impacts of the discovery of the Yanachocha Peruvian mine, the second largest gold mine in the world. Both of these studies fail to identify a loss of productivity spillovers caused by crowding-out effects.

[7]This argument is considered more as an implicit mechanism not usually tested within the literature but used to justify the evidence of positive productivity spillovers and positive effects of the resource sector in the local economy.

foster the creation of these linkages between firms in the resource sector and local suppliers.[8]

Productivity spillovers from backward productive linkages are a key feature in understanding the impacts of the booming sector. This is because they denote the existence of external economies of scale that eventually lead to more agglomeration and long-term local economic development. The importance of this channel, however, depends on the extent to which firms in the resource sector pass cost reductions to upstream suppliers. This necessarily implies that these suppliers operate in imperfect competitive markets that involve the existence of these external economies, and that there is a minimum scale within those firms in the supply chain of extractive industries. Nevertheless, such mechanisms escape the formalization of the *Dutch disease* from the spatial equilibrium view of the local economic impacts of resource booms of Allcott and Keniston (2018), in which there are no external economies generated by the resource sector through productive linkages with local firms, and from most of the empirical literature on the topic as well.[9]

More importantly, the current rationale underestimates the fact that the effectiveness of productive linkages is highly mediated by MNCs (Rodríguez-Clare, 1996a; Antràs and Helpman, 2008), which is a dominant feature of the resource sector.[10] The evidence on the role that MNCs' productive linkages play in fostering the productivity of domestic firms in the host country is mixed (Aitken and Harrison, 1999; Javorcik, 2004; Haskel et al., 2007; Keller and Yeaple, 2009; Alfaro and Chen, 2018; Alfaro-Ureña et al., 2019, 2021). Most recent compelling evidence supports the notion of positive productivity spillovers from MNCs to domestic firms via productive linkages (Alfaro-Ureña et al., 2019). However, in theory, a higher number of MNCs in the local economy in comparison to domestic firms might also lead to productivity losses in the host country in the form of foregone economies of scale, as a type of *leakage effect*.[11] These losses happen when the share of domestically purchased intermediates inputs by MNCs per unit of labor is lower than that of domestic firms being displaced by MNCs (Rodríguez-Clare, 1996a).[12] Which might amplify the foregone *agglomeration economies* and

[8]See for example: Battat et al. (1996); Altenburg and Meyer-Stamer (1999); Javorcik (2004); Alfaro-Ureña et al. (2019). For a critical analysis of these policies specific to the resource sector, see Ramos (1998); Perez (2010); Korinek (2020); Bravo-Ortega and Muñoz (2021).

[9]More recently, Faber and Gaubert (2019) have proposed a framework that, although conceptualized for the tourism sector, is more ad-hoc for analyzing the local and aggregate economic impacts of the resource sector. This static spatial quantitative trade model is particularly useful to understand the formation of productivity spillovers from local productive linkages that emerge from scale economies at the firm level.

[10]However, MNCs in the resource sector have been a source of major concern in the literature on resource economics and economic geography (Arias et al., 2014), especially given the historical role of MNCs in Latin America (Méndez-Chacón and Van Patten, 2022).

[11]This argument is more exploited in case studies on extractive industries to support the idea of an *enclave* generated by the resource sector (e.g., Arias et al., 2014; Atienza et al., 2021).

[12]This is because the number of locally offered varieties is a function of the share of domestically purchased

learning-by-doing from crowding-out effects of the booming sector.[13]

Moreover, if MNCs are incentivized to source inputs from abroad because the size of the local economy is providing insufficient increasing returns to scale and diminishing the cost of specialized inputs, a type of *enclave* equilibrium might take place (Rodríguez-Clare, 1996a).[14] *Accordingly, a resource boom may not induce sufficient productivity spillovers, and a local economy may not be endowed with a sizable scale*.[15] However, these arguments neglect another important channel through which MNCs can be beneficial for the local economy. This is the fact that MNCs can cause higher productivity spillovers to the local economy than domestic firms, by accessing to a larger variety of cheaper inputs through international trade.[16] This argument goes on the opposite direction of the *enclave* hypothesis, and supports the notion of the creation of a *cluster* via local specialization, being consistent with the increasingly convincing evidence in favour of the linkage approach (Alfaro-Ureña et al., 2019). In particular, the access to a large variety of foreign inputs might lead to pro-competitive effects, inducing an increase in the quality of domestic intermediate goods, and productivity spillovers in the form of *learning-by-importing*.[17]

When looking at features of the real world of emerging mineral economies, one can see that these economies are characterized by *enclave* features such as high levels of foreign direct in-

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inputs per unit of labor. Further, if MNCs have a lower demand for local inputs than the domestic firms displaced by them (Javorcik and Spatareanu, 2008), then the number of varieties and subsequent linkages would be a decreasing function of the number of MNCs. Moreover, the empirical evidence of large-scale mining MNCs indicates that they source an important amount of their inputs from abroad.

[13]This is because the local "resource movement" effect might be negligible in comparison to the type of local "spending effect" (Corden and Neary, 1982; Allcott and Keniston, 2018). However, this direct "resource movement" effect becomes more relevant once we include the productive linkage channel, even if those linkages are not entirely done domestically.

[14]The enclave hypothesis has a long tradition among Latin American economics and formally suggests a scenario in which the extractive sector induces negligible impacts in the local economy at the same time that large rents of the sector are repatriated by MNCs (Prebisch, 1950; Singer, 1950; Myrdal, 1957; Hirschman, 1958; Myint, 1958; Girvan and Girvan, 1970; Weisskoff and Wolff, 1977; Auty, 1993; Robinson and Conning, 2009). In particular, this negative view of MNCs was build over the bad reputation that these companies have in Latin America in the decades previous to the 1990's, however more recent research challenge that idea also (Méndez-Chacón and Van Patten, 2022). The literature on economic geography also discusses the distinction between a modern and traditional *enclave* (Arias et al., 2014).

[15]Moreover, considering that productivity spillovers to local supplier firms arise only when the lower average cost induced by the increase in the demand for intermediates is not directly internalized by firms in the resource sector. Furthermore, given that MNCs can access specialized inputs in other countries at a lower cost and, arguably, possess more bargaining power to negotiate contracts with local suppliers, they would more likely require a lower amount of intermediate goods domestically than domestic firms in the resource sector.

[16]There is a growing literature exploring this component, see for example: Broda and Weinstein (2006); MacGarvie (2006); Amiti and Konings (2007); Kasahara and Rodrigue (2008); Goldberg et al. (2010); Bøler et al. (2015); Kee (2015); De Loecker et al. (2016); Pierola et al. (2018); Oberfield (2018); Bisztray et al. (2018); Lu et al. (2022).

[17]Notwithstanding, in particular to the resource sector, there is an important amount of criticism to the linkage approach of MNCs. This criticism has been motivated by the long-term decline experienced in resource rich regions after the booming period (Auty, 1993), which challenges the relative importance of this effect.

vestments with weak local productive linkages, high participation of unskilled labor force, and a lack of knowledge spillovers in the local economy (Arias et al., 2014). Furthermore, the lack of amenities and agglomeration economies characterize places with large endowments of natural resources in remote locations. These attributes are usually reinforced by the presence of negative environmental externalities in the resource sector that reduce the localization incentives for workers and firms to locate in cities near extraction sites, as a type of dis-amenity effect. All these features hinder the development of within- and between-industries' increasing returns to scale that foster the formation of *agglomeration economies* or *learning-by-doing* and, consequently, forms of long-term local economic development based in the resource sector.

This study aims to integrate these theoretical mechanisms in a framework consistent with the different sets of empirical evidence attained from emerging mineral economies. Accordingly, I expand the theoretical model of local—within country—*Dutch disease* to consider how the potential of the booming sector to offset the negative effects of the resource boom by inducing within and cross-sectoral spillovers from productive linkages, both domestic and international, are limited —or reinforced— by how MNCs organize their production. Furthermore, by combining these frameworks, I test the heterogeneous effects between domestic firms and MNCs in the series of mechanisms related to the local *Dutch disease*. The specific role played by these firms in the formation of productivity spillovers through productive linkages is studied as a source to offset the long-term negative effects of the resource sector. Pertinently, the present framework also acknowledges the role of endogenous local amenities that mitigate or foster these effects and, consequently, determine the welfare and productivity effects of resource booms and busts, as a key mechanism highlighted by the literature in resource economics.

To provide compelling and rigorous empirical evidence on the set of mechanisms described previously, this study exploits heterogeneous spatio-temporal variation from mining activity between domestic firms and MNCs in Chile, an emerging economy concentrating several of the world largest copper mines, and with a thought-provoking role and history of MNCs in the mining industry. For this purpose, I combine population and economic censuses of manufacturing firms, households surveys, and satellite data. For the mining sector, I construct detailed data for each mining plant for almost two decades with information on production and ownership. The causal identification of the effects of mining activity on a wide range of local economic outcomes is performed by a novel instrumental variable introduced in this study. This variable uses plant-specific exogenous shocks resulting from the spatio-temporal variation in the concentration of heavy-metals found in mining sites. It also predicts the geology-driven profitability of each mine. This instrumental variable is constructed annually using a combination of different spectral indices computed using the non-visible range of satellite images relying on the remote sensing literature.

The contributions of this paper are various. First, this study complements the predictions in Allcott and Keniston (2018). In particular, I show that the linkage effect can offset the crowding-out induced by the resource sector.[18] Moreover, an increase over linked tradable inputs tends to prevail over the crowding-out induced through final tradable goods. This is consistent with the results found in Black et al. (2005), Michaels (2011), Aragon and Rud (2013), Bjørnland and Thorsrud (2015), James (2015), Allcott and Keniston (2018) and De Hass and Poelhekke (2019), by accounting for the productivity gains from linkage formation, and more general with a large literature on international trade documenting the gains from specialization. However, I also allow for the potential negative correlation between resource booms and local amenities, capturing features such as the negative environmental effects from living in close proximity to resource extraction sites. I show that this dis-amenity effect can prevail in the long-term, explaining the long-term population losses taking place in cities highly specialized in the resource sector. Usually, depicted in the literature as *"company towns"*.

Second, by providing a new set of empirical insights on the use of remote sensing data for causal identification in the context of understanding the local economic impacts of mining activity (especially large-scale mining), this study provides evidence on the role played by MNCs in the resource sector to induce long-term local economic development. This has been a longstanding policy discussion for many resource-rich emerging economies. Specifically, this study explores the heterogeneous generation of spillovers from productive linkages with the local economy and its potential long-term consequences within the local *Dutch disease* chain of events. Accordingly, this study demonstrates that, although the direct linkage effect of MNCs is lower than that of domestic firms due to offshoring, the empirical evidence suggests that slightly higher local relative productivity spillovers are induced by MNCs than domestic firms, via indirect channels such as *learning-by-importing* and pro-competitive effects of trade in intermediate inputs. This is consistent with similar empirical evidence in other contexts, such as Alfaro-Ureña et al. (2019, 2021) and Méndez-Chacón and Van Patten (2022). And provide key evidence against the hypothesis that MNCs foster a local *enclave* more relative to domestic firms in the resource sector.

[18] The theoretical framework and empirics only consider the domestic linkage channel, and shutdown the import channel, and therefore, the pro-competitive effects of trade on intermediate inputs. Therefore, the estimates can be considered as a lower bound of the true productivity gains of the resource boom through productive linkages.

Finally, across the wide range of local economic outcomes that have been explored, an important channel that displays robust large differences in magnitude between MNCs and domestic firms are amenity effects.[19] This is the fact that MNCs in the resource sector can affect the local economy by indirectly increasing the cost of living, captured through housing rents, via higher wages, as a response to dis-amenities generated by the resource sector. This partially explains the empirical evidence provided in this study, showing limited welfare gains for Chile from the resource boom and bust, which were caused by the resource sector induced by MNCs in relation to domestic firms as an equivalent to a local *spending effect*. It is also consistent with the empirical evidence that suggests a higher cost-of-living in mining compared to non-mining municipalities in the context of Chile (Iturra and Paredes, 2014). Similar evidence has been attained for Peru (Aragon and Rud, 2013), and more generally in Costa Rica (Alfaro-Ureña et al., 2022). These results suggest that a combination of policies promoting long-term local economic development in resource-rich emerging economies via investments in local amenities and the promotion of backward productive linkages should be emphasized to mitigate the potential welfare long-term losses from a resource bust.

The remainder of the paper is organized as follows. Section 2 describes the background, and Section 3 discusses the theoretical mechanisms. Subsequently, Section 4 details the data, and Section 5 presents the empirical strategy. Further, Section 6 shows the reduced form and causal evidence. Finally, Section 7 concludes the study by providing policy implications.

2 Background

In the resource sector, mining activity is especially relevant, particularly the extraction of hard minerals such as gold, silver, copper, and iron, among others. Hard minerals account for an important proportion of total global trade of minerals. They form a fundamental export base for many emerging economies and key inputs for the production of a large variety of intermediate inputs. The demand for these minerals is expected to rise with the increasing use of renewable energies and electric mobility.[20] The vast production of hard minerals is dominated by large-scale mining, which currently accounts for more than 80% of the global transactions related to hard minerals. Mining operations are largely concentrated in Latin American and Sub-Saharan Africa and are usually owned by large international MNCs, such

[19] This is consistent with recent evidence in other contexts (Méndez-Chacón and Van Patten, 2022).

[20] Copper is particularly important for the green energy transition, and likely to become a critical mineral (Hendrix, 2023). The amount of minerals extracted in the last two decades is estimated to be higher than all previously extracted in history. For some of these minerals, the demand is expected to double in the next 20 years. Chile is expected to receive investments worth a total of 75 billion US$ by 2028. Demand for these commodities tends to be volatile in the short-term but relatively stable in the medium- and long-terms.

as Rio Tinto (UK), Freeport (USA), Barrick Gold (Canada), Glencore (Switzerland), Xstrata (Switzerland), and BHP (Australia).

Several Latin American economies rely on mineral commodities, in which large-scale mining concentrates an important percentage of total mineral exports, especially surface mining or open-pit mines that contribute to approximately 90% of total global mineral output. Chile comprises seven of the 20 largest open–pit mines in the world and is the main extractor of copper. Since its return to democracy in 1990, Chile has experienced large inflows of foreign direct investments.[21] A considerable amount of these inflows has been dedicated to the mining sector where Chile is one of the most attractive emerging mineral economies to invest (Humphreys, 2014). Where 10 of the 20 world largest companies by market capitalization have investments in the country, including the most important operation of BHP, and Rio Tinto. As shown in Figure 1, in less than 10 years, the production in this sector changed from being predominantly dominated by domestic (mostly state-owned) firms to being largely owned by foreign MNCs.[22] Nowadays, MNC-based production comprises approximately 75% of the total production in Chile, with the mining sector representing 26% of total FDI, 55% of total exports, and 10% of GDP.

The large-scale mining sector has a complex and long-term oriented production structure.[23] The life-cycle of a mine is composed of the following four stages: (1) projection and exploration, (2) development, (3) extraction, and (4) closure. Usually, most local investments in the mining sector are received in the first two phases and given that this sector is capital-intensive, most of the labor is hired during the development phase of the mining project.[24] The opening of a large-scale-mining plant is usually a long process that takes several years. Even when the mine is ready for operation, it can take a few more years to remove the waste material before high concentrations of minerals are extracted. In fact, the closure of a large mine can take up to 10 years to minimize the potential environmental damage. Along these lines there is evidence of heterogeneous behaviour on the compliance to environmental regulations in favour

[21]This is different from the documented productivity spillovers in the manufacturing sector during military dictatorship (Pavcnik, 2002) and coincides with a global trend in privatization of the mining sector during the 1990s (Humphreys, 2015). Many foreign countries likely did not invest in Chile until the end of its dictatorship. This is more likely the case of the mining sector.

[22]Interestingly, Chile experienced nationalization of the Copper industry between 1960 and 1973, which was not reverted during the military dictatorship. This was induced by the large rents of the industry and reluctance of foreign investors to invest during the years of the dictatorship.

[23]The long-term nature of large-scale mining projects difficult the study of their impacts in the local economy using a event-study strategy without a long-term span dataset encompassing the initial exploratory stages of each mining project.

[24]This makes the direct effects in employment negligible in comparison to its indirect effects (Corden and Neary, 1982).

to MNCs.[25] Additionally, to avoid fluctuations in mineral prices, large-scale mining companies can negotiate several decades of future production in forward contracts in which MNCs have more bargaining power. In some cases, these contracts can be traded in stock markets, which can also affect mineral prices.[26] All these conditions might affect the price-elasticity of mineral production and, consequently, its contemporaneous economic impacts.[27]

Finally, the 2000's commodity prices super cycle induced an increase of investments in the mining sector, as a supply response of mining companies to the demand shock from Asian economies. This led to an increase in purchases within- and between the resource sector and other sectors in the economy. However, as Figure 2 shows, during this time mining companies also experienced an increase in offshoring, which implies that an important proportion of these domestic purchases were not spent locally. Moreover, the geography of mining-related activities present a spatial sorting (see Figure 1, Panel b, for the geography of cities and large-scale-mining in Chile). While extractive activities are mainly localized in small and medium-sized cities, higher-order urban centers house more knowledge-intensive activities, as seen in Chile (Arias et al., 2014; Atienza et al., 2021). These elements may limit and determine the nature of agglomeration economies across the urban system because cities in close proximity to mines have not reached a minimum level of development to capture the growth effects of foreign direct investment (Phelps, 2008). In fact, it is estimated that more than 90% of purchases from the mining sector were made to suppliers located in the capital region and not in the regions in which those mines are located, and approximately less than 6% of the increase in domestic purchases was spent locally (Atienza et al., 2021). These low incentives for local investment are reinforced by the lack of local productive advantages in mineral zones, as the *enclave* hypothesis suggest (Arias et al., 2014; Phelps et al., 2015).

3 Theory

The model is built directly over the within-country version of the *Dutch disease*, in which the contemporary productivity of each sector in each city is a function of past *agglomeration effects*

[25]MNCs tends to have higher standards of environmental quality in their operations in the host country in comparison to domestic firms, in order to comply to international regulations in the parent country.

[26]For example, forward contracts of one of the subsidiaries of the largest state-owned copper producer CODELCO, signed between 2005 and 2007, are estimated to have cost approximately MMUS$ 4.66 in future revenues to the company.

[27]The correlation between prices and production is not strong due that large-scale mining projects are long-term oriented investments that can take several years from the stages of exploration to production, even when a mine is operating can have limited production in the early phases. However, small-scale and artisanal mining tends to be much more cyclical with price booms, especially in the production of precious metals, such as gold and silver.

and *learning-by-doing*. This is done by comparing three static equilibrium points that describe a pre- and post-booming economy in which the resource boom might undermine the formation of these *agglomeration effects* or *learning-by-doing* due to local *Dutch disease*.[28] The model setting adapts this framework to include an intermediate sector, endogenous amenities, and MNCs.[29] By modeling an intermediate sector, I explicitly incorporate the formation of backward productive linkages generated by the resource sector and its productivity spillovers through this channel. Additionally, by allowing for the heterogeneous effects of domestic firms and MNCs in the formation of these productive linkages, I capture the heterogeneity in how MNCs and domestic firms foster local *agglomeration externalities* or *learning-by-doing*, both due to domestic purchases and due to the import of intermediate inputs.[30] Finally, endogenous amenities play an important role capturing the negative externalities of the resource sector, which all together ultimately translates into heterogeneous effects in productivity and social welfare.

3.1 Model Environment

The environment comprises a small open economy with two cities, indexed by $c \in \{a, b\}$. Time is discrete and composed of three periods denoted by $t \in \{0, 1, 2\}$. Each city c is endowed with L_c amounts of labor. There are three final goods sectors $j \in \{m, l, r\}$, where m denotes tradable goods, l local non-tradable goods, and r the booming sector. There is an intermediate goods sector z that supplies the three final goods sectors. Additionally, there is a housing sector h with absentee landlords, which does not require labor, and its inverse supply is given by

$$r_c = H_0 L_c^h, \tag{1}$$

where r_c is the rent of housing in city c, H_0 is a specific supply component common to both cities, and h is the elasticity of housing supply. Labor is assumed to be imperfectly mobile

[28]The sustainability of the local economy is a concern considering the long-run equilibrium of the economy instead of the dynamics required to reach a steady state.

[29]This is because the introduction of MNCs in the resource sector implies modeling the production of intermediate goods in the economy, as explored in Rodríguez-Clare (1996a). Besides, this study follows the notation of Allcott and Keniston (2018) as much as possible.

[30]Rodríguez-Clare (1996b) describe the conditions for an *enclave* formation at the country level, although enclaves are local by nature. Rodríguez-Clare (1996a) further show that, generally, the extent of the market is characterized by the production of a wide variety of intermediate goods and primarily explains the persistence of underdevelopment. It also induces an under-develop trap. Nevertheless, recent evidence points toward a modern *enclave* (Arias et al., 2014). Note that this model does not determine whether a firm can become multinational, which has been extensively studied in the literature (e.g., Grossman and Helpman, 2002; Antràs, 2003; Antràs and Helpman, 2004; Grossman and Helpman, 2005; Helpman, 2006; Grossman and Rossi-Hansberg, 2008; Antràs, 2016). Nonetheless, it examines the implications for local economic development, given the amount inputs offshored by MNCs.

across cities but perfectly mobile amid sectors within cities.

3.1.1 Production

Each sector producing final goods $j \in \{m, l, r\}$ is composed by a representative firm that can be a domestic firm or a MNC, denoted by $k = \{DOM, MNC\}$. These firms use a nested production structure, which at the upper level employ K^k_{jc} capital, L^k_{jc} workers, and use a combination of $M^{k,z}_{ijc}$ intermediate inputs from $i \in \{m, l, r\}$ sectors that can be sourced domestically or imported $z = \{DOM, IMP\}$, to produce Q^k_{jc} amounts of a final good, using Cobb-Douglas technology

$$Q^k_{jc} = v_{jk} A^k_{jc} (K^k_{jc})^{\delta_{jk}} (L^k_{jc})^{\vartheta_{jk}-\delta_{jk}} \prod^{i} (M^{k,z}_{ijc})^{\rho_{ijkz}} \tag{2}$$

with $\delta_k, \vartheta_{jk}, \rho_{ijk} \in (0,1)$ and $1 - \vartheta_{jk} = \sum_i \rho_{ijk}$.[31] At the bottom level, these intermediate inputs are derived from a continuum set of differentiated intermediate goods produced according to the following CES specification,

$$M^{k,z}_{ijc} = z^{k,z}_{ijc}(\omega) \left(\int_0^{\omega^{k,z}_{ijc}} m_{ijc}(\omega)^{\alpha} d\omega \right)^{\frac{1}{\alpha}}, \tag{3}$$

where the number of varieties is normalized between 0 and 1, $0 < n^{k,z}_{ijc} < 1$, and $0 < \alpha < 1$, implying that intermediate varieties n_{ijc} are imperfect substitutes within each pair sector ij.[32] $z^{k,z}_{ijc}(\omega)$ is a productivity shifter which is specific to a sector j located in city c sourcing inputs from sector i by type-of-firm k, either domestically or by importing. Additionally, note that,

[31] Assuming imperfect substitution between domestic and imported inputs will imply using a second level CES structure instead, as in Broda and Weinstein (2006), that would require to identify these different elasticities of substitution in the data. The selection of a Cobb-Douglas second-tier allows to establish in a simple way the productivity spillovers derived from the gains in domestic and foreign varieties that can be easily taken to the data. In addition, this structure also maps directly to other work on the boundaries of MNCs (Nunn and Trefler, 2013). An alternative simplified version of this model can consider offshoring, lets say λ^k_{jc} as a type of labor-augmenting shock as in Alfaro and Rodríguez-Clare (2004). In such a case, the variety effect from intermediate inputs —or equivalently the extent of the market of intermediates— is limited by the propensity of firms to offshore $1 - \lambda^k_{jc}$. However, such framework will not capture properly productivity spillovers from importing.

[32] It is important to note, however, that within each type of these inputs, the substitution parameter α does not vary by $k \in \{DOM, MNC\}$, in other words, within the use either domestic, or intermediate inputs, domestic and MNCs are assumed to have the same elasticity of substitution. Notwithstanding, given that in the upper Cobb-Douglas tiers ρ_k and δ_k vary among domestic firms and MNCs, they differ in the intensity in which they use domestic or foreign inputs ρ_k, as well as the intensity in which they use labor or intermediate inputs δ_k.

as standard in models with production networks, cost minimization implies

$$a_{ijkz} = \frac{p^{k,z}_{ijc}}{p^{z}_{jc}} \frac{M^{k,z}_{ijc}}{M^{k,z}_{jc}}, \qquad \mathbf{A^{kz}} = \begin{bmatrix} a^{kz}_{11} & a^{kz}_{12} & \cdots \\ \vdots & \ddots & \\ a^{kz}_{nn} & & a^{kz}_{nn} \end{bmatrix} \tag{4}$$

where $a_{ijkz} \equiv \rho_{ijkz} / \sum_i \rho_{ijkz}$, and the *Leontief inverse matrix* can be defined as $\mathbf{H} = (\mathbf{1} - \mathbf{A})^{-\mathbf{1}}$.

Each firm in the intermediate goods sector produces one variety with $1/z_i$ units of labor, to produce $m_{ijc}(\omega)$ units of a variety, with a fixed cost $\varphi_{ijk} \geq 1$. There is monopolistic competition in the production of intermediate goods and free entry and exit of firms, with mark-up pricing $p^k_{ijc} = w^k_{ijc}/\alpha$. Consequently, the scale of firms selling intermediate goods is $l^k_{ijc} = \varphi_{ijk}\left(\frac{\alpha}{1-\alpha}\right)\frac{1}{w^k_{ijc}} = \varphi_{ijk}\theta\frac{1}{w^k_{ijc}}$, where $\theta \equiv \left(\frac{\alpha}{1-\alpha}\right)$ is the elasticity of substitution of input varieties. Firms in final good sectors use symmetric quantities of intermediate inputs, which implies that $\left(\int_0^{n^{k,z}_{ijc}} m_{ijc}(\omega)^\alpha d\omega\right)^{\frac{1}{\alpha}} = (N^{k,z}_{ijc})^{\frac{1}{\alpha}-1} N^{k,z}_{ijc} m^{k,z}_{ijc}$, which for the case of domestic inputs $m = D$, given the assumption that each variety is produced with one unit of labor, we can use the fact that $L^k_{zjc} = N^{k,D}_{jc} z^{k,D}_{jc}$, while for foreign inputs $m = M$, we can conveniently not make this assumption in order to keep the volume of intermediate imports in the problem as $M^k_{zjc} = N^{k,M}_{jc} z^{k,M}_{jc}$. Due to these assumptions, the Cobb-Douglas production function of final-good producers can be formulated in the following form.$\vartheta_k \equiv \delta_k + \rho_k(1-\delta_k)$, $\vartheta_k \in (0,1)$, $\vartheta_k > \delta_k$, an externality from upstream linkages as

$$\Omega^{k,z}_{jc} \equiv \prod^{i} [\zeta^{k,z}_{ijc}(\omega)]^{\rho_{ijk}} (N^{k,z}_{ijc})^{\eta_{jck}} \tag{5}$$

and $\eta_{ijk} \equiv \frac{\rho_{ijk}}{\theta}$ is the *love-for-variety* of inputs effect, which states that an expansion in the number of either domestic or imported varieties, $N^{k,z}_{jc}$, will induce a more than proportional increase in the productivity of firms in the final good sector j and city c.

3.1.2 Multinationals

Following a wide literature on the behaviour of MNCs, the production of final-good producing MNCs and domestic firms will differ in the input elasticities and total quantity of inputs demanded. This would induce differences in the size and intensity of the backward productive linkages generated by them. Formally, the following assumptions are established: MNCs use more intensively intermediate goods than labor ($\delta_{MNC} < \delta_{DOM}$), and MNCs offshore a larger proportion of intermediate inputs ($\rho_{MNC} < \rho_{DOM}$). Note that the first assumption establishes that MNCs rely more on intermediate goods, implying that they have a greater *love-for-inputs* effect $\eta_{MNC} > \eta_{DOM}$, have a lower unit cost, and pay higher wages than domestic firms.[33] These assumptions imply heterogeneous backward productive linkages between MNCs and domestic firms. In particular, these productive linkages in each city are given by

$$w_{jc}^{k} L_{jc}^{k} = (\vartheta_{jk} - \delta_{jk}) \sum_{i} (1/\rho_{ijk}) p_{ijc}^{k} M_{ijc}^{k}. \tag{6}$$

Note that the offshore parameter λ_{jc}^{k} and the labor input elasticity δ_k will drive the difference in productive linkages between MNCs and domestic firms. Precisely, it follows directly from $\lambda_{jc}^{MNC} > \lambda_{jc}^{DOM}$ that the size of backward productive linkages for MNCs is lower than that for domestic firms.[34] However, this is contrarrested by the fact that MNCs are more intensive in the use of intermediate inputs and, consequently, the linkage multiplier $\frac{1-\delta_k}{\delta_k}$ would be higher for MNCs than for domestic firms. Furthermore, given that MNCs have a greater *love-for-inputs* effect, the productivity spillovers from MNCs will be larger than those of domestic firms.[35] This may be because MNCs are more intensive in intermediate inputs, which is why they would induce a larger variety of intermediate firms in the domestic market and a proportionally higher output increase in final-good producers per unit of intermediate input used.[36] The level of MNCs in the local economy in each sector would be given by the relative costs between MNCs and domestic firms in the final good sector. More specifically, and anagolously to Rodríguez-Clare (1996a), this is described by

3.1.3 Agglomeration and Learning Externalities

The physical productivity A_{jc}^{k} of a representative firm $k = \{DOM, MNC\}$ in each final good sector j and each city c evolves over time with past labor in sector j and city c, total labor in city c, and a sector-specific idiosyncratic component ζ_j^k. According to the following law of motion,

$$A_{jct+1}^{k} = (A_{jct}^{k})^{\psi_j} (L_{jct}^{k})^{\phi_j} (L_{ct}^{k})^{\Lambda} \zeta_j^k. \tag{7}$$

Further, analogous to the idea of dynamic localization economies, the existence of *learning-by-doing* implies that $\phi_j > 0$, which indicates the sector's current productivity, increases with

[33] This assumption is also consistent with the fact that MNCs tend to be more capital-intensive than domestic firms (Alfaro and Rodríguez-Clare, 2004).

[34] Note that these conditions are slightly different from Rodríguez-Clare (1996a) and Alfaro and Rodríguez-Clare (2004). This is because, in this study, the equilibrium determination of the endogenous number of MNCs compared to domestic firms is not explored. Specifically, this implies that the unit cost function does not have a term to specify the relative differences between the prices charged by MNCs and domestic companies.

[35] Recall that $\delta_{MNC} < \delta_{DOM}$ implies $\eta_{MNC} > \eta_{DOM}$.

[36] The differences in productivity spillovers of MNC firms have been largely documented in empirical studies (e.g., Aitken and Harrison, 1999, Javorcik, 2004, and Alfaro-Ureña et al., 2019).

sector past employment. Agglomeration spillovers are more similar to the concept of urbanization economies, implying that $\Lambda > 0$—the sector's current productivity increases with past local population. In addition, Eqn. 7 also captures heterogeneity among MNCs and domestic firms in the persistence in the productivity of each sector, given by $\psi_j^k > 0$, and the idiosyncratic differences between sectors ζ_j^k.

3.1.4 Consumption

On the consumer side, each individual i in city c consumes C_i units of a local good l, a tradable good m, and H_i units of housing, at prices p_{lc}, p_{mc} and r_c respectively. p_{lc} is endogenous, p_m is set as the numeraire (exogenous), and r_c follows Eqn. 1. Additionally, consumers receive a utility $B_c\epsilon_{ic}$ for living in city c, with B_c level of amenities. ϵ_{ic} is the individual idiosyncratic taste for city c. Individuals have Cobb-Douglas preferences, maximizing $U_{ic} = C_{il}^{\gamma} C_{im}^{\varrho} H_i^{\varphi} B_c \epsilon_{ic}$ subject to a budget constraint $p_{lc}C_{il} + C_{im} + r_c H_i = w_c$, with γ, φ, and $\varrho \in (0,1)$, and $\gamma + \varphi + \varrho = 1$. Then, the indirect utility function yields

$$U_{ic} = \frac{w_c B_c \epsilon_{ic} \kappa}{p_{lc}^{\gamma} r_c^{\varphi}} \tag{8}$$

where $\kappa = \gamma^{\gamma}\varphi^{\varphi}\varrho^{\varrho}$. ϵ_{ic} is assumed distributed type I extreme value with scale parameter ξ^2 with $\xi \in (0, \infty)$. Individuals choose to live in a instead of b, if $U_{ia} > U_{ib}$. Therefore, under spatial equilibrium $U_{ic} = \overline{U}$, and the relative inverse labor supply is $L_a/L_b = \left(B_a w_a / p_{la}^{\gamma} r_a^{\varphi}\right)^{\xi} / \left(B_b w_b / p_{lb}^{\gamma} r_b^{\varphi}\right)^{\xi}$.

3.1.5 Equilibrium

Given the assumptions of differences in the intensity and use of intermediate inputs between MNCs and domestic firms, an equilibrium with either only domestic firms or only MNCs is the particular case in which $\lambda_{jc}^{MNC} = \lambda_{jc}^{DOM}$ and $\delta_{MNC} = \delta_{DOM}$. Consequently, for simplicity, here onward I omit the subscript k distinguishing both types of firms, to focus on the equilibrium relationships regarding the resource boom and bust.[37] Then, I will describe the comparative statics between an equilibrium dominated by MNCs and a scenario with a high presence of domestic firms by comparing how these relationships change for different values of the parameters λ and δ. For convenience, for the aggregate tradable sector n —denoting

[37] Due that the identification strategy relies on spatial variation, I will express the equilibrium conditions from the model in relative terms from city a —more exposed to the resource boom— and city b —less exposed—. On the other hand, Allcott and Keniston (2018) distinguish between relative and absolute effects from the resource boom and bust to refer to direct and general equilibrium effects that consider spatial spillovers between cities. This is not in the original Moretti (2010) model who only focuses on the relative effects to map to the econometric framework.

both the tradable manufacturing and resource sectors— the local —onshore— revenue productivity in each city is $X_{nc} \doteq \lambda_c^{\eta} \sum_{j=m,r} p_{jc} A_{jc}$.[38]

For the local good, the equilibrium price in the local non-tradable goods sector is obtained by equalizing the local demand, which is individual demand times number of workers in the city L_c, with local supply. Further, the fact that there is perfect mobility of workers between sectors within a city implies that $w_{jc} = w_c$. Hence, the relative equilibrium price for the local good is $\log \hat{p}_l = \delta \log \hat{w} + \log \hat{L} - \log \hat{X}_l$. The price in the resource sector p_{rc} is exogenously determined in international markets, while that in the tradable sector is defined as the unitary $p_{mc} = 1$. Thus, the equilibrium relative population is

$$\log \hat{L} = \rho\tau \Big(\log \hat{X}_n + (1+\eta) \log \hat{L}_n \Big) + \gamma\tau \log \hat{S} + \tau \log \hat{B} \tag{9}$$

where $\rho \equiv 1 - \gamma$ and $\tau \equiv \frac{1}{1+\varphi h+\xi}$. Eqn. 33 is known as the migration equation and is important to notice that in terms of the impact of the booming sector, migration would be higher if $\rho\tau$ is larger—if the production is more labor-intensive—or equivalently if δ is smaller. Additionally, if housing supply is more elastic—h is smaller—or the housing expenditure share φ is lower, the location preferences of the individual are weak—ξ is smaller. By substituting this population difference in the relative inverse labor demand, we get the equilibrium relative wage difference,

$$\log \hat{w} = (1-\rho\tau) \Big(\log \hat{X}_n + (1+\eta) \log \hat{L}_n \Big) - \gamma\tau \log \hat{S} - \tau \log \hat{B} \tag{10}$$

which shows that an increase in the productivity of the tradable or resource sector would induce higher nominal wages. Simultaneously, higher consumption amenities or an increase in overall productivity would imply a lower nominal wage. This is because, under the spatial equilibrium framework, workers are willing to accept lower nominal wages in exchange for a higher level of amenities. Further, for housing market equilibrium, taken Eqn. 1, the relative housing supply is a function of the relative population between the two cities given by $\log \hat{r} = h \log \hat{L}$, which implies that in equilibrium housing rents are determined by

$$\log \hat{r} = \rho\tau h \Big(\log \hat{X}_n + (1+\eta) \log \hat{L}_n \Big) + \gamma\tau h \log \hat{S} + \tau h \log \hat{B}. \tag{11}$$

[38]Given the assumption that $\lambda_{jc}^{MNC} > \lambda_{jc}^{DOM}$, MNCs will shift-abroad a larger proportion of their revenue productivity. This offshoring effect is intensified by the fact that MNCs rely more on intermediate inputs, implying $\eta_{MNC} > \eta_{DOM}$. This is consistent with a growing literature on the profit-shifting behaviour of MNCs (e.g., Dowd et al., 2017 and Tørsløv et al., 2022).

Eq. 32, analogous to Allcott and Keniston (2018), shows that a resource boom would increase wages and that relative equilibrium wages are defined by the relative size and total revenue productivity of the final good sector. However, relative equilibrium wages are mitigated by the revenue productivity of the non-tradable sector and relative amenities. Therefore, if the resource sector (or equivalently the tradable sector) is not inducing a crowding-out effect in the non-tradable sector or increasing the demand for intermediate goods, then it would induce a decrease in nominal wages. A major implication of this is that the productivity increments in the tradable sector can offset this negative effect of movement of labor, while productivity increments in the resource sector cannot offset this effect. Notwithstanding, both of these effects are mediated by the level of local amenities and migration.

3.1.6 Social Welfare

The cumulative indirect utility of people who live in city c across all periods is $\log U_c = \sum_t \log U_{ct} = \sum_t \zeta^t \left(\log w_{ct} - \gamma \log p_{Ict} - \varphi \log r_{ct} + \log B_{ct}\right)$, where ζ is a discount factor. The underlying assumption is that the social planner only focuses on permanent residents, as in Allcott and Keniston (2018). This is because eliminates the need to keep track of migrants' idiosyncratic taste shocks ε_{ic}, implying that the social welfare is computed over infra-marginal individuals, as represented in Fig. 3 (see Kline and Moretti, 2014 for a further discussion). Additionally, producer surplus is ignored assumed that firms are owned by absentee shareholders. Therefore, the relative cumulative social welfare effect between the two cities can be rewritten as a function of the relative population

$$\log \hat{U} = \sum_t \zeta^t \xi \log \hat{L}_t. \tag{12}$$

Which establishes a direct mapping between relative population and welfare under the standard assumption that people vote with their feet. Replacing the relative population from Eqn. 33 yields the effect of the resource sector on social welfare.

3.2 Predictions

3.2.1 Multinationals, Linkages, and Leakages

Before establishing the contemporaneous and long-term effects of the resource boom, I will represent the characterization of the conditions that lead to industrial agglomeration due to the formation of productive linkages with the local economy, or the opposite idea of *enclave*, as characterized by a type of *leakage effect*, this is the foregone economies of scale in the form of *learning-by-doing* and/or *agglomeration effects* due to offshoring. It is important to note, however, that the existence of a *leakage effect* implies that these foregone productivity spillovers from the resource boom cannot be offset by the productivity spillovers derived from trade in intermediate inputs, such as *learning-by-importing*. Note that the labor market clearing condition implies that when the economy is dominated by MNCs, then $\sum_j L_{jc}^{MNC} = L_c - L_{zc}$. Then, taking this to Eqn. 53, we have $\frac{w_{jc}}{P_{zjc}} = \left(\frac{1}{\delta_k}\right)\left(\frac{\vartheta_k}{1-\vartheta_k}\right)$, and substitute in Eqn 54. An equilibrium with only MNCs therefore implies that the relative marginal costs of MNCs in relation to domestic firms is:

$$\rho_{jc}(L_c, n) = \gamma_k^{\vartheta_{MNC}-\vartheta_{DOM}} n_{jc}^{\rho_{MNC}\eta_{MNC}-\rho_{DOM}\eta_{DOM}} \left(\frac{L_{jc}-n_{jc}}{M_{jc}}\right)^{\vartheta_{MNC}-\vartheta_{DOM}} \tag{13}$$

where $\gamma \equiv (\delta_{MNC}(1-\vartheta_{MNC})\vartheta_{DOM} + \delta_{DOM}(1-\vartheta_{DOM})\vartheta_{MNC}) / \vartheta_{MNC}\vartheta_{DOM}$, and implies that $\rho_{DOM}(L_c, n) > \rho_{MNC}(L_c, n)$. I.e., for a same level of endowments, the relative costs of final goods (MNCs in relation to domestic firms) is lower when there is complete specialization in MNCs. More importantly, assuming L_c fixed, then $\rho_{DOM}(n) > \rho_{MNC}(n)$. Then, ρ is increasing in n from the point in which there is complete specialization in MNCs, and other in which ρ reach a maximum, when there is complete specialization in domestic firms.

This happens because on the one hand, the neoclassical effect is related to labor scarcity, as the increase in the production of intermediate varieties will induce a decrease in the amount of labor available for the production of final goods. Or in other words, this is a crowding-out effect from intermediate to final good sectors. Inducing a relative decrease in the cost of final good firms that use the intermediate input more intensively, i.e. a decrease in ρ. While the love for variety effect, on the other hand, implies a decrease in the costs of production for both firms, MNCs and DOM. However, because MNCs use intermediate inputs more intensively, they will experience a larger decrease in costs that domestic firms, given that they have a larger love for variety effect. ρ is the key determining the share of MNCs in each local labor market. And given that parameters do not vary by location but by type of firm. Substituting the share of imports together with the labor market clearing condition, and taking in to consideration the zero profit condition in the intermediate sector, we can express the share of imports in total labor per each firm k, in sector j in city c, as

$$\frac{M_{jc}}{L_{jc}} = \sum_k (1-n_{jc}^k)\delta_k \left(\frac{1}{\varphi_k}\right)\left(\frac{1-\vartheta_k}{\vartheta_k}\right) \tag{14}$$

Which establishes that the share of imports is a decreasing function of the number of intermediate local varieties. The share is going to approach to 0 as the number of local intermediate varieties approach to 1, i.e., the upper bound of the set of input varieties. While is going to approach to 1 otherwise. Given that MNCs are more intensive in foreign inputs that domestic firms, they will also import a larger amount of inputs in relation to final good labor.[39]

3.2.2 The Resource Boom and Bust

Following Allcott and Keniston (2018), the predictions of a resource boom and bust are derived from a comparison of three static equilibrium points in which the resource boom is modeled as an exogenous shock to revenue productivity of the resource sector in one of the periods and cities each. The boom increases revenue productivity through an exogenous increase in prices P_{rc} (e.g., an increase in world demand) or due to an exogenous increase in physical productivity A_{rc} (e.g., a new discovery of natural resources). The two cities start at an initial symmetric equilibrium in $t = 0$ with no natural resources—$X_{ra,t=0} = X_{rb,t=0} = 0$. Further, in $t = 1$, city a experiences a resource boom as a shock that exogenously affects the revenue productivity in the resource sector—$X_{ra,t=1} > 0$. However, city b does not have natural resources, and therefore, $X_{rb,t=1} = 0$ in every period. The resource boom ends in $t = 2$, and cities go back to the initial symmetric equilibrium, $X_{ra,t=2} = X_{rb,t=2} = 0$, as displayed in the following timeline.

$t = 0$	$t = 1$	$t = 2$
$X_{ra} = X_{rb} = 0$	$X_{ra} > 0$ and $X_{rb} = 0$	$X_{ra} = X_{rb} = 0$

3.2.3 Effects on Population/Employment, Wages, and Rents

The first prediction is related to the contemporaneous relative effects on cities. In $t = 1$, assuming $X_{jat} = X_{jbt}$ for $j \in \{l, m\}$, and $B_{at} = B_{bt}$, the resource boom implies $X_{rat} - X_{rbt} > 0$. Thus, the relative effects of population and wages are partially obtained by differentiating Eqn. 33 with respect to $\hat{X}_r$, and equivalently for Eqn. 32 and 11, which yield

$$\frac{\partial \hat{L}_{t=1}}{\partial \hat{X}_{n,t=1}} = \rho\tau > 0 \qquad \frac{\partial \hat{w}_{t=1}}{\partial \hat{X}_{n,t=1}} = (1 - \rho\tau) > 0 \qquad \frac{\partial \hat{r}_{t=1}}{\partial \hat{X}_{n,t=1}} = \rho\tau h > 0,$$

where $\tau \equiv \frac{1}{1+\varphi h+\xi}$. The resource boom increases the demand for labor in the local goods (non-tradable) sector at the same rate as population $\rho\tau$. The effect on the rents (and more generally on the price of non-tradables) is analogous to the spending effect given in Corden and Neary (1982), which states, as in Allcott and Keniston (2018), that the price of non-tradables rises faster than the increase in wages.

[39] We can also rewrite this equation to identify the equilibrium number of local input varieties, as $n^k_{jc} = L_{jc} - M_{jc} \sum_k \left(\frac{\varphi_k}{\delta_k}\right)\left(\frac{\vartheta_k}{1-\vartheta_k}\right)$.

3.2.4 Effects on the Size and Productivity of the Manufacturing Sector

In the case of the tradable sector m, analogous to the resource movement effect from Corden and Neary (1982) and Allcott and Keniston (2018), a resource boom would crowd-out employment in the tradable sector. However, this crowding-out effect is mitigated by the productive linkages. More precisely, the relative effect of the resource boom on the size and productivity of the tradable —manufacturing— sector is given by

$$\frac{\partial \hat{L}_{mt}}{\partial \hat{X}_{nt}} = -\frac{1}{(1+\eta)} \qquad\qquad \frac{\partial \hat{A}_{m,t+1}}{\partial \hat{X}_{nt}} = \rho\tau\Lambda - \frac{\phi_m}{(1+\eta)}.$$

Contrary to Allcott and Keniston (2018), these derivatives show that the negative total effect of the resource sector on the local tradable sector (manufacturing employment) is mitigated by the positive indirect effect of the resource boom caused by the creation of productive linkages in upstream industries, captured in the parameter η. Therefore, the total crowding-out effect, although is always negative, can be considerably small. As it approaches to zero with the increasing number of varieties, as larger the *love-for-inputs effect*, smaller the crowding-out induced by the resource boom. This has important implications regarding the potential of the resource sector to induce local economic development via linkage creation, as increased offshoring directly decreases this potential to mitigate the crowding-out of other industries. This provides a reasonable argument against one of the key mechanisms of the *Dutch disease* and provides a plausible explanation to explain the lack of a crowding-out effect of the resource boom in the manufacturing sector, as in Allcott and Keniston (2018) for the US oil and gas sector and Aragon and Rud (2013) for the Peruvian gold mining industry, among others.

The resource boom increases the productivity of the local good sector in $t+1$ due to the accumulation of sectoral and aggregate labor in the previous period t—*learning-by-doing* and *agglomeration effects*. The effect of the resource boom in the productivity of the non-tradable sector is always positive and more than proportional to the effect experienced by this sector in the previous period, which has been reinforced through agglomeration Λ and *learning-by-doing* ϕ_m. This effect can be magnified if the resource boom also increases the demand for intermediate goods, as this would rise the number of varieties. δ plays a key role in magnifying the *learning-by-doing* effect. Thus, considering the assumption that domestic firms rely more on labor than MNCs—$\delta_{DOM} > \delta_{MNC}$, this implies that this magnification effect would be higher for domestic firms than for MNCs. Taking these results together we can establish the following proposition,

Proposition 1. Predictions from the resource boom and bust. *Consider a resource boom and bust as an exogenous increase and subsequent decrease in the revenue productivity of the resource sector in a given location X_{ra}, due to a price shock P_{ra} or/and a resource discovery A_{ra}. When the productivity gains from local input variety are sufficiently large, i.e. $\eta \rightarrow \infty$. Then, demand linkages from the resource sector to upstream suppliers:*

1.1 *Cause an specialization in the intermediate sector in the booming city, due to the neoclassical effect $L_c - \sum_k \sum_j L_{jc}^{k,DOM}$ that is reinforced by weak agglomeration forces, which*

1.2 *Offset the crowding-out effects induced by the resource boom on local —manufacturing— tradable employment during the booming period $\frac{\partial \hat{L}_{m,t}}{\partial \hat{X}_{r,t}} \rightarrow 0$, and*

1.3 *Mitigate subsequent productivity losses due to foregone learning-by-doing during the bust period. In which case the productivity gains from spillovers from the resource boom to manufacturing firms approximate to a weighted agglomeration elasticity $\frac{\partial \hat{A}_{m,t+1}}{\partial \hat{X}_{r,t}} \rightarrow \rho \tau \Lambda$.*

This proposition establishes "the condition for local *Dutch disease*". To the extent that sectoral externalities of the manufacturing firms in the form of localization economies are too large in relation to overall agglomeration effects $\frac{\phi_m}{\Lambda}$, then the condition is more likely to be violated. I.e., this term will be higher than the local multiplier and location preferences. In addition, this let us to establish the following proposition, that buils on Rodríguez-Clare (1996a,b).

Proposition 2. Predictions in relation to MNCs and domestic firms. *As long as MNCs are more intensive than domestic firms in the use of intermediate inputs, i.e. $\eta_{MNC} > \eta_{DOM}$. Then*

2.1 *MNCs induce larger productivity spillover than domestic firms per unit of labor hired. However,*

2.2 *to the extent that MNCs offshore a larger amount of intermediate inputs than domestic firms, i.e. $\lambda_{MNC} < \lambda_{DOM}$, backward productive linkages from the resource sector are less likely to offset productivity losses from crowding-out effects.*

2.3 *If MNCs are skill-biased in their offshoring, MNCs induce higher specialization in low-skill intensive jobs in booming cities in comparison to domestic firms.*

3.2.5 Effects on Social Welfare

Note that relative welfare will increase as a direct consequence of the resource boom. Therefore, aggregating over all periods and focusing on the impact of a resource boom in $t = 1$, keeping everything else constant, yield the following expression

$$\frac{\partial \hat{U}}{\partial \hat{X}_{nt}} = \frac{\xi(1-\gamma\delta)}{1+\tau\delta} > 0.$$

Assuming that the resource boom only happens in $t = 1$ (i.e., $L_{ra} = 0$ in $t = 0$ and $t = 2$), then social welfare in city a increases as a direct consequence of the resource boom *ceteris paribus*. Notwithstanding, this would vary across MNCs and domestic firms, given that $\delta_{MNC} < \delta_{DOM}$, implying $\frac{\partial \hat{U}}{\partial \hat{X}_{nt}^{MNC}} > \frac{\partial \hat{U}}{\partial \hat{X}_{nt}^{DOM}}$.

3.2.6 Equilibrium with Endogenous Amenities

As is largely documented in the literature on resource economics, the booming sector generates negative consumption externalities in the form of dis-amenities, such as environmental hazards. To understand the implications for the previous equilibrium in such situations, I derive the effects assuming that the booming sector generates a dis-amenity effect in proximity to a resource extraction site. Specifically, suppose that the resource sector operates s extraction sites located at a distance τ from the booming city. Then the total amenity effect will now be an endogenous measure that follows $B_{ct}^{k} = b_{ct}\left(L_{rct}^{k}/L_{ct}^{k}\right)^{-\omega_k}$. Which states that local amenities increase with local population L_{ct} like in consumer cities, but these amenity effects are limited by the size of the resource sector L_{rct}, capturing the negative externalities from the resource sector. Moreover, the final amenity effect hinges on the magnitude of these components and is captured by ω. This implies that the effect of the resource boom in relative population, wages, and housing rents is

$$\frac{\partial \hat{L}_{t=1}}{\partial \hat{X}_{n,t=1}} = \rho\tau\mu > 0 \qquad \frac{\partial \hat{w}_{t=1}}{\partial \hat{X}_{n,t=1}} = (1-\rho\tau)\mu > 0 \qquad \frac{\partial \hat{r}_{t=1}}{\partial \hat{X}_{n,t=1}} = \rho\tau h\mu > 0,$$

where $\mu \equiv \frac{1}{1-\omega\tau}$. Compared to the case without the dis-amenity effect generated by the resource sector, the effect on wages is always positive by the magnitude $(\tau+\gamma)/(1+\tau\delta)$. Here, the positive effect on wages is heavily discounted by the factor $\omega(2+\delta\iota-2\gamma\delta)$. Despite the effect being positive, this dis-amenity effect is the result of the resource sector having important implications for the relative welfare effects of the resource sector. These effects also differ between the MNCs and domestic firms case in δ. Finally, the effect of housing rents is obtained by substituting the equilibrium relative population and partially differentiating with respect to $\hat{X}_{n,t=1}$. This yields the same effect as in the previous case.

$$\frac{\partial \hat{L}_{mt}}{\partial \hat{X}_{nt}} = -\frac{1}{(1+\eta)} \qquad\qquad \frac{\partial \hat{A}_{m,t+1}}{\partial \hat{X}_{nt}} = \rho\tau\Lambda\mu - \frac{\phi_m}{(1+\eta)}.$$

All these effects, considering the dis-amenity effect, yield the following theorem.

Proposition 3. *When amenities are negatively correlated with the resource boom these externalities limit the productivity and social welfare gains from the resource boom.*

3.2.7 Additional Sources of Heterogeneity

Two additional

3.2.8 Summary and Implications for the Empirics

One important feature of this model is that allows us to formalize the conditions by which a resource boom might favor an *enclave* or an industrial agglomeration, which is consistent with the literature in economic geography. A taxonomy that define these two opposite extremes scenarios. In summary, we can characterize a modern *enclave* equilibrium considering the following conditions.

Definition. *A modern enclave equilibrium induced by the booming sector is characterized by:*

1.1 *Large productivity losses due to foregone scale economies: the crowding-out of the tradable sector induced by a local resource movement and spending effect that implies productivity losses in the long term (local Dutch disease). This is reinforced by limited linkage creation that does not offset the crowding-out of tradable —manufacturing— industries.*

1.2 *Social welfare losses due to local spending effect: the higher wages paid by the resource sector that induces higher local rents that induces a decrease in real wages. This is reinforced by the negative externalities of production in the form of dis-amenities.*

The existence of linkage creation by resource sectors rules out the possibility of local *Dutch disease* due to the absence of a crowding-out effect of the resource sector. Given that these effects nullify each other, limited linkage creation by MNCs can empirically imply that these linkages cannot offset the crowding-out of firms in the tradable sector. This situation will be consistent with the previous literature based on case studies but not with more quantitative large-scale evidence. If the existence of spillover effects is related to that of crowding-out effects, it is difficult to expect negative spillovers. Further, the final effect on wages and rents is more likely to determine the long-term equilibrium of the booming city. The dis-amenity effect induced by the resource sector might lead to limited real wage gains and, consequently, limited population gains in the long-term. These effects are more sensitive to the assumptions characterizing the behavior of MNCs and domestic firms in the resource sector. In particular to the fact that MNCs offshore a larger proportion of their intermediate input requirements. These effects are illustrated in Figure 3.

In Figure 3, the blue-shaded area under the yellow curve and above the red curve represents the social welfare gains from the booming period. From the symmetric equilibrium of the pre-booming economy, the fraction of workers is equal to 0.5 in both cities. However, the resource boom city A increases its population to 0.6 relative to total population in both cities. This change in the population of city A between $t = 0$ and $t = 1$, is denoted in the figure by $\Delta\hat{L}_1$. However, the dis-amenity effects of the resource sector are persistent and will affect the relative welfare in the bust period $t = 2$. In particular, two scenarios are described in the figure. Under the first scenario, for which the marginal relative utility is represented by the orange curve, the welfare losses induced by the dis-amenity effect are lower than the welfare gains during the booming period. Therefore, the total welfare gains from the booming and bust periods are positive, and the population change in relation to the pre-booming period is 0.05. Under the second scenario, the welfare losses induced by the dis-amenity effect are larger than the welfare gains from the booming period.[40] Consequently, the overall welfare effect from the booming and bust period is negative, and the booming city loses population in the long-term.

3.2.8.1 Theorem. *Consider that the resource sector is dominated by MNCs such that* $\lambda_{ra} \to 0$ *and* $\delta \to 0$. *Then a resource boom* $X_{ra,t} \equiv P_{ra,t}A_{ra,t} > 0$ *is more likely to induce an equilibrium with enclave features.*

4 Data

To provide empirical evidence on the mechanisms described previously, this study builds a rich dataset for Chile by combining information on mining activity and performance of local firms and workers' conditions in local labor markets, encompassing the mineral price boom.

[40] Note that this is possible because the amenity measure accumulates over time.

4.1 Mining Companies

To capture yearly and spatial variation in mining activity, I construct a measure of the intensity of mining operation at the plant-level for more than two decades by combining daytime and night-time satellite images based on recent advances in the field of remote sensing (Connette et al., 2016; Werner et al., 2020). Intuitively, imitating the restoration of an old picture, I use the latest available LandSat medium-resolution satellite images along with official geo-referenced data from the USGS and Chilean Ministry of Mines to identify the location and actual area of operation of the mining active and inactive sites. Further, for these areas, I compute statistics of night-time lights for each year between 1992 and 2017 as a proxy of the intensity of activity, as in Hodler and Raschky (2014) (for other contexts see: Chor and Li, 2021). This idea relies on the documented fact that large mining sites operate on a 24-7 basis, which implies that night-time lights data are arguably a potential good source of information to proxy the intensity of activity of each mining plant.

To complement and validate the satellite information, for each mine identified and available, I compile administrative records about the following criteria: the type of extracted mineral, years of operation, ownership, and production level. Regrettably, yearly production reported for each plant is only available for a sample of the largest mines at certain years. Therefore, this information is only used to complement and validate the indicator of the intensity of activity of each mining plant, constructed using satellite images. A detailed description of the remote-sensing methodology used and results of the validation exercise are provided in the Online Appendix. Additionally, I use spectral bands—non-visible range—of the satellite images to construct an instrumental variable that captures the spatio-temporal variation in the concentration of heavy minerals in the soil of mining sites as a predictor of the yearly profitability of each mine. This novel methodology is inspired on the work of Faber and Gaubert (2019) and a well-grounded literature on mineral geology (see e.g., Segal, 1982; Drury, 1987; Wolf, 2012).

4.2 Firms

To study the cross-sectoral and firm-specific spillover effects from the resource boom, I use manufacturing surveys and aggregated sector-municipality level tax records. Longitudinal data from manufacturing surveys are openly available from 1995 to 2014, provided by the Chilean National Institute of Statistics (INE). The Chilean manufacturing survey (ENIA) collects information about all Chilean manufacturing firms with more than ten employees. It has information on the location of production, number of employees, wages, workers' skill level, capital, and material inputs used for production. This information is internally contrasted by the Chilean statistical office with the financial balance of each firm reported in their annual tax records (INE, 2006). Given that economic censuses that compile information about all the economic sectors are considerably recent in Chile, and the manufacturing surveys only report localization at the regional level, I complement this information with publicly available aggregate data for all economic sectors at the municipality level based on the tax records from 2005 to 2015. This in order to observe changes in non-tradable sectors.

4.3 Workers

The previous information is complemented with more detailed data from the supply-side of the labor market. A pool of household surveys from 2000 onward is used. The analysis is based on Chilean socioeconomic household Survey (CASEN). CASEN is constructed by the Office of National Statistics.[41] This includes information on wages and workers' characteristics, such as age, gender, education, occupation, and sector. A repeated cross-section of nine waves of the CASEN is used—the 2000, 2003, 2006, 2009, 2011, 2013, 2015, 2017 and 2019 waves. The pool contains a total of 1,927,822 observations, from which 703,512 report wages. Wages have been deflated using the Chilean Consumer Price Index (100=2008). Additionally, the sample is restricted to cities with a population of more than 25,000 inhabitants.

5 Empirics

The empirical evidence is divided in three parts. First, I test the predictions of the within-country version of the *Dutch disease* considering the heterogeneous effects between MNCs and domestic firms in the resource sector. This is done to understand if there is evidence to support the hypothesis that the mining sector is inducing unsustainable long-term local economic development by reducing workers' welfare and decreasing the gains from industrial agglomeration caused by crowding-out effects and productivity losses by foregone agglomeration externalities, considering the heterogeneous effects between MNCs and domestic firms. Second, I document the existence of spillovers from local productive linkages of the mining sector to quantify its potential as a source to offset the negative effects of the *Dutch disease*. Finally, I present evidence on the role played by MNCs in the mining sector for forming these

[41]CASEN is available since 1990, however, previous to 2000, the survey does not have geographical representation. Since 2000, the survey has representation for most urban municipalities. Given that the focus of this paper is over cities, defined with a population threshold over 25,000 inhabitants, this reassure representation for the main outcomes for workers analyzed in this paper. Robustness checks with different cut-off of population size are explored in the online appendix.

local productive linkages to better understand how the organization and production of the resource sector interact with the local agglomeration, and the extent to which this foster an *enclave* or *cluster* scenario.

5.1 Relative Effects in Local Labor Markets

Previous empirical literature identifying the local economic impacts of resource-based activities has usually based its research strategy on an indicator of natural resource endowments in a given area that determine the exposure of local workers and firms to shocks in the resource sector, using a quasi-experimental shift-share design. It uses the arguably exogenous spatial variation induced by geological factors and/or the temporal variation in global commodity prices (e.g., Aragon and Rud, 2013; Caselli and Michaels, 2015; Allcott and Keniston, 2018). In this study, the impacts of mining on local economic outputs are mainly observed using an exposure variable that follows a similar strategy but varies between the exposures of MNCs and domestic firms in the mining sector. Specifically, the empirical strategy rely on spatial variation by comparing cities more exposed to mining activity against cities less exposed, in which the general equation to be estimated, as a first-order approximation of Eqns. 33, 32 and 11, takes the following form:

$$\Delta \log Y_{ct} = \beta^k \log \left(Exposure^k_{ct-1} \right) + \mathbf{X'}_{ct_0}\gamma + \delta_t + \epsilon_{ct}, \tag{15}$$

where Y_{ct} = are the different economic outcomes in city c, year t: (1) population and employment, (2) wages and rents, (3) number and aggregate sales and revenue of firms, and (4) total factor productivity. $k = \{domestic, multinational\}$, $\mathbf{X'}_{ct_0}$ = control variables at the initial year, δ_t = year fixed effect.

5.1.0.1 Local Exposure to Mining Shocks The exposure to a mining shock for city c, located at a distance $d_{c,s}$ from a mining plant s of property $k = \{domestic, multinational\}$, with Q^k_{st} level of production, is defined by the following:

$$Exposure^k_{ct} = \sum_s Q^k_{st} \left(d^k_{c,s} \right)^{-1} \tag{16}$$

where Q^k_{st} is proxied by the sum of night-time lights within the area of a given mining plant. Here, the exposure is defined over a continuous space, which is more realistic than standard approaches where the exposure variable varies across a discrete space of regions, natural resource endowments, or the production of commodities. All these criteria equally affect the agents within the region and have a discontinuity given by the administrative borders.

Instead, the exposure variable in Eqn. 16 captures geographical spillovers to more distant locations that are also being affected by mining activity due to long-distance commuters or increases in local investments due to national fiscal windfalls.[42] Under the plausible assumption that these effects falls with the distance to mining plants.

The endogeneity of this variable is determined by the extent to which local conditions affect the activity of mining companies, for example, local workers' strikes common in the sector for both domestic firms and MNCs (see e.g., The Economist, 2006; Financial Times, 2010; BBC, 2011; Durán-Palma, 2011). Their production levels are not mainly driven by geological conditions for mining exploitation. Identification is based on the following factors: exogenous geological factors influencing mining production and exogenous variations in mineral prices. As explained later, this is arguably the case, as is revealed in the small correction of the IV strategy in most estimates.[43]

5.1.1 Population and Employment

The first set of hypotheses is that the resource boom causes short-term positive impacts on population and employment with larger effects induced by MNCs in comparison to domestic firms in the resource sector. These effects are estimated in Eqn. 15, where the outcomes $Y_{ct} =$ are population and employment (dis-aggregated by sector). These effects are informative of the different mechanisms that affect location patterns of workers and firms. Although these effects are expected to be positive, the final result depends on the magnitude of the different mechanisms at play. For example, the effects on population would be positive if the increase in local wages is more than proportional to the increase in local rents and if the dis-amenity effect caused by proximity to mines is negligible. However, the total effect on employment would be positive if the mining sector is important in relation to other sectors, and the labor directly and indirectly created by the resource boom is significantly higher than potential crowding-out effects, as predicted by theory.

[42] Long-distance commuting or fly-in/fly-out commuting is a common phenomenon in mineral economies (Aroca, 2001; Aroca and Atienza, 2011; Paredes et al., 2018).

[43] Owing to the time span of the data and nature of hard minerals production described previously in the life cycle of large-scale mines, I do not study the cyclicality of the phenomenon, as in Allcott and Keniston (2018).The cyclicality of the booms and busts of the mineral sector is likely to be different than it is evidenced in the oil and gas sector of the US. This is because the exploration and developing phases take more time, and when the mine is in the extraction phase, it incurs large exit costs to close (e.g., can take ten years of monitoring of toxic residuals of mining ponds once the mine is closed). Additionally, they tend to negotiate future contracts of production at fixed prices. This implies that an event-study design is unfeasible, leading to take advantage of the exogenous spatial variation characteristic of mining activity. However, I provide robust evidence on the contemporaneous and long-run local economic impacts of mining to argue that the estimates are robust to time-trends and confounders that might occur during the boom.

5.1.2 Wages and Rents

The key mechanisms underlying the average relative impacts of mining on local population and employment, as well as the effects on social welfare later explored, are the effects in local wages and rents. Eqn. 15 is estimated with Y_{ct} = log of residualized wages and rents in city c. These residuals are obtained from a standard wage and rent equation. These effects are expected to be positive according to the chain of events of the local *Dutch disease*. Specifically, a positive shock in the mining sector generates more demand for labor, which raises wages in the resource sector. If the mining sector is locally important, the excess of demand for labor would induce higher local wages in other sectors as well, as these sectors will compete for the same pool of labor. The increase in local wages raises the prices of non-tradables, which results in higher living costs. These costs would be captured by higher rents. These productivity effects can be masked by amenity effects on wages and rents, which might differ in their direction, depending on how workers and firms perceive mining activity.

The positive effects on wages and rents are predicted under the assumption that the resource boom is treated as a productive local amenity in the spatial equilibrium setting. However, this might not be the case if mining activity generates negative externalities, such as environmental impacts that affect workers' and firms' decisions. In that case, these effects are captured by wages and rents and move in opposite directions (negative). Nevertheless, if the environmental effects of mining on cities are negligible, and mining activity induces higher wages and rents, the extent to which the magnitude of the rise in rents might offset the wage increase would depend on a different set of factors. If the demand of labor increases significantly, and local areas cannot meet the supply of labor required for the new equilibrium, a high proportion of workers might end up living far away from mining cities. This might be reinforced by two main elements—the lack of local amenities affecting location incentives of workers and convenient working shifts offered by mining companies to its workers.[44]

5.1.3 Industrial Agglomeration

As previously described, an important set of evidence to understand the long-term impacts of mining activity are the effects that this sector induces in other sectors. A specific case is if mining decreases the size and profitability of more tradable non-linked sectors. Eqn. 15, to be estimated for evidence on these mechanisms, considers Y_{ct} = log of number of firms and aggregate sales and revenue in city c and year t, distinguishing between manufacturing and services sectors. According to the Dutch-Disease channel, the resource boom should induce a crowding-out effect in the manufacturing (or more tradable) sector. The crowding-out effect

[44] For example, seven days working in the mine and seven days off, 15x10, etc.

does not necessarily induce a long-term decline in overall growth, unless it is accompanied by a productivity loss in these non-linked tradable sectors. However, the higher local demand for non-tradables may be caused by an increase in wages and might provoke an increase in the size and profitability of these sectors. The demand for intermediate goods and services directly or indirectly required by the mining sector may generate an increase in the number of firms in linked tradable sectors as well. In this case, the net result would depend on the relative size of those effects and size of the shock in the resource sector (Lufin and Soto-Díaz, 2022). Empirically, it is not clear which of these effects would dominate, but a high degree of sectoral heterogeneity is expected in these impacts.

5.1.4 Productivity Spillovers

The last mechanisms of the local Dutch Disease and key for the identification if the resource sector is inducing a decrease in long-term growth are productivity spillovers. The crowding-out effect of the resource sector in the manufacturing (tradable) sector should lead to a loss of positive externalities such as localization economies and/or *learning-by-doing*, which could induce a decrease in manufacturing productivity. This last negative effect is the key mechanism in the *Dutch disease* story and is the factor that induces a decline in economic growth in the long term. Therefore, it causes unsustainable economic development in the mining sector. In this case, the identification is done at the firm level. Specifically, Eqn. 15 takes the following form as first order approximation of Eqn. 2,

$$\Delta \log Y_{jrt} = \alpha + \beta^k \log \left(Exposure^k_{rt-1} \right) + \mathbf{X'}_{jrt_0} \gamma + \delta_j + \delta_r + \epsilon_{jrt}, \tag{17}$$

where the long-run difference over Y_{jrt} = the total factor productivity of the firm j in region r and year t (distinguishing between linked and non-linked activities) is regressed against the exposure variable aggregated at the regional level, $\mathbf{X'}_{jrt_0}$ = is a vector of firm-level control variables at the initial year, δ_j = is a plant fixed effect, and δ_r = is a region fixed effect.

$$y_{it} = f(l_{it}, k_{it}) + \omega_{it} + \xi_{it}, \qquad \omega_{it+1} = g(\omega_{it}) + \xi_{it} \tag{18}$$

Note that the increase in the demand for intermediate goods and services offered by local suppliers to mining companies may induce a reduction in the average cost. Subsequently, this improvement in efficiency would imply a higher productivity. This may be generated by direct knowledge transfer, higher requirements for product quality and on-time supply, or economies of scale (Javorcik, 2004). If mining companies do not internalize this average cost reduction by bargaining for a lower price on their intermediate inputs, these spillover effects of mining companies would arise for the supplier. However, mining companies are likely to have high bargaining power and good information on these externalities induced on suppliers (because they are inducing some of them and are significantly large in terms of size and importance to the local economy). Hence, it is expected that these spillovers would be small. Additionally, some of these spillovers might be offset by the competition effects (Aitken and Harrison, 1999). This is because the reduction in the average costs induced by the spillover effects can also be captured by new entrants and, consequently, the number of competitors in the market, which would spread the reduction in the average costs over a larger number of competitors.

Although it is expected that technological improvements in the mining sector spill over in the domestic firms belonging to other sectors and increase their productivity, these productivity effects offset the potential loss of productivity induced by the crowding-out effects in non-linked sectors. It is also expected that spillovers within the mining sector are limited to activities that are not necessarily knowledge-intensive or profitable in the long-term. Moreover, MNCs offer incentives in the resource sector to delocalize these types of activities to more competitive locations. Furthermore, the lack of urbanization and localization in economies characterize the cities that are more specialized in resource-based activities.

MNCs might be highly reliable on imported intermediates and source parts of their activities to foreign suppliers, weakening the capacity of the resource sector to generate productivity spillover effects. However, domestic firms are more likely to develop linkages with domestic suppliers. For example, public-private partnership for mining projects have been developed to mitigate these effects. Further, a priory, the effects are uncertain and are likely to be dependent on the degree of foreign ownership for each project.[45] Spillovers are weakened by *enclave* features of the resource sector in resource-oriented cities, but MNCs might overcome these limitations that generate spillovers due to the following factors: (1) direct knowledge transfer to local suppliers, (2) higher requirements for product quality and on-time delivery, and (3) increasing demand for intermediate products inducing the formation of scale economies (Javorcik, 2004).[46] MNCs can introduce new to better technologically advanced inputs from foreign markets in the domestic industry, which also might offset the losses caused by the delocalization of knowledge-intensive activities.

[45] One example of this is the Gabi mining project, in which the state-owned company CODELCO own 51% of the shares.

[46] Numerous case studies document these effects in mineral economies: (Auty, 2001a,b; Atienza et al., 2021; Arias et al., 2014), inter alia. These factors demonstrate the capacity of MNCs to generate productive linkages that induce productivity spillovers. One concrete example of this is the requirement of mining companies for suppliers to obtain the International Standard Organization (ISO) quality certification on products and behaviors.

5.2 Identification Strategy

The main empirical challenge is to disentangle the within and cross-sector spillovers generated by the mining activity from natural location advantages or location fundamentals. Authors usually rely on exogenous natural events or law enforcement. In this study, to identify the plausible causal effects of mining on local economic development, I use two sources of exogenous variation. The instruments that I present try to capture both of these factors. First, exploiting the exogenous geological conditions that explain the location decision of mining plants would help identify the spatial variation in the distance variable. Second, exogenous time-variant component is given by the following two considerations: (1) the demand-driven shock of mineral prices induced by the super-cycle of mineral prices and (2) exogenous variations in plants that might predict variation in supply requirements.

5.2.1 Mining Planning, Mineral Production, and Heavy Metal Indices

Open-pit mines are characterized by spatial variation or greater concentrations of heavy metals and temporal variation or changes in heavy metal indices on the time and changes in elevation. These changes in heavy metal indices might explain the profit ratio of each open-pit mine and explain future patterns of production. This is stated more precisely in the following quote that describes the uncertainty in open-pit mining and planning: *"the mine plan has to be developed with uncertain information such as the characteristics of the ore body and the economic drivers (prices and costs) of the mining project..."* (Arteaga et al., 2014). Therefore, the identification strategy follows three routes, depending on the parameters to be identified within the theoretical framework. First, I use exogenous geological variables to determine the location and intensity of production of mining plants, in addition to exogenous variation in mineral prices. The key identifying assumption is that residuals are uncorrelated with exogenous changes in mineral prices and geological factors underlying mining production in plants. For price variation, mining companies should not have sufficient market power to move global mineral prices.

5.2.1.1 Variation in Heavy Metals in Soil within Mines After the exploration phase, the development and extraction phases of a mining site are the longest phases. The extraction phase of a mining plant can range from 5 to 50 or more years, depending on the estimated amount of minerals underground. Every phase of the process is uncertain, based on the exogenous factors. The extraction is particularly characterized by exogenous elements that can be tracked using satellite data. Specifically, using the infrared sensors of satellite, one can track temporal variations in concentration of minerals in soil, during the extraction.

This variation in soil minerals determines the profit ratio of each mine, which is the main variable behind the organization and production of each mine. Specifically, this measure is affected by the ratio between the mineral extracted and waste material. In the mining and planning process, engineers are oriented to maximize this profit ratio. A priori, they only rely on initial estimates based on soil samples to compute the expected profits of a mine, until they start operations in the developing phase. During the firsts years of this phase, most of the material removed is waste rock. However, as soon as they start to observe an increase in the profit ratio, they change the method of extraction, specifically, the altitude and slope of each bench. All these variations in the soil mineral concentration can be proxied using the invisible spectral bands of satellite data, as shown in Figure 4.

This contributes an important source of exogenous spatial and temporal variation, which are likely to meet the exclusion restriction in the IV design. This is because it is correlated with local economic outcomes only through its effects on the profit and production of each mining plant. Therefore, for each mine and year, I compute a series of indices that capture mineral characteristics of the soil. However, they have low variation without human intervention, especially when a mine is open due to the removal of soil and mineral deposits that present important variation. These indices are computed using non-visible spectral bands of satellites. This predicts the effect of the intensity of the mining activity for each plant and is likely to fit the exclusion restriction for each mine, given the different city-level economic outcomes.

These indices also have temporal variation, together with the elevation of the terrain. The temporal variation of these indices explain the profit ratio of the exploitation or, in other terms, the amount of minerals being extracted in comparison to waste material. They also help predict future production. This is a proxy because the information used for mining and planning also relies on geological studies, which are unavailable. To show that remote sensing indices of heavy metals on soil are a good predictor of mineral production, I describe the correlation between these indices and actual production of minerals for a sample of mines.

5.2.1.2 IV: Mineral Concentration One of the main problems of identification, as the case of identifying infrastructure impacts the local economy, is to show that these estimates are independent of local economic conditions. For this purpose, I introduce a measure of mining potential that predicts the potential of a mine based on observed geological factors, given the concentration of heavy metals in the soil. This exogenous measure can help identify the effects different from local conditions. Specifically, this measure is as follows:

$$MineralConcentration_{ct}^{k} = \sum_{s} M_{cst}^{k} \tag{19}$$

with M_{cst} = the intensity of mineral indices on plant s in year t (within 500km from a city c), and $k = \{MNC, DOM\}$. Intensity of minerals in soil is measured as the median of the product of Clay Minerals Ratio (CMR), Ferrous Minerals Ratio (FMR), Iron Oxide Ratio (IOR), and Bare Soil Index (BI). The shock of prices on mining production is plant-specific. For each plant, the main mineral produced is identified, and then the production in this plant is multiplied by the price of that specific mineral.[47] Figure A.5 describes the evolution of the aggregate index in minerals during the sample years. [48]

5.2.1.3 Identification of Productivity Spillovers Additional concerns are raised in the identification of causal effects of the boom in the mining sector on the productivity of manufacturing firms. These considerations derive from the following three main stylized facts explaining firms' behavior: (1) firms tend to be highly heterogeneous in productivity, within and between sectors; (2) this productivity tends to be highly persistent; (3) there is an important turnover of firms exiting and entering the market (Bartelsman and Doms, 2000). All these facts might induce the following three main sources of endogeneity: (1) there is a simultaneity bias in the selection of inputs and productivity; (2) there is a selection bias toward high productive firms in the sample; (3) there is a measurement error bias on inputs and output prices. To deal with the problem of endogenous inputs and selection bias of firms entering and exiting the market, a semi-parametric estimation strategy based on Olley and Pakes (1996) is implemented. Additionally, firms' productivity estimates are corrected following Levinsohn and Petrin (2013) to account for the simultaneity of inputs and productivity. Total factor productivity is computed by following these approaches. Moreover, the variable measuring local exposure to mining shocks is separately regressed on these corrected measures of productivity of each plant.

5.3 Estimates

5.3.1 Relative Effects in the Labor Market

According to theory, it is expected that an increase in mining activity would lead to contemporaneous positive effects on the local population and employment in the non-tradable sector. Notwithstanding, the total effect of increased mining activity on employment and, consequently, population depends on the relative importance of the non-tradable sector in relation to more tradable sectors and to what extent the mining sector induces a crowding-

[47] One of the limitations is that the instrument is not specific to local firms in the manufacturing sector.

[48] Most mining plants are specialized in the production of a specific mineral, and usually, other minerals are classified as subproducts. Despite the importance of their absolute value, they tend to represent a small share of annual production. For example, the annual production of subproducts of Escondida, one of the largest copper producers in Chile and the world, was sufficient to cover all the initial investments of the developing phase.

out effect on the tradable sector, suggested by the mechanisms of the *Dutch disease*. Given that non-tradables account for a large proportion of the workforce and usually comprise high employment multipliers of the mining sector (Fleming and Measham, 2014), the effect on total employment would likely be positive, as suggested by the empirical evidence in other contexts (Aragon and Rud, 2013). Even if there is a decline in employment in the manufacturing sector, this would be probably offset by the positive effects in the local non-tradable sector. The top panel in Table 2 shows the estimations of the exposure to mining shocks on population and employment in local labor markets. Results seems to be consistent with this argument when exploring the heterogeneous effects. They show a weaker effect for MNCs in comparison to domestic firms in local population, but no differences for overall employment.

Theory also predicts that the resource boom would induce higher local wages, which, to some extent, would be offset by higher local rents. This is because under a spatial equilibrium framework *à la Roback*, it is expected that differences in wages and rents capitalize the differences in workers' utility and firms' costs generated by spatial variations in local amenities. Specifically, within the Allcott and Keniston (2018) model, the resource boom is formalized as an exogenous shock that increase the revenue productivity in the resource sector. However, even if the resource boom increases the level of local wages due to this productivity shock, it implies a growth in the size of the sector. This should be accompanied, in some moment, by higher local prices induced by the spending effect in the local *Dutch disease* framework.

The bottom panel of Table 2 shows the average and heterogeneous effects of the exposure to mining shocks on local wages and rents. Both elasticities, on wages and rents, are positively significant. The magnitude of the elasticities of rents tends to be much higher than that of wages. This is expected under a spatial equilibrium scenario, given that households tend to spend a high proportion of their income in rents. Therefore, rents offset higher wages, and if this difference is sufficiently large, it can explain the observed pattern of long-distance commuters that characterizes mining regions (Paredes et al., 2018). The effects on wages consider all sectors. It is predicted as an increase in the average wage across all sectors, which is explained by the fact that despite the lack of an increment in the productivity of workers' or improvements in firms' efficiency in other sectors, local firms not linked to the resource sector have to compete for the local labor with mining companies that offer higher wages. This increases the average local wage for non-linked tradable and non-tradable sectors.

Note that the amenity effect associated with proximity to mining activity might confound the spending and/or resource movement effect of the *Dutch disease*. For instance, negative environmental externalities of mines can induce a decrease in the productivity of firms located near extraction sites. These effects might nullify possible positive spillovers due to productive linkages, *learning-by-doing* or localization economies. However, if workers are also affected by these environmental externalities, they may bargain higher wages as an incentive to work in those areas with environmental problems or lack of natural amenities, as is suggested in the spatial equilibrium framework. This might further amplify the increase in local wages due to the resource boom. Housing rents also capitalize on these negative amenity effects, as the evidence for Chile suggests (Rivera, 2020). It might outweigh the increase in local prices induced by the spending effect in the within-country *Dutch disease* model.[49]

These amenity effects are important in mining regions, which is consistent with the large number of long-distance commuters in those regions. These long-distance commuters represent nearly 35% of the workforce in the mining sector and 12% of the total workforce in all sectors within regions specialized in mining activities. The economic incentives for long-distance-commuting is partially given by the negative externalities associated to proximity to mining-extraction sites (Paredes et al., 2018). It is common that these sites are located in places with lack of natural amenities. Consequently, these negative environmental externalities correlate with the lack of natural amenities and remoteness of mining regions (Soto and Paredes, 2016). Therefore, local controls include amenity controls at the city level, such as local crime, education quality, share of highly skilled workforce, and local per capita fiscal resources. These might affect location incentives of workers and firms by providing a different set of local public goods.

5.3.2 Social Welfare

The plausible causal evidence identified previously inform the social welfare measure by relying on the mapping between these elasticities and primitives of the model. In particular, the effects on population, wages, and rents, determine the social welfare in the model, assuming that local prices of the tradable and non-tradable sectors are captured in housing rents (Hornbeck and Moretti, 2022). Therefore, these elasticities are sufficient statistics of the welfare consequences of a resource boom and bust. Further, adapted from Allcott and Keniston (2018), in the cumulative indirect utility function in Equation 12, social welfare estimates for a city c are given by the following formulation:

$$\hat{W} = \frac{1}{14} \sum_{t=2000}^{T=2013} \left[\Delta \log X_{r,t} \left(T - t + 1 \right) \left(\hat{\beta}_{wage} - 0.3\hat{\beta}_{rent} - \hat{\beta}_{amenity} \right) \right].$$

[49] Despite the importance of these amenity effects in the resource-oriented regions, these are overlooked in the Allcott and Keniston (2018) setting.

The social welfare estimates are reported in Table 3. The main difference from Allcott and Keniston (2018) is that, here, the local exposure to mining shocks variable already captures the spillovers. Therefore, it is measure of absolute effects. These estimates reveal a negative long-term effect of the mining boom in the real wage and population gain. This is consistent with the hypothesis of *immiserizing growth* related to the original *Dutch disease* theory by Corden and Neary (1982), but in a within-country framework. Specifically, the contemporaneous increments in local wages and employment caused by the resource boom are insufficient to offset the increase in local rents. In this case, they are insufficient to outweigh the negative variations in mining activity experienced during the period. This is because, even though $wage - 0.3(rent)$ is positive but small (0.082), the annual average real wage and population gains are negative.

5.4 Mechanisms

5.4.1 Relative Heterogeneous Effects in Sectoral Employment and Revenue

Another level of evidence for the local economic impacts of mining activity, and an important mechanism of the *Dutch disease* (both in the within- and between-country version), is the shrink in the manufacturing non-linked sector. This is because local manufacturing firms in non-related sectors have to compete for local labor against the higher wages offered by the resource sector, due to the positive shock of productivity caused by the resource boom (resource movement effect). Moreover, the increase in local prices, increases the average cost of production (spending effect). However, manufacturing firms can implement different strategies to tackle with the higher cost of production, without necessarily implying a reduction in the number of firms at the local level. Therefore, different outcomes for firms at the local level are used in the following regressions to study the effects on the overall size and profitability of the sector.

The effect on aggregate employment, although positive and significant, is masking the heterogeneity of the impact of employment on tradable and non-tradable sectors, predicted in theory. Table 4 distinguishes between employment in manufacturing and services sectors. The effects of mining and services employment are positive and significant across all estimations. As predicted, increments in mining activity lead to proportional increments in mining employment (elasticity close to 1). However, the proportional increments in employment in the services sector are comparatively smaller (elasticity of approximately 0.2). The difference in the effects of employment between these sectors is statistically significant.

However, the effects on manufacturing employment are non-significant. The manufacturing sector is related to different levels of tradability of manufacturing goods. Further, the effects of employment may be insignificant because the classification might be too aggregated and mask the negative effects caused by the resource movement and crowding-out of manufacturing non-linked firms. As found by Allcott and Keniston (2018), in the oil and gas sector in the US, it is more likely for the negative effects of a boom in the resource sector to be highly localized for manufacturing firms producing goods that are highly tradable and non-linked to the mining sector. Considering this, exporting firms are more likely to be exposed to the crowding-out effects, given the high levels of tradability and the fact that those firms are subject to within-country *Dutch disease* effects and classical between-country effects of currency appreciation.

The estimates of the exposure to mining shocks on the size and profitability of the mining, manufacturing, and services sectors in each city, are presented in Table 4. Results are positive for mining, services and manufacturing sectors, which suggests that there are no crowding-out effects of the mining sector on the number of manufacturing firms and city-level aggregate sales and revenue. This evidence is consistent with the results founded by Allcott and Keniston (2018). However, these estimates have to be interpreted with caution, given that this data are derived from tax declaration aggregated at the city level, and only considers firms in the formal sector. This is despite the fact that the formal sector accounts for approximately 75% of total non-agricultural employment in Chile. The IV estimates imply that a 10% increase in mining activity would lead to more than proportional increments in the services sector. These increments would be about 5% for the number of local firms, and about 10% for the average sales and profits.

Given that the manufacturing sector is mainly producing goods locally or with low tradability, it is also comprehensible that an increase in mining activity would lead to an increase in the size and profitability of local manufacturing firms, as observed in the data. Further, high elasticities are expected because the mining sector is capital intensive but indirectly requires a high number of employees from other sectors, such as transport and communications, construction, and other services. Moreover, higher wages increase the local consumption of non-tradables. This is the first strong evidence against local *Dutch disease*. However, this is an average aggregate effect, and it is expected that this effect would be heterogeneous according to the level of tradability of goods and services produced by these firms, and the extent to which these activities are directly or indirectly linked to the resource sector.

5.4.2 Productivity Spillovers

Firms can implement different strategies to tackle economic shocks, and therefore, aggregate local indicators such as the number and total revenue of firms, which might not identify the negative impacts related to the local *Dutch disease*.[50] In fact, the key mechanism that distinguishes a *Dutch disease* scenario from a local specialization case in the resource sector is induced by comparative advantages such as those predicted by the Rybczynski theorem. These are the negative effects in the productivity of the manufacturing sector that, *ceteris paribus*, might induce a decline in long-term economic growth. However, the average effects of mining activity on the agglomeration of firms are positive and robust (Table 4), indicating that there is no evidence of crowding-out effects. Further, there are no reasons to expect that the effect on the productivity of firms would be negative. As the crowding-out effect is a necessary but not a sufficient condition for the *Dutch disease*.

Additionally, the high heterogeneity of firm performance is an important insight in considering the productivity spillovers from exposure to mining activities that are also highly heterogeneous. These heterogeneous effects on firms are also to be expected in terms of the size of the firm. Large firms with more capital can resist negative shocks on productivity whereas small firms cannot, inducing positive selection. Therefore, older firms are expected to be more productive than new firms entering the industry (Olley and Pakes, 1996). This is in addition to the fact that, according to the *Dutch disease* framework, the crowding-out effects of the resource boom are expected to be concentrated on firms that produce more tradable goods and services. Notwithstanding, plant fixed-effects and firm-level-time-varying controls should capture part of those differences in the size of firms, or more generally, any idiosyncratic factor influencing productivity.

A controversial hypothesis of this study is that the existence of local positive spillovers from the resource sector are not enough to induce long-term productivity gains, given the offshoring of MNCs in the resource sector. If this is true, a first insight to be observed, is a difference in the spillover effects between MNCs in the mining sector and domestic firms. Specifically, the effect induced by MNCs should be significantly lower than that for domestic firms. Table 5 shows the average and heterogeneous productivity spillover effects from the exposure to mining shocks. The effects are positive but the effects induced by domestic mining firms are slightly lower than the effects of foreign MNCs. The power of the IV in the first stage is particularly high for MNCs. Notwithstanding, coefficients are not very distinct from the OLS with plant- and industry-fixed effects and time-varying firm controls. However, it

[50] Given the relationship between profits and productivity, we can formulate a empirical test in relation to both of these variables.

is more likely that the production of foreign mining companies is driven by other external factors instead of the profit ratio of each mine, that is, the amount of minerals extracted in relation to waste material.

6 Conclusions and Policy Implications

Within the existing economic literature, the evidence of positive effects of the resource sector in the local economy is usually theoretically grounded in environments where productivity spillovers spontaneously arise from an increase in productive linkages. These linkages are induced by a resource boom, which ultimately foster local *agglomeration effects* and *learning–by–doing*. In other words, the formation of within- and between-sectors increasing returns to scale induced by the resource sector, is understood as a direct consequence of a resource boom. This overstates the potential of the resource sector to offset negative externalities or future productivity losses caused by crowding-out effects. Specifically, in this study, I show that the observed large concentration of MNCs in the resource sector and the incentives of these companies to offshore activities, implies that a resource boom might foster an *enclave* equilibrium. This is despite the presence of contemporaneous local positive spillovers from productive linkages.

In doing so, this study exploits within-country spatial variation by integrating the mechanisms of the local *Dutch disease* accounting for the heterogeneous impacts between MNCs and domestic firms in the generation of local productive linkages and externalities. This is based on an expansive literature related to economic geography and the relationship between natural resources, MNCs, and *enclave* formation. This is crucial in understanding the ability of the resource sector to mitigate the potential de-industrialization caused by the *Dutch disease* and its long-term welfare implications. Considering the incentives of MNCs in the resource sector to generate local productive linkages, improves our understanding of the capacity of the resource sector to induce a more sustainable long-term local economic development.

The existence of potential social welfare losses and externalities in production from the resource boom and bust, reveal that local policy interventions relating the resource sector are therefore necessary. This argument of the importance of local economic conditions is not by any means specific to the resource sector, as is also implicit in the design of place-based policies. In particular, establishing a set of local economic conditions that define those long-term welfare implications, and therefore, the expected returns of local investments, is critical for policy purposes. This paper, therefore, enriches the existing literature with economic theory, a rich data setting and methodologies that allows to understand better the within-country geography mechanisms of economic development in resource-oriented economies. Specifically, a contemporaneous understanding of such phenomenon implies a good description of the nature and behaviour of MNCs involved in the global production network of minerals.

By relating the capacity of the resource sector to generate productivity spillovers with the local economy through the formation of local productive linkages, the analysis presented in this paper gives insights on the potential of different policy tools for contemporaneous and long-term local economic development based on the resource sector. Particularly, the results question the relative effectiveness of policies that increase location incentives of workers and firms toward particular resource-endowed locations, such as investments in local public goods and amenities. Conversely, policies with a focus on the production side foster the creation of local productive linkages that might generate productivity spillovers such as subsidizing local services suppliers. The distinction between these two kinds of policies is not straightforward. Governments and private companies usually invest large amounts of money in reinforcing the competitiveness of local suppliers of the resource sector. However, at the same time, governments in resource-oriented regions in the developing world spend little effort to invest in local amenities and resource-rich locations which could attract workers and firms, and are more likely to have positive long-term effects.

More specifically, the evidence in this paper points towards a complemented strategy between fostering local productive linkages and developing local amenities. This is because, even if important efforts are being made to improve the productivity of local suppliers of the resource sector. The lack of local conditions that favour location incentives towards those areas, would have a detriment effect on such policies. Given that firms would continue delocalizing these upstream activities towards areas that are more competitive and with a thick labor market. If these linkages are not being developed in activities that would have more value added and would generate within- and between-sectors productivity spillovers, then the expected long-term effects of such policies might be limited. Moreover considering the cyclical nature of booms and busts and the level of offshoring in the resource sector. This is because local planners have to deal with the negative amenity effects such as environmental externalities associated with mining extraction and the local increase in prices that offset the increase in local wages. These effects are pushing workers and firms towards other locations with better provision of public goods and agglomeration economies. Creating incentives for long-distance commuting and low population growth.

On the other hand, a precise knowledge on the expected local and aggregate economic impacts of new mining projects is very important for policy purposes. For example, establishing the economic setting for an ex-ante evaluation is necessary to clarify the local incentives that allow policy makers to take decisions based on the requirements that mining companies should meet to open a new mining plant. This decision is usually partially informed, and the consideration of general equilibrium effects, such as the spillovers to the local economy, are not usually carefully considered. This paper also contributes to this issue by proposing a model and an empirical strategy for the estimation of such effects with a more appropriate consideration of the role of MNCs in the formation of these spillovers. However, this article is limited on the extent to consider the fully extension of general equilibrium effects.

Given the extent of the topics explored in this article, insightful general equilibrium channels through which the resource boom and bust can affect the local economy with heterogeneous effects among MNCs and domestic firms are left to be explored in further research. In particular, exploring the productivity spillovers and the pro-competitive effects from trade in intermediate inputs. This is the incentives of firms to exploit economies of scale and access to cheaper inputs. To fully capture the role of *learning-by-importing* and *learning-by-exporting* for intermediate suppliers, the decision to offshore have to be endogenous, and explored with further data. Notwithstanding, to the extent that these spillovers exists, the productivity effects reported in this paper represent a lower bound of the potential productivity gains from the resource sector, and therefore, more likely to offset the negative effects induced by the crowding-out of manufacturing industries. With expected higher productivity spillovers from MNCs in comparison to domestic firms. However, to properly capture the full impacts of MNCs, the import channel should be incorporated in the theory and empirics. In order to capture the productivity gains from access to intermediate varieties abroad. To account for this in the empirics, a measure of the inputs required by MNCs and domestic firms should be included. This article, however, offers a robust approximation of the implications that the given heterogeneous level of offshoring between MNCs and domestic firms have in local labor markets, in the context of a resource boom and bust.

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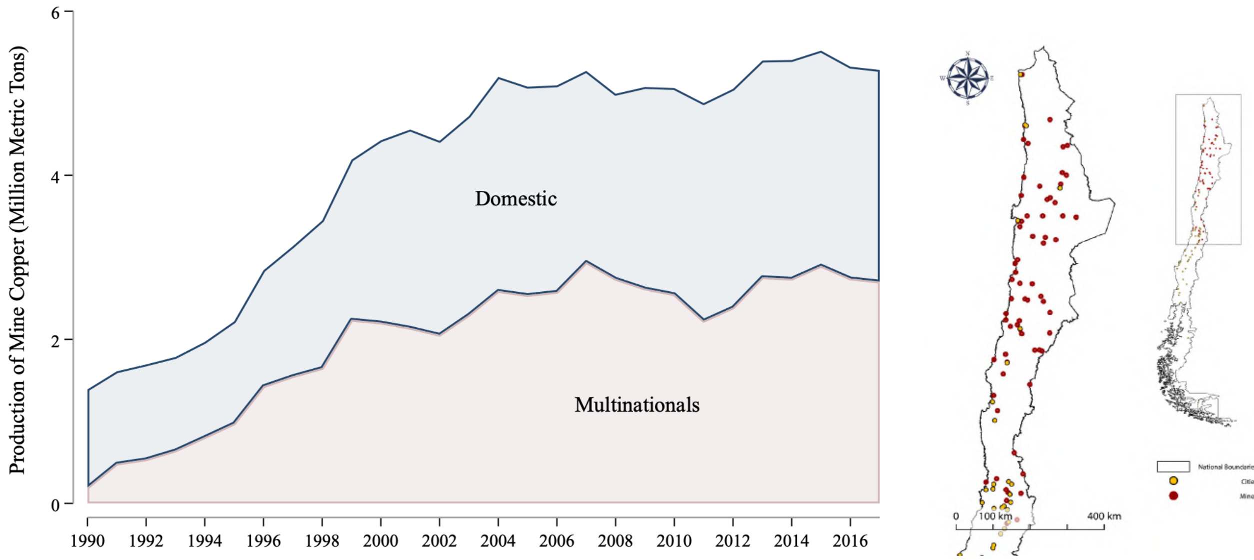
Figures

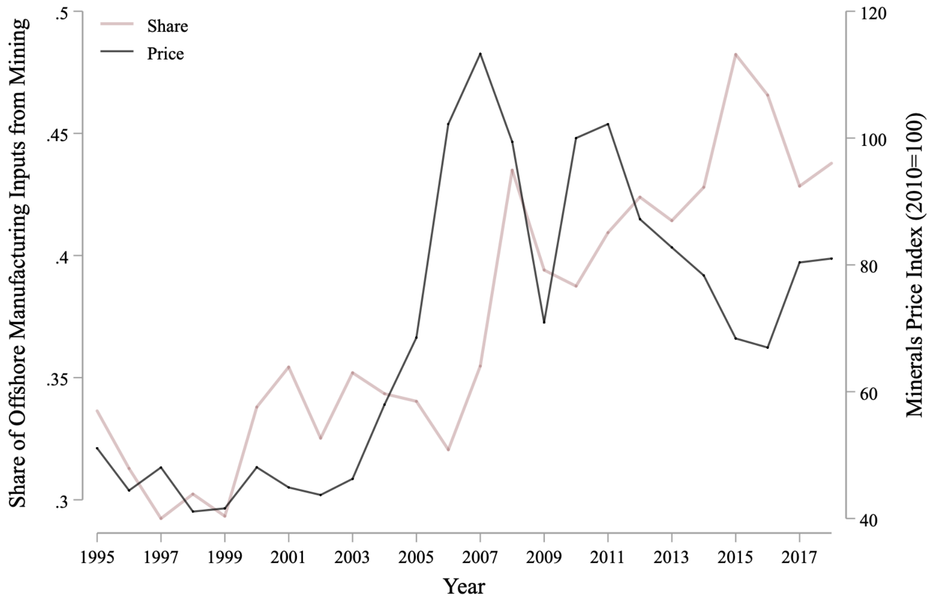


(a) Production by Ownership

(b) Cities and Mines

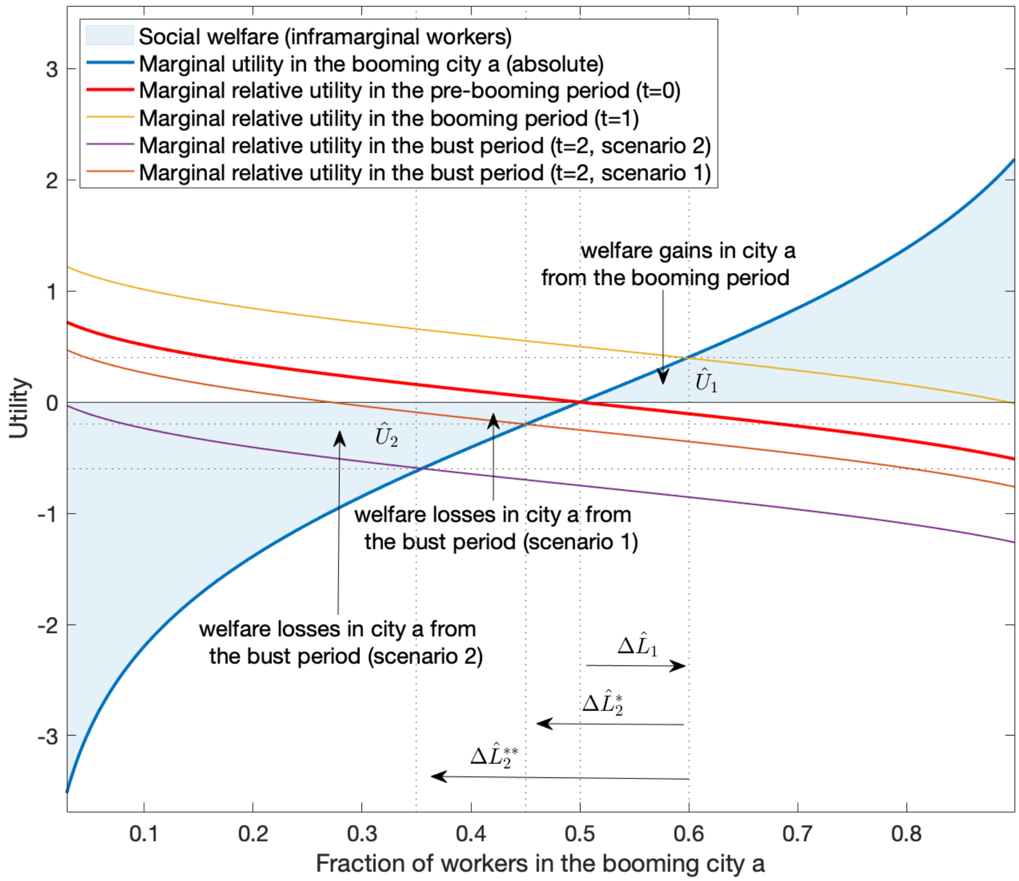
Notes: The figure (a) displays the temporal evolution of production of mine copper among MNCs and domestic firms. As well as the variation of the price of copper. The state-owned corporation, Codelco, concentrates 31.5% of national copper production, and 68.5% is private investment. The total contribution of the mining sector to the GDP is about 10%. For some regions, this is 54% of the GDP (in the Antofagasta Region). The figure (b) shows the geographical distribution of cities (with population over 25,000 at the beginning of the sample), and large-scale mines. While population distribution is highly concentrated in the central part of the country, mines are more spread over the central-north and northern regions. These regions are characterized by dry land less favourable to agriculture. This particular spatial distribution yields heterogeneous exposure to mining activity for cities in the north in comparison to cities in the central and south of Chile. *Source:* Own elaboration based on data from the Chilean Copper Corporation (Cochilco).

Figure 1: Expansion of the Chilean Copper Industry



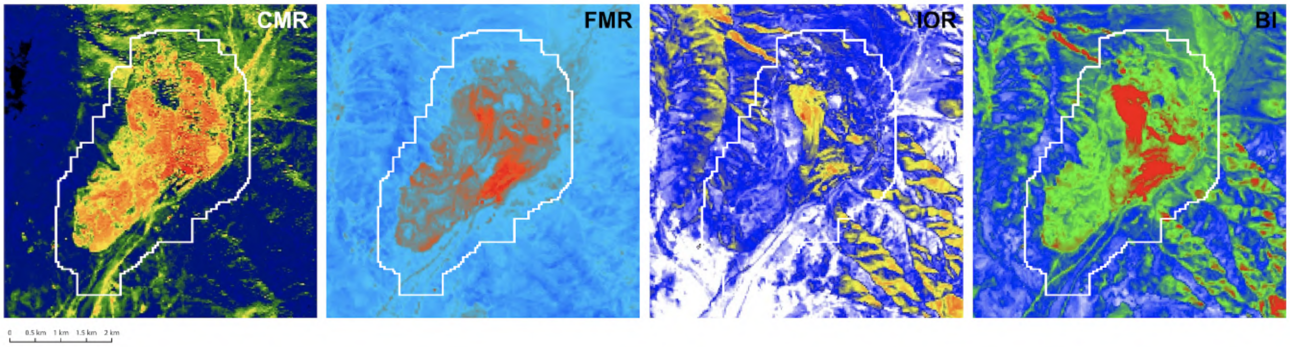
Notes: The figure shows the surge in offshoring of manufacturing inputs in the Chilean mining industry during the super-cycle of mineral prices. Offshoring is measured as the ratio between manufactured inputs imported by the mining sector over the total manufactured inputs used by the sector. Domestic purchases can be considered a potential indicator of the creation of productive linkages in the national economy. The tendency of purchases follows the super-cycle of mineral prices. The mining within-sector purchases follows the same path. *Source:* Own elaboration based on data from OECD Input-Output Tables and World Bank.

Figure 2: Offshoring and the Minerals Price Boom



Notes: The figure illustrates a numerical example over the model to compare the relative welfare gains and losses from a resource boom and bust in city a (booming city). The figure depicts two post-booming scenarios. One with low disamenity effects caused by the resource sector, and another with large disamenity effects. The last one can lead to population losses in the booming city in the long-term. *Source:* Own elaboration based on Kline and Moretti (2014).

Figure 3: Relative Welfare Effects from the Resource Sector



Notes: The figure describes concentration of heavy metals within the boundaries of the Chuquicamata copper mine. These indexes were computed using the non-visible spectral bands of the LandSat images. *Source:* Own elaboration.

Figure 4: Concentration of Heavy Metals in Mining Sites

Tables

Table 1: Qualitative Relative Predictions of a Resource Boom and Bust

	Overall Effects	Comparison MNCs/Domestic Firms' Eq.
Booming Period (short-term)		
Population and Employment	$+$	$\downarrow$
Wages and Housing Rents	$+$	$\uparrow$
Manufacturing Employment	$-$	$\downarrow$
Bust Period (long-term)		
Manufacturing Productivity	$-/+$	$\uparrow$
Social Welfare	$-/+$	$\uparrow$

Notes: The table describes the qualitative predictions of the theoretical model of a city more exposed to the resource boom in comparison to a city less exposed. The short-term predictions consider the booming period in $t = 1$, while the long-term refers to the cumulative effects considering the bust period $t = 2$. Overall effects shows the expected signs of the shock in the resource sector without distinguishing between MNCs and domestic firms, but, in comparison to Allcott and Keniston (2018), it considers the effects of the resource shock via productive linkages. The comparison between MNCs and domestic firms equilibrium consider the case in which the city that experiences the resource boom is dominated by MNCs in relation to the equilibrium in which the exposed city is dominated by domestic companies. Social welfare effects assumes amenities negatively correlated with the boom.

Table 2: Relative Effects in the Labor Market

	Change in Log Population						Change in Log Employment					
	Overall		Domestic		Multinationals		Overall		Domestic		Multinationals	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	OLS	2SLS	OLS	2SLS	OLS	2SLS	OLS	2SLS	OLS	2SLS	OLS	2SLS
Log Exposure	0.007	0.011	0.015	0.016	0.013	0.003	0.006	0.008	0.006	0.009	0.008	0.009
	(0.004)	(0.005)	(0.004)	(0.005)	(0.006)	(0.005)	(0.001)	(0.002)	(0.002)	(0.003)	(0.003)	(0.006)
Year FE + Controls	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Adjusted R^2	0.093		0.140		0.102		0.145		0.144		0.144	
Observations	365	365	365	365	365	365	365	365	365	365	365	365
First-Stage:												
K-P F-stat		39.427		77.681		218.893		39.427		77.681		218.893
Mineral Intensity		0.792		0.628		0.514		0.792		0.628		0.514
		(0.126)		(0.071)		(0.035)		(0.126)		(0.071)		(0.035)
	Change in Log Wages						Change in Log Rents					
	Overall		Domestic		Multinationals		Overall		Domestic		Multinationals	
	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)	(23)	(24)
	OLS	2SLS	OLS	2SLS	OLS	2SLS	OLS	2SLS	OLS	2SLS	OLS	2SLS
Log Exposure	0.004	0.008	0.004	0.010	0.005	0.014	0.021	0.022	0.010	0.022	0.031	0.067
	(0.003)	(0.004)	(0.003)	(0.007)	(0.004)	(0.005)	(0.007)	(0.009)	(0.009)	(0.016)	(0.014)	(0.012)
Year FE + Controls	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Adjusted R^2	0.785		0.785		0.785		0.757		0.900		0.901	
Observations	365	365	365	365	365	365	365	365	365	365	365	365
First-Stage:												
K-P F-stat		44.995		80.227		328.827		44.995		80.227		328.827
Mineral Intensity		0.791		0.627		0.510		0.791		0.627		0.510
		(0.118)		(0.070)		(0.028)		(0.118)		(0.070)		(0.028)

Notes: $^{*}p < .10$, $^{**}p < .05$, $^{***}p < .01$. Standard errors in parenthesis and 95% confidence intervals in square brackets. Standard errors are clustered at the regional level. First-stage results are reported in the Appendix. Control variables, which varies with time and location, include: wages, population, quality of education, fiscal dependency on national government, per capita fiscal income.

Table 3: Relative Welfare Effects

	Relative Welfare					
	Overall		Domestic Firms		Multinationals	
	(1)	(2)	(3)	(4)	(5)	(6)
	OLS	2SLS	OLS	2SLS	OLS	2SLS
Wage elasticity	0.004	0.008	0.004	0.010	0.005	0.014
	(0.003)	(0.004)	(0.003)	(0.007)	(0.004)	(0.005)
Rent elasticity	0.021	0.022	0.010	0.022	0.031	0.067
	(0.007)	(0.009)	(0.009)	(0.016)	(0.014)	(0.012)
$\hat{\beta}_{wage} - 0.3\hat{\beta}_{rent}$	-0.002	0.002	0.000	0.004	-0.004	-0.006
Annual average real wage (log points)	-0.002	0.002	0.000	0.002	-0.005	-0.007
Population elasticity	0.007	0.011	0.015	0.016	0.013	0.003
	(0.004)	(0.005)	(0.004)	(0.005)	(0.006)	(0.005)
Annual average population gain (log points)	0.003	0.005	0.001	0.001	0.008	0.002

Notes: $^{*}p < .10$, $^{**}p < .05$, $^{***}p < .01$. Standard errors in parenthesis. Period 2000-2013. Cities 73.

Table 4: Relative Heterogeneous Effects in Employment and Revenue by Sector

	Change in Log Employment											
	Manufacturing						Services					
	Overall		Domestic		Multinationals		Overall		Domestic		Multinationals	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	OLS	2SLS	OLS	2SLS	OLS	2SLS	OLS	2SLS	OLS	2SLS	OLS	2SLS
Log Exposure	-0.011	-0.039	-0.027	-0.038	-0.020	-0.053	0.010	0.012	0.016	0.013	0.017	0.003
	(0.010)	(0.020)	(0.017)	(0.022)	(0.014)	(0.022)	(0.006)	(0.009)	(0.009)	(0.014)	(0.010)	(0.011)
Year FE + Controls	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Adjusted R^2	0.198		0.200		0.198		0.108		0.109		0.108	
Observations	365	365	365	365	365	365	365	365	365	365	365	365
First-Stage:												
K-P F-stat		39.427		77.681		218.893		39.427		77.681		218.893
Mineral Intensity		0.792		0.628		0.514		0.792		0.628		0.514
		(0.126)		(0.071)		(0.035)		(0.126)		(0.071)		(0.035)

	Change in Log Revenue											
	Manufacturing						Services					
	Overall		Domestic		Multinationals		Overall		Domestic		Multinationals	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	OLS	2SLS	OLS	2SLS	OLS	2SLS	OLS	2SLS	OLS	2SLS	OLS	2SLS
Log Exposure	0.052	0.055	0.078	0.023	0.097	0.095	0.139	0.166	0.183	0.192	0.217	0.157
	(0.030)	(0.046)	(0.055)	(0.061)	(0.052)	(0.048)	(0.047)	(0.058)	(0.040)	(0.058)	(0.055)	(0.061)
Year FE + Controls	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Adjusted R^2	0.133		0.139		0.137		0.203		0.230		0.209	
Observations	365	365	365	365	365	365	365	365	365	365	365	365
First-Stage:												
K-P F-stat		39.875		53.598		119.803		39.875		53.598		119.803
Mineral Intensity		0.751		0.584		0.548		0.751		0.584		0.548
		(0.119)		(0.080)		(0.050)		(0.119)		(0.080)		(0.050)

Notes: $^{*}p < .10$, $^{**}p < .05$, $^{***}p < .01$. Standard errors in parenthesis and 95% confidence intervals in square brackets. Standard errors are clustered at the regional level. First-stage results are reported in the Appendix. Control variables, which varies with time and location, include: wages, population, quality of education, fiscal dependency on national government, per capita fiscal income.

Table 5: Effects on the Productivity of Manufacturing Firms

	Change in Log TFP											
							Olley-Pakes method					
	Overall		Domestic		Multinationals		Overall		Domestic		Multinationals	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	OLS	2SLS	OLS	2SLS	OLS	2SLS	OLS	2SLS	OLS	2SLS	OLS	2SLS
Log Exposure	0.060	0.088	0.078	0.023	0.097	0.095	0.048	0.051	0.025	0.017	0.075	0.067
	(0.028)	(0.033)	(0.055)	(0.061)	(0.052)	(0.048)	(0.027)	(0.031)	(0.020)	(0.022)	(0.030)	(0.036)
Year FE + Controls	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Adjusted R^2	0.037		0.139		0.137		0.030		0.029		0.029	
Observations	2,215	2,215	2,215	2,215	2,215	2,215	2,215	2,215	2,215	2,215	2,215	2,215
First-Stage:												
K-P F-stat		17.762		112.169		112.169		17.762		112.169		112.169
Mineral Intensity		0.333		0.525		0.525		0.333		0.525		0.525
		(0.079)		(0.050)		(0.050)		(0.079)		(0.050)		(0.050)

Notes: *$p < .10$, **$p < .05$, ***$p < .01$. Extended results and Levinsohn-Petrin estimates of the TFP are reported in the Appendix. Standard errors (in parentheses) are clustered at the regional level. 95% confidence intervals in square brackets. Controls include the size of the plant, the type of property of the plant, the percent of shares of domestic ownership, the type of firm, and the value of exported goods. The TFP is computed by residualizing the value added against wages and labor and the total value of capital stock. The Olley-Pakes estimation includes the value of investments as a proxy variable of the probability of exit. The correlation between the logarithm of exposure to mining shocks and the logarithm of backward linkages is 0.962.

A Appendix

A.1 Mathematical Appendix

A.1.1 Housing and Local Goods Market Equilibrium

The equilibrium price in the local non-tradable goods is obtained equalizing local demand which is individual demand for non-tradables times the number of workers in the city L_c, with local supply. Then, considering free mobility of workers across sectors within a city, i.e. $w_{lc} = w_{zlc} = w_c$ and substituting the number of local varieties Ω_{lc} yields

$$\begin{aligned}
L_c(\gamma w_c) = p_{lc}Q_{lc} &= p_{lc}(vA_{lc}\Omega_{lc}^{\eta}L_{lc}^{\delta}L_{zlc}^{1-\delta}) \\
&= p_{lc}vA_{lc}\Omega_{lc}^{\eta}L_{lc}^{\delta}\left[\alpha\left(\frac{1-\delta}{\delta}\right)\frac{w_{lc}L_{lc}}{w_{zlc}}\right]^{1-\delta} \\
\iff p_{lc} &= \left(\frac{\gamma\delta}{\alpha^{1-\delta}}\right)\frac{w_c L_c}{A_{lc}\Omega_{lc}^{\eta}L_{lc}} \\
&= \left(\frac{\gamma\delta^{1+\eta}}{\alpha^{1-\delta}(1-\alpha)^{\eta}(1-\delta)^{\eta}}\right)\frac{w_c^{1-\eta}L_c}{\lambda_c^{\eta}A_{lc}L_{lc}^{1+\eta}}.
\end{aligned} \tag{20}$$

Taking the logs yields

$$\log p_{lc} = (1-\eta)\log w_c + \log L_c - \eta\log\lambda_c - \log A_{lc} - (1+\eta)\log L_{lc} + k_p \tag{21}$$

where $\kappa_p = \log\left(\frac{\gamma\delta}{\alpha^{1-\delta}}\right)$. Taking the log of the ratio (equivalent notation to the difference in logs in Allcott and Keniston, 2018) between the two cities $c = \{a, b\}$, we can represent the relative prices for the local non-tradable sector as

$$\log\hat{p}_l = (1-\eta)\log\hat{w} + \log\hat{L} - \eta\log\hat{\lambda} - \log\hat{A}_l - (1+\eta)\log\hat{L}_l \tag{22}$$

where $\hat{p}_l \equiv \left(\frac{p_{la}}{p_{lb}}\right)$, $\hat{w} \equiv \left(\frac{w_a}{w_b}\right)$, $\hat{L} \equiv \left(\frac{L_a}{L_b}\right)$, $\hat{A}_l \equiv \left(\frac{A_{la}}{A_{lb}}\right)$, $\hat{\Omega}_l \equiv \left(\frac{\Omega_{la}}{\Omega_{lb}}\right)$, and $\hat{L}_l \equiv \left(\frac{L_{la}}{L_{lb}}\right)$. In the case of housing, given the constant elasticity supply functions in Eqn. 1 $r_c = H_0L_c^h$, we can express the relative housing supply as

$$\log\hat{r}_c = h\log\hat{L} \tag{23}$$

where $\hat{r}_h \equiv \left(\frac{r_{ha}}{r_{hb}}\right)$, and $\hat{L} \equiv \left(\frac{L_a}{L_b}\right)$. The price in the resource sector p_{rc} is exogenously set in international markets, while the price in the tradable sector is defined as the numeraire $p_{mc} = 1$.

A.1.2 Labor Market Equilibrium

Aggregate Labor Demand

Aggregate labor demand equals the labor in the final good and intermediate sectors. We can express the aggregate labor in city c in terms of labor in the final good sector as

$$
\begin{aligned}
L_c &= \sum_j L_{jc} + \sum_j L_{zjc} \\
L_c &= \sum_j L_{jc} + \left(\frac{1-\delta}{\delta}\right) \sum_j L_{jc} \\
L_c &= \left(\frac{1}{\delta}\right) \sum_j L_{jc}
\end{aligned}
$$

where $\left(\frac{1}{\delta}\right)$ is the multiplier effect.

Given the assumption that wages equalize across sectors within a city and given that firms pay minimum cost wages, then $w_c = w_{jc} = \alpha^{\frac{1-\delta}{\delta}} (p_{jc} A_{jc} \Omega_{jc}^{\eta})^{\frac{1}{\delta}} / w_{zjc}^{\frac{1-\delta}{\delta}}$. Using the cost-minimizing wages, rearranging terms and substituting the equilibrium price in the non-tradable sector, yields

$$
\begin{aligned}
\alpha^{1-\delta}\left(\frac{1}{\delta}\right) \sum_j p_{jc} A_{jc} \Omega_{jc}^{\eta} L_{jc} &= \alpha^{1-\delta}\left(\frac{1}{\delta}\right) \sum_j p_{jc} A_{jc} \Omega_{jc}^{\eta} L_{jc} \\
\sum_j w_{jc} L_{jc} &= \alpha^{1-\delta}\left(\frac{1}{\delta}\right) \sum_j p_{jc} A_{jc} \Omega_{jc}^{\eta} L_{jc} \\
\left(\frac{1}{\alpha^{1-\delta}}\right) w_c \sum_j L_{jc} - p_{lc} A_{lc} \Omega_{lc}^{\eta} L_{lc} &= p_{mc} A_{mc} \Omega_{mc}^{\eta} L_{mc} + p_{rc} A_{rc} \Omega_{rc}^{\eta} L_{rc} \\
\left(\frac{\delta}{\alpha^{1-\delta}}\right) w_c L_c - \left(\frac{\gamma\delta}{\alpha^{1-\delta}}\right) \frac{w_c L_c}{A_{lc} \Omega_{lc}^{\eta} L_{lc}} A_{lc} \Omega_{lc}^{\eta} L_{lc} &= X_{mc} \Omega_{mc}^{\eta} L_{mc} + X_{rc} \Omega_{rc}^{\eta} L_{rc} \\
(1-\gamma)\delta w_c L_c &= \alpha^{1-\delta} \sum_{j=m,r} X_{jc} \Omega_{jc}^{\eta} L_{jc}.
\end{aligned}
$$

We can simplify more this expression by taking advantage of the total number of local varieties in equilibrium Ω_{jc},

$$(1-\gamma)\delta w_c L_c = \alpha^{1-\delta} \sum_{j=m,r} X_{jc} \left((1-\alpha) \left(\frac{1-\delta}{\delta} \right) \lambda_{jc} w_{jc} L_{jc} \right)^{\eta} L_{jc}$$

$$(1-\gamma)\delta w_c^{1-\eta} L_c = \alpha^{1-\delta} \left[(1-\alpha) \left(\frac{1-\delta}{\delta} \right) \right]^{\eta} \lambda_c^{\eta} \sum_{j=m,r} X_{jc} L_{jc}^{1+\eta}$$

$$w_c = \left(\kappa_w \lambda_c^{\eta} \sum_{j=m,r} \frac{X_{jc} L_{jc}^{1+\eta}}{L_c} \right)^{\frac{1}{1-\eta}} \tag{24}$$

where $\kappa_w \equiv \left(\frac{\alpha^{1-\delta}}{(1-\gamma)\delta} \right)^{\frac{1}{1-\eta}} \left[(1-\alpha) \left(\frac{1-\delta}{\delta} \right) \right]^{\frac{\eta}{1-\eta}}$. Then aggregate inverse labor demand taking logarithms gives

$$(1-\eta) \log w_c = \eta \log \lambda_c + \log \sum_{j=m,r} X_{jc} + (1+\eta) \log \sum_{j=m,r} L_{jc} - \log L_c + \kappa_w. \tag{25}$$

In consequence, for the case of two cities $c = \{a, b\}$, the relative inverse labor demand can be written as

$$(1-\eta) \log \hat{w} = \eta \log \hat{\lambda} + \log \sum_{j=m,r} \hat{X}_j + (1+\eta) \log \sum_{j=m,r} \hat{L}_j - \log \hat{L} \tag{26}$$

where $\hat{w} \equiv \left(\frac{w_a}{w_b} \right)$, $\hat{\lambda} \equiv \left(\frac{\lambda_a}{\lambda_b} \right)$, $\hat{L}_j \equiv \left(\frac{L_{ja}}{L_{jb}} \right)$, and $\hat{L} \equiv \left(\frac{L_a}{L_b} \right)$.

Aggregate Labor Supply

In terms of aggregate labor supply. Assuming spatial equilibrium $U_{ic} = \overline{u}$, and that $\log \epsilon_{ic}$ is distributed type I extreme value with scale parameter ξ^2 with $\xi \in (0, \infty)$, and considering that the tradable good m is the numeraire, then the inverse labor supply can be written as

$$\log w_c = \log \overline{U} + \gamma \log p_{lc} + \varphi \log r_c - \log B_c + \xi \log L_c - \kappa_u, \tag{27}$$

and in relation to both cities $c = \{a, b\}$,

$$\log \hat{w} = \gamma \log \hat{p}_l + \varphi \log \hat{r} - \log \hat{B} + \xi \log \hat{L} \tag{28}$$

where $\hat{w} \equiv \left(\frac{w_a}{w_b} \right)$, $\hat{p}_l \equiv \left(\frac{p_{la}}{p_{lb}} \right)$, $\hat{r} \equiv \left(\frac{r_a}{r_b} \right)$, $\hat{B} \equiv \left(\frac{B_a}{B_b} \right)$, and $\hat{L} \equiv \left(\frac{L_a}{L_b} \right)$.

A.1.3 Relative Effects in Local Labor Markets

Substituting in the aggregate inverse labor supply (Eqn. 28), the equilibrium relative local goods prices from Eqn. 22 and the relative equilibrium housing prices from Eqn. 23 yields

$$\log \hat{w} = \gamma\Big((1-\eta)\log \hat{w} + \log \hat{L} - \eta \log \hat{\lambda} - \log \hat{A}_l - (1+\eta)\log \hat{L}_l\Big) + \varphi h \log \hat{L} - \log \hat{B} + \xi \log \hat{L}$$
$$\iff [1-\gamma(1-\eta)]\log \hat{w} = (\gamma + \varphi h + \xi)\log \hat{L} - \gamma \log \hat{A}_l - \gamma(1+\eta)\log \hat{L}_l - \log \hat{B}$$

Substituting the relative inverse labor demand (Eqn. 26) and solving for the relative population difference gives

$$\begin{aligned}(\gamma + \varphi h + \xi)\log \hat{L} - \gamma \log \hat{A}_l - \gamma(1+\eta)\log \hat{L}_l - \log \hat{B} &\\ = \rho\Big(\eta \log \hat{\lambda} + \log \sum_{j=m,r} \hat{X}_j + (1+\eta)\log \sum_{j=m,r} \hat{L}_j - \log \hat{L}\Big)&\\ \iff [\gamma + \varphi h + \xi + \rho]\log \hat{L} = \rho\eta \log \hat{\lambda} + \rho \log \sum_{j=m,r} \hat{X}_j + \rho(1+\eta)\log \sum_{j=m,r} \hat{L}_j&\\ + \gamma \log \hat{A}_l + \gamma(1+\eta)\log \hat{L}_l + \log \hat{B}&\end{aligned} \tag{29}$$

where $\rho \equiv \frac{[1-\gamma(1-\eta)]}{(1-\eta)} = 1-\gamma$. Defining $\tau \equiv \frac{1}{\gamma+\varphi h+\xi+\rho} = \frac{1}{1+\varphi h+\xi}$, we can express the equilibrium relative population equation (or migration equation) as

$$\log \hat{L} = \rho\tau\eta \log \hat{\lambda} + \rho\tau \log \sum_{j=m,r} \hat{X}_j + \rho\tau(1+\eta)\log \sum_{j=m,r} \hat{L}_j + \gamma\tau \log \hat{A}_l + \gamma\tau(1+\eta)\log \hat{L}_l + \tau \log \hat{B} \tag{30}$$

Then, substituting this population difference again in the relative inverse labor demand Eqn. 26, yields the equilibrium relative wages

$$\begin{aligned}(1-\eta)\log \hat{w} &= \eta \log \hat{\lambda} + \log \sum_{j=m,r} \hat{X}_j + (1+\eta)\log \sum_{j=m,r} \hat{L}_j\\ &-\Big(\rho\tau\eta \log \hat{\lambda} + \rho\tau \log \sum_{j=m,r} \hat{X}_j + \rho\tau(1+\eta)\log \sum_{j=m,r} \hat{L}_j + \gamma\tau \log \hat{A}_l + \gamma\tau(1+\eta)\log \hat{L}_l + \tau \log \hat{B}\Big)\\ \iff (1-\eta)\log \hat{w} &= \eta(1-\rho\tau)\log \hat{\lambda} + (1-\rho\tau)\log \sum_{j=m,r} \hat{X}_j + (1+\eta)(1-\rho\tau)\log \sum_{j=m,r} \hat{L}_j\\ &-\gamma\tau \log \hat{A}_l - \gamma\tau(1+\eta)\log \hat{L}_l - \tau \log \hat{B}\end{aligned}$$

then, let define

$$\hat{X}_n \equiv \hat{\lambda}^{\eta} \sum_{j=m,r} \hat{p}_j \hat{A}_j \tag{31}$$

the relative equilibrium wages are

$$\log \hat{w} = (1-\rho\tau)\Big(\log \hat{X}_n + (1+\eta)\log \hat{L}_n\Big) - \gamma\tau\Big(\log \hat{A}_l + (1+\eta)\log \hat{L}_l\Big) - \tau \log \hat{B} \tag{32}$$

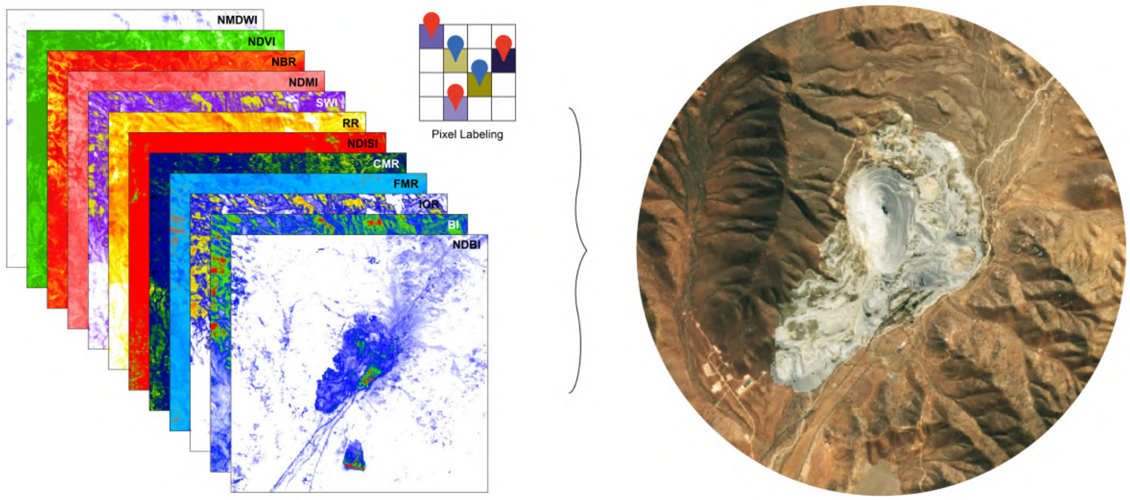
and the migration equation can be expressed as

$$\log \hat{L} = \rho\tau\Big(\log \hat{X}_n + (1+\eta)\log \hat{L}_n\Big) + \gamma\tau\Big(\log \hat{A}_l + (1+\eta)\log \hat{L}_l\Big) + \tau \log \hat{B}. \tag{33}$$

The effects on the productivity of the manufacturing sector can be obtained substituting equilibrium conditions in the productivity evolution for the tradable sector, and solving for

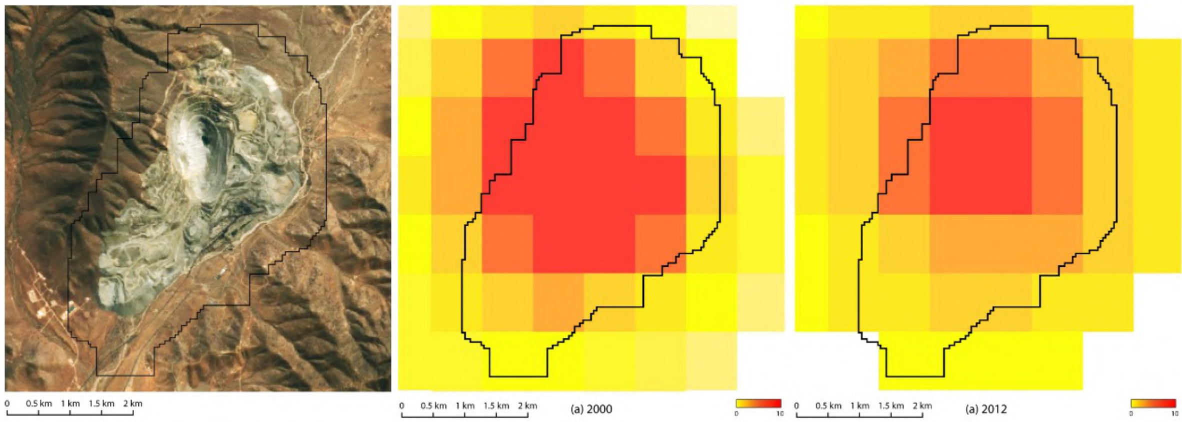
$$\begin{aligned}
&\log \hat{A}_{m,t+1} = \psi_m \log \hat{A}_{m,t} + \phi_m \log \hat{L}_{m,t} + \Lambda \log \hat{L}_t \\
&\quad\Longleftrightarrow\ \log \hat{A}_{m,t+1} = \psi_m \log \hat{A}_{m,t} + \phi_m \log \hat{L}_{m,t} + \Lambda\Big[\rho\tau\Big(\log \hat{X}_n + (1+\eta)\log \hat{L}_n\Big) \\
&\qquad\qquad + \gamma\tau\Big(\log \hat{A}_l + (1+\eta)\log \hat{L}_l\Big) + \tau \log \hat{B}\Big].
\end{aligned}$$

A.2 Additional Figures

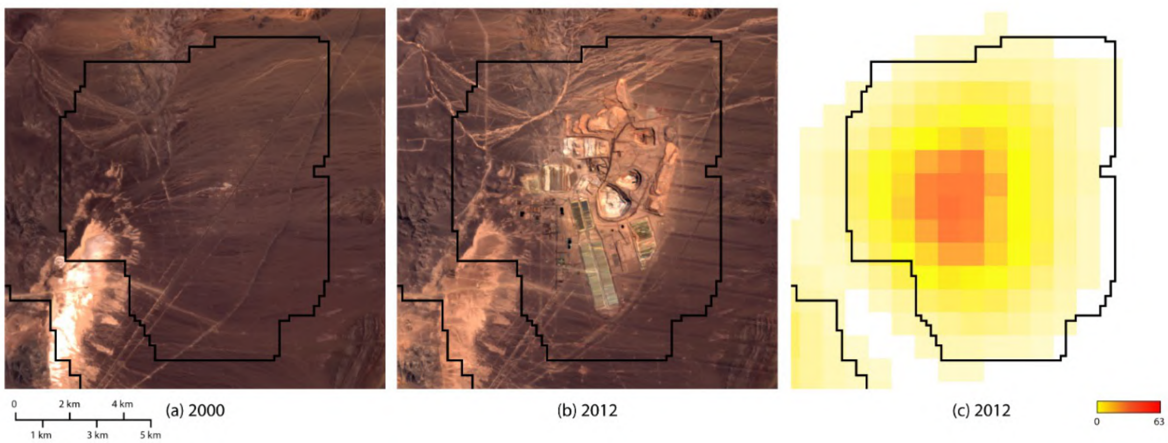


The figure summarizes the methodology used to identify the area of each mining site. This methodology roughly follows Connette et al. (2016) and Werner et al. (2020). The method consist of a seven-step procedure. (1) In the first place, the following spectral indexes are computed using the visible and invisible range of the Sentinel and LandSat satellites. These indexes are NMDWI, NDVI, NBR, NDMI, SWI, RR, NDISI, CMR, FMR, IOR, BI, and NDBI, and summarize information on Water, Vegetation. In addition NTL is used. (2) In the second step a Support Vector Machine (SVM) classification algorithm is used to classify images (10x10m), using the most recent satellite information. A mask of vegetation, water, and dark areas is used to diminish the amount of pixels to classify for mines. (3) With the remaining pixels, a random forest algorithm is used to define which pixels are mine and the others that are not. (4) A focal statistical with a kernel of 5 (50m) is used to make easy build polygons of mines. (5) Classified pixels averaged by the max to a 5m resolutions are grouped and transformed to vectors (polygons). (6) For each polygon built in the previous step, the quantity of pixels that are classified as part of mines are computed and a filter of at least 100 mine pixels is applied to reduce the number of classified polygons from 489 with at least 1 pixel identified as mine to 89. (7) centroid coordinates of mines, area used for production (pixels classified as mines), and the light intensity on each pixel classified as mines is computed.

Figure A.1: Identification of the Area of Mining Sites



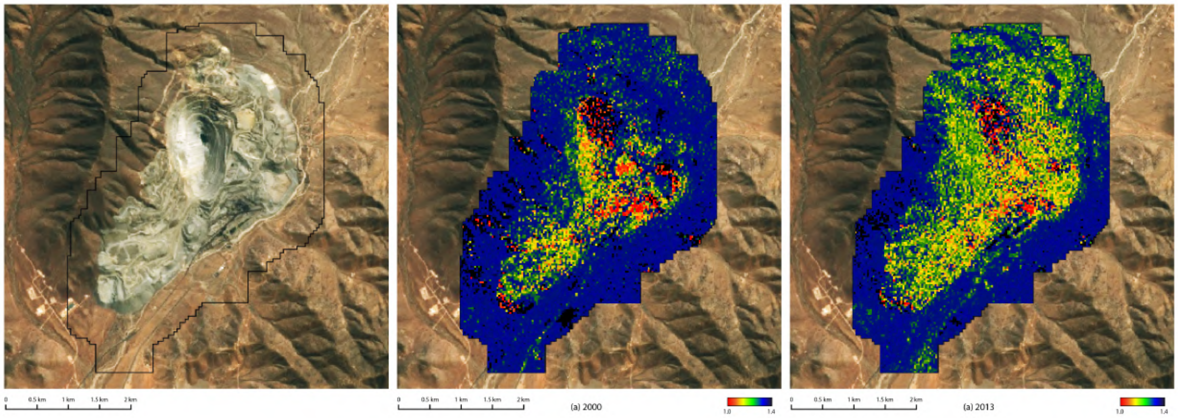
(a) El Romeral Mine



(b) BHP Spence Mine

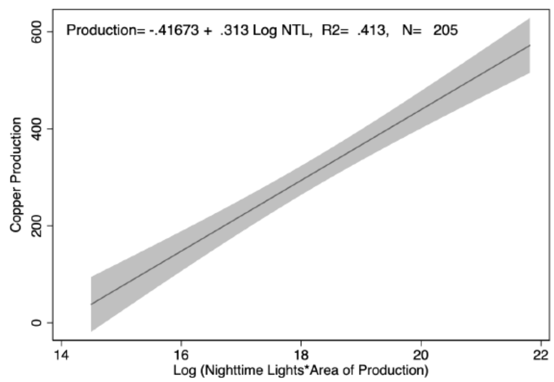
The figure compares the aggregate production of minerals against the aggregate nighttime lights on mining plants between 1992 and 2012. Data for validation was obtained from (Baker et al., 2017). Which contains recent geospatial data from the UGSG on explorations, mines, and ports that exports mineral commodities in Latin America.

Figure A.2: Examples of Area and Nighttime Lights Identified

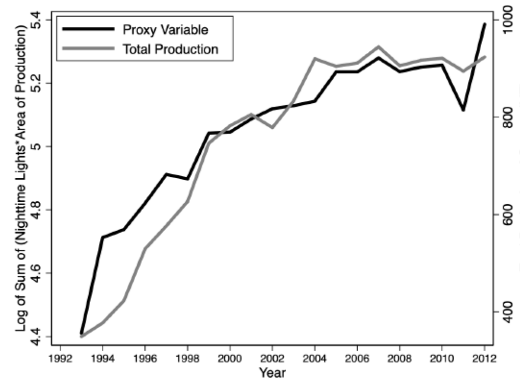


Following the intuition of Faber and Gaubert (2019) to identify the intrinsic characteristics of a place (quality of beaches in their case), and a wide literature in mineral geology such as: Segal (1982), Drury (1987), and Wolf (2012). I use different multispectral satellite mineral-related indices as a proxy measure of the quality of the mineral extracted and therefore as predictor of the profit ratio of each mine. These indices use the visible and infrared information capture by satellites. Visible light capture by cameras cover the Blue (450-495, μm), Green (495-570, μm), and Red (620-750, μm) bands of the satellite. While the infrared are divided in: Near Infrared (NIR, 750-900, μm), Short Wave Infrared (SWIR, 900-3000, μm), and Thermal Infrared (TIR, 3000-14000, μm). Specifically, the concentration of particular minerals are identified using the spectral range of the satellite (i.e. that are non-visible to the human eye) that can be measure with LandSat-7, which are: the clay minerals ratio (CMR), the ferrous minerals ratio (FMR), the iron oxide ratio (IOR), the WorldView New Iron Index (WV-II) and the WorldView Soil Index (WV-SI). In addition, the Bare Soil Index (BI) is used to improve the accuracy of other indices. The clay minerals ratio is computed as the quotient between the shortwave infrared (SWIR) that lie between 1.55 to 1.75 μm (LandSat7 satellite band 5) over shortwave infrared in the range 2.08 to 2.35 μm (LanSat7 satellite band 7). $CMR = \frac{SWIR1}{SWIR2}$. The ferrous minerals ratio (FMR) is the quotient between the shortwave-infrared in the range 1.55 to 1.75 μm over the near infrared in the range 0.76 to 0.8 μm (LandSat7 satellite band 4). $FMR = \frac{SWIR}{NIR}$ The iron oxide ratio (IOR) is computed as the quotient between the red (0.63-0.69 μm, LandSat-7 satellite band 3) and blue bands (0.45-0.52 μm, LandSat-7 satellite band 1) of the satellite. $IOR = \frac{Red}{Blue}$ The bare soil index is computed as $BI = \frac{B4+B2-B3}{B4+B2+B3}$.

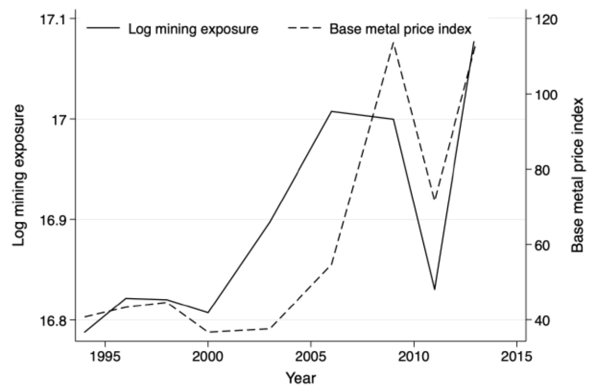
Figure A.3: Illustration of the Instrumental Variable



(a) Validation with Individual Plant Production



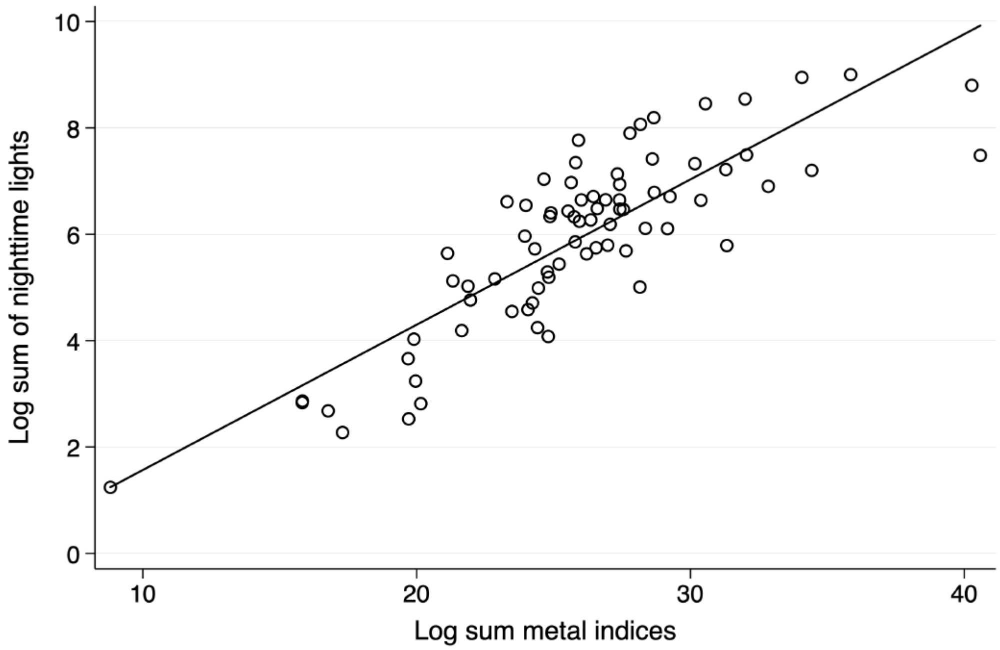
(b) Validation with Aggregate Total Production



(c) Validation with Price Trends

The figure compares the aggregate production of minerals against the aggregate nighttime lights on mining plants between 1992 and 2012. Data for validation was obtained from (Baker et al., 2017). Which contains recent geospatial data from the UGSG on explorations, mines, and ports that exports mineral commodities in Latin America.

Figure A.4: Validation of Satellite Measures of Mining Activity



Notes: The figure compares logarithm of the sum of the concentration of heavy metals in soil within the boundaries of the mining plants, against the logarithm of the sum of nighttime lights on mining plants between 1992 and 2012. *Source:* Own elaboration.

Figure A.5: Prediction of Total Annual Production of Each Mining Plant

B Supplementary Material

Table B1: Effects on Population – Overall – (extended results)

	Log Population							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS
Log exposure to mining	0.009**	0.007	0.006	0.006	0.006	0.005	0.004	0.003
	(0.004)	(0.004)	(0.004)	(0.005)	(0.005)	(0.006)	(0.006)	(0.006)
Local economic conditions:								
- % of High-Skill Workers		0.241**	0.009	-0.015	-0.016	-0.153	-0.201	-0.186
		(0.094)	(0.130)	(0.146)	(0.149)	(0.160)	(0.162)	(0.151)
- Krugman Specialization Index			-0.112**	-0.132**	-0.132**	-0.138**	-0.115*	-0.124*
			(0.041)	(0.051)	(0.052)	(0.054)	(0.059)	(0.068)
- Mining Royalty				0.000	0.000	0.000	0.000	0.001
				(0.002)	(0.002)	(0.003)	(0.003)	(0.003)
- Fiscal Dependency					0.000	-0.005	-0.010	-0.008
					(0.000)	(0.006)	(0.008)	(0.008)
- Fiscal Windfalls (per capita)						0.006*	0.003	0.004
						(0.003)	(0.004)	(0.005)
Local amenities:								
- Crime							0.011	0.011
							(0.008)	(0.008)
- No of Sports Clubs								-0.003
								(0.006)
Constant	-0.114*	-0.101	-0.062	-0.056	-0.057	-0.097	-0.107	-0.105
	(0.061)	(0.061)	(0.057)	(0.068)	(0.068)	(0.074)	(0.068)	(0.080)
Adjusted R^2	0.062	0.081	0.107	0.101	0.098	0.073	0.077	0.064
F-stat	4.870	9.656	8.173	4.412	5.642	3.315	4.614	3.501
Observations	365	365	365	300	300	236	236	221

Notes: $^{*}p < .10$, $^{**}p < .05$, $^{***}p < .01$. Standard errors in parenthesis and 95%. Standard errors are clustered at the regional level.

Table B2: Effects on Population – Multinationals – (extended results)

	Log Population							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS
Log exposure to mining	0.015**	0.012**	0.012**	0.014*	0.014*	0.012	0.011	0.010
	(0.005)	(0.005)	(0.005)	(0.007)	(0.007)	(0.009)	(0.009)	(0.008)
Local economic conditions:								
- % of High-Skill Workers		0.210**	-0.005	-0.035	-0.035	-0.129	-0.162	-0.158
		(0.089)	(0.114)	(0.139)	(0.142)	(0.140)	(0.137)	(0.131)
- Krugman Specialization Index			-0.115**	-0.139**	-0.139**	-0.143**	-0.123*	-0.134*
			(0.040)	(0.051)	(0.053)	(0.056)	(0.060)	(0.068)
- Mining Royalty				-0.000	-0.000	-0.000	-0.000	0.000
				(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
- Fiscal Dependency					-0.000	-0.006	-0.010	-0.008
					(0.000)	(0.006)	(0.008)	(0.008)
- Fiscal Windfalls (per capita)						0.005	0.002	0.003
						(0.003)	(0.003)	(0.005)
Local amenities:								
- Crime							0.010	0.009
							(0.007)	(0.007)
- No of Sports Clubs								-0.002
								(0.005)
Constant	-0.180**	-0.160**	-0.124*	-0.142*	-0.142*	-0.169*	-0.170*	-0.161*
	(0.068)	(0.071)	(0.065)	(0.079)	(0.079)	(0.091)	(0.085)	(0.089)
Adjusted R^2	0.069	0.087	0.115	0.112	0.109	0.081	0.083	0.070
F-stat	8.762	9.700	7.979	4.955	6.220	2.997	3.532	2.811
Observations	365	365	365	300	300	236	236	221

Notes: $^{*}p < .10$, $^{**}p < .05$, $^{***}p < .01$. Standard errors in parenthesis and 95%. Standard errors are clustered at the regional level.

Table B3: Effects on Population – Domestic – (extended results)

	Log Population							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS
Log exposure to mining	0.016***	0.015***	0.015***	0.020***	0.020***	0.022**	0.021**	0.021***
	(0.005)	(0.005)	(0.004)	(0.006)	(0.006)	(0.007)	(0.007)	(0.007)
Local economic conditions:								
- % of High-Skill Workers		0.201*	-0.021	-0.053	-0.050	-0.170	-0.184*	-0.186*
		(0.097)	(0.109)	(0.126)	(0.124)	(0.099)	(0.097)	(0.098)
- Krugman Specialization Index			-0.118***	-0.149**	-0.148**	-0.146**	-0.137**	-0.155**
			(0.039)	(0.052)	(0.053)	(0.054)	(0.059)	(0.068)
- Mining Royalty				-0.001	-0.001	-0.003	-0.002	-0.002
				(0.001)	(0.001)	(0.002)	(0.002)	(0.002)
- Fiscal Dependency					-0.000	-0.010*	-0.012	-0.010
					(0.000)	(0.005)	(0.007)	(0.007)
- Fiscal Windfalls (per capita)						0.007**	0.006*	0.006
						(0.003)	(0.003)	(0.005)
Local amenities:								
- Crime							0.004	0.003
							(0.006)	(0.005)
- No of Sports Clubs								-0.001
								(0.004)
Constant	-0.177***	-0.172***	-0.140***	-0.180***	-0.180***	-0.252***	-0.251***	-0.244**
	(0.054)	(0.051)	(0.043)	(0.057)	(0.058)	(0.083)	(0.076)	(0.088)
Adjusted R^2	0.106	0.123	0.153	0.163	0.160	0.136	0.134	0.119
F-stat	13.369	30.759	21.074	8.073	9.135	3.109	2.770	2.187
Observations	365	365	365	300	300	236	236	221

Notes: $^{*}p < .10$, $^{**}p < .05$, $^{***}p < .01$. Standard errors in parenthesis and 95%. Standard errors are clustered at the regional level.

Table B4: Effects on Employment – Overall – (extended results)

	Log Employment							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS
Log exposure to mining	0.003*	0.002	0.002	-0.000	-0.000	0.002	0.002	0.000
	(0.001)	(0.001)	(0.002)	(0.003)	(0.003)	(0.002)	(0.003)	(0.003)
Local economic conditions:								
- % of High-Skill Workers		0.114	0.213	0.041	0.055	0.082	0.095	0.183
		(0.086)	(0.134)	(0.137)	(0.139)	(0.189)	(0.207)	(0.192)
- Krugman Specialization Index			0.048	0.040	0.046	0.082	0.076	0.064
			(0.050)	(0.048)	(0.050)	(0.069)	(0.060)	(0.071)
- Mining Royalty				0.000	0.000	-0.003**	-0.003**	-0.001
				(0.001)	(0.001)	(0.001)	(0.001)	(0.002)
- Fiscal Dependency					-0.001	0.000	0.001	0.005
					(0.001)	(0.004)	(0.008)	(0.009)
- Fiscall Windfalls (per capita)						0.001	0.002	0.007
						(0.003)	(0.004)	(0.006)
Local amenities:								
- Crime							-0.003	-0.002
							(0.011)	(0.012)
No. of Sports Clubs								-0.013**
								(0.005)
Constant	-0.013	-0.007	-0.024	0.025	0.029	-0.020	-0.017	-0.042
	(0.023)	(0.023)	(0.026)	(0.041)	(0.043)	(0.053)	(0.047)	(0.057)
Adjusted R^2	0.200	0.199	0.198	0.209	0.207	0.222	0.218	0.221
F-stat	3.237	2.197	2.314	0.688	0.730	1.573	1.975	0.948
Observations	365	365	365	300	300	236	236	221

Notes: $^{*}p < .10$, $^{**}p < .05$, $^{***}p < .01$. Standard errors in parenthesis and 95%. Standard errors are clustered at the regional level.

Table B5: Effects on Employment – Multinationals – (extended results)

	Log Employment							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS
Log exposure to mining	0.006**	0.006**	0.006**	0.005*	0.005*	0.005	0.006	0.001
	(0.002)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.004)	(0.005)
Local economic conditions:								
- % of High-Skill Workers		0.024	0.126	-0.086	-0.090	-0.020	-0.006	0.066
		(0.150)	(0.217)	(0.223)	(0.224)	(0.288)	(0.307)	(0.280)
- Krugman Specialization Index			0.055	0.016	0.014	0.051	0.043	0.038
			(0.058)	(0.052)	(0.053)	(0.069)	(0.057)	(0.060)
- Mining Royalty				0.000	0.000	-0.003***	-0.003***	-0.002
				(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
- Fiscal Dependency					0.000	-0.003	-0.002	0.002
					(0.000)	(0.003)	(0.006)	(0.007)
- Fiscal Windfalls (per capita)						0.002	0.003	0.014**
						(0.003)	(0.004)	(0.005)
Local amenities:								
- Crime							-0.004	-0.004
							(0.009)	(0.011)
- No of Sports Clubs								-0.017***
								(0.004)
Constant	-0.057	-0.054	-0.072*	-0.039	-0.039	-0.037	-0.036	-0.100*
	(0.033)	(0.031)	(0.035)	(0.047)	(0.047)	(0.050)	(0.053)	(0.049)
Adjusted R^2	0.153	0.150	0.149	0.165	0.162	0.181	0.178	0.196
F-stat	6.699	3.520	2.574	1.071	1.003	2.991	3.391	3.778
Observations	365	365	365	300	300	236	236	221

Notes: $^{*}p < .10$, $^{**}p < .05$, $^{***}p < .01$. Standard errors in parenthesis and 95%. Standard errors are clustered at the regional level.

Table B6: Effects on Employment – Domestic – (extended results)

	Log Employment							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS
Log exposure to mining	0.006***	0.005***	0.005**	0.003	0.003	0.006**	0.007**	0.005
	(0.002)	(0.002)	(0.002)	(0.003)	(0.003)	(0.003)	(0.003)	(0.005)
Local economic conditions:								
- % of High-Skill Workers		0.027	0.127	-0.081	-0.084	-0.031	-0.015	0.060
		(0.150)	(0.216)	(0.224)	(0.225)	(0.289)	(0.308)	(0.278)
- Krugman Specialization Index			0.053	0.015	0.014	0.050	0.039	0.032
			(0.058)	(0.052)	(0.052)	(0.069)	(0.057)	(0.060)
- Mining Royalty				0.000	0.000	-0.004***	-0.004***	-0.003*
				(0.001)	(0.001)	(0.001)	(0.001)	(0.002)
- Fiscal Dependency					0.000	-0.004	-0.002	0.002
					(0.000)	(0.003)	(0.006)	(0.007)
- Fiscal Windfalls (per capita)						0.003	0.004	0.014***
						(0.004)	(0.004)	(0.005)
Local amenities:								
- Crime							-0.005	-0.006
							(0.009)	(0.010)
- No of Sports Clubs								-0.017***
								(0.004)
Constant	-0.041*	-0.040**	-0.054**	-0.011	-0.011	-0.043	-0.044	-0.133***
	(0.019)	(0.018)	(0.024)	(0.040)	(0.040)	(0.043)	(0.049)	(0.036)
Adjusted R^2	0.153	0.151	0.150	0.165	0.162	0.182	0.179	0.197
F-stat	12.490	6.470	4.376	0.938	0.811	2.838	4.024	5.218
Observations	365	365	365	300	300	236	236	221

Notes: $^*p < .10$, $^{**}p < .05$, $^{***}p < .01$. Standard errors in parenthesis and 95%. Standard errors are clustered at the regional level.

Table B7: Minncerian Wage Equations

	Log of Wages			
	(1)	(2)	(3)	(4)
	OLS	OLS	OLS	OLS
Man (=1)	0.322***	0.322***	0.322***	0.297***
	(0.003)	(0.003)	(0.003)	(0.003)
Years of schooling	0.055***	0.055***	0.055***	0.043***
	(0.001)	(0.001)	(0.001)	(0.001)
High-school education (=1)	0.073***	0.073***	0.073***	0.056***
	(0.004)	(0.004)	(0.004)	(0.004)
College-level education (=1)	0.299***	0.299***	0.299***	0.288***
	(0.007)	(0.007)	(0.007)	(0.006)
Age	0.041***	0.041***	0.041***	0.035***
	(0.001)	(0.001)	(0.001)	(0.000)
Potential experience (Age^2)	0.000***	0.000***	0.000***	0.000***
	(0.000)	(0.000)	(0.000)	(0.000)
Worked hours per week	-0.002***	-0.002***	-0.002***	0.004***
	(0.000)	(0.000)	(0.000)	(0.000)
Occupation dummies		✓	✓	✓
Industry dummies			✓	✓
Year dummies				✓
Constant	11.061***	11.061***	11.061***	9.838***
	(0.031)	(0.031)	(0.031)	(0.028)
Adjusted R^2	0.395	0.395	0.395	0.533
Observations	340,166	340,166	340,166	340,166

Notes: * $p < .10$, ** $p < .05$, *** $p < .01$. Residuals from Column (4) are used in main estimations. Robust standard errors in parentheses.

Table B8: Hedonic Rent Equations

	Log of Rents		
	(1)	(2)	(3)
	OLS	OLS	OLS
Number of bedrooms	0.081*** (0.007)	0.081*** (0.007)	0.080*** (0.006)
Number of toilets	0.128*** (0.027)	0.128*** (0.027)	0.092*** (0.022)
Water source	✓	✓	✓
Water system	✓	✓	✓
Sanitation	✓	✓	✓
Electricity source	✓	✓	✓
Floor material		✓	✓
Floor condition		✓	✓
Roof material		✓	✓
Roof condition		✓	✓
Walls material		✓	✓
Walls condition		✓	✓
Year dummies			✓
Constant	10.310*** (0.065)	10.310*** (0.065)	10.458*** (0.056)
Adjusted R^2	0.278	0.278	0.634
Observations	341,974	341,974	341,974

Notes: * $p < .10$, ** $p < .05$, *** $p < .01$. Residuals from Column (3) are used in main estimations. Robust standard errors in parentheses.

Table B9: Effects on Wages – Overall – (extended results)

	Log Wage (city-level aggregate residual)							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS
Log exposure to mining	0.005	0.004	0.006	0.003	0.003	0.008	0.008	0.008
	(0.004)	(0.005)	(0.005)	(0.006)	(0.006)	(0.006)	(0.006)	(0.007)
Local economic conditions:								
- % of High-Skill Workers		0.109	0.221	0.106	0.111	0.117	0.111	0.143
		(0.127)	(0.141)	(0.152)	(0.152)	(0.156)	(0.154)	(0.165)
- Krugman Specialization Index			0.140**	0.122	0.129	0.093	0.109	0.076
			(0.062)	(0.083)	(0.088)	(0.113)	(0.117)	(0.134)
- Mining Royalty				0.001	0.001	-0.001	-0.002	-0.002
				(0.002)	(0.002)	(0.002)	(0.002)	(0.003)
- Fiscal Dependency					-0.001	-0.004	-0.007	-0.004
					(0.001)	(0.005)	(0.007)	(0.008)
- Fiscal Windfalls (per capita)						-0.004	-0.006	-0.009
						(0.005)	(0.005)	(0.008)
Local amenities:								
- Crime							0.007	0.009
							(0.007)	(0.011)
- No of Sports Clubs								-0.005
								(0.006)
Constant	0.063	0.064	-0.001	0.062	0.068	0.092	0.089	0.109
	(0.066)	(0.073)	(0.076)	(0.096)	(0.097)	(0.095)	(0.099)	(0.102)
Adjusted R^2	0.662	0.663	0.664	0.679	0.678	0.732	0.731	0.708
F-stat	1.354	0.916	2.696	1.378	1.013	1.293	1.040	1.568
Observations	365	365	365	300	300	236	236	221

Notes: $^{*}p < .10$, $^{**}p < .05$, $^{***}p < .01$. Standard errors in parenthesis and 95%. Standard errors are clustered at the regional level.

Table B10: Effects on Wages – Multinationals – (extended results)

	Log Wage (city-level aggregate residual)							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS
Log exposure to mining	0.004	0.003	0.005	-0.002	-0.002	0.003	0.002	0.003
	(0.005)	(0.006)	(0.007)	(0.008)	(0.008)	(0.006)	(0.006)	(0.007)
Local economic conditions:								
- % of High-Skill Workers		0.112	0.219	0.108	0.113	0.112	0.105	0.137
		(0.127)	(0.142)	(0.156)	(0.155)	(0.159)	(0.157)	(0.169)
- Krugman Specialization Index			0.133*	0.120	0.127	0.086	0.104	0.069
			(0.065)	(0.085)	(0.090)	(0.112)	(0.117)	(0.135)
- Mining Royalty				0.002	0.002	0.000	0.000	0.000
				(0.002)	(0.002)	(0.002)	(0.002)	(0.003)
- Fiscal Dependency					-0.001	-0.004	-0.007	-0.004
					(0.001)	(0.006)	(0.008)	(0.009)
- Fiscal Windfalls (per capita)						-0.004	-0.006	-0.008
						(0.005)	(0.005)	(0.008)
Local amenities:								
- Crime							0.008	0.010
							(0.007)	(0.012)
- No of Sports Clubs								-0.006
								(0.006)
Constant	0.077	0.084	0.025	0.127	0.131	0.160	0.161	0.177*
	(0.077)	(0.084)	(0.085)	(0.108)	(0.110)	(0.097)	(0.098)	(0.095)
Adjusted R^2	0.662	0.663	0.664	0.678	0.678	0.731	0.730	0.707
F-stat	0.663	0.666	2.287	0.542	0.431	1.007	0.736	1.470
Observations	365	365	365	300	300	236	236	221

Notes: $^{*}p < .10$, $^{**}p < .05$, $^{***}p < .01$. Standard errors in parenthesis and 95%. Standard errors are clustered at the regional level.

Table B11: Effects on Wages – Domestic – (extended results)

	Log Wage (city-level aggregate residual)							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS
Log exposure to mining	0.004	0.003	0.004	-0.003	-0.002	-0.003	-0.004	-0.006
	(0.004)	(0.004)	(0.004)	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)
Local economic conditions:								
- % of High-Skill Workers		0.113	0.221	0.108	0.113	0.111	0.103	0.135
		(0.126)	(0.141)	(0.156)	(0.155)	(0.161)	(0.160)	(0.173)
- Krugman Specialization Index			0.132^{*}	0.121	0.128	0.085	0.108	0.076
			(0.065)	(0.085)	(0.090)	(0.110)	(0.115)	(0.134)
- Mining Royalty				0.002	0.002	0.001	0.001	0.002
				(0.002)	(0.002)	(0.002)	(0.002)	(0.003)
- Fiscal Dependency					-0.001	-0.003	-0.007	-0.003
					(0.001)	(0.006)	(0.008)	(0.009)
- Fiscal Windfalls (per capita)						-0.004	-0.007	-0.008
						(0.005)	(0.005)	(0.007)
Local amenities:								
- Crime							0.010	0.012
							(0.007)	(0.011)
- No of Sports Clubs								-0.007
								(0.006)
Constant	0.094^{*}	0.088	0.041	0.125	0.126	0.216^{**}	0.220^{*}	0.251^{***}
	(0.048)	(0.052)	(0.049)	(0.090)	(0.090)	(0.098)	(0.102)	(0.078)
Adjusted R^2	0.662	0.663	0.664	0.679	0.678	0.731	0.730	0.707
F-stat	0.936	0.818	2.849	0.547	0.429	1.144	0.956	1.515
Observations	365	365	365	300	300	236	236	221

Notes: $^{*}p < .10$, $^{**}p < .05$, $^{***}p < .01$. Standard errors in parenthesis and 95%. Standard errors are clustered at the regional level.

Table B12: Effects on Rents – Overall – (extended results)

	Log Rent (city-level aggregate residual)							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS
Log exposure to mining	0.022**	0.018*	0.019*	0.022**	0.022*	0.029**	0.029**	0.032**
	(0.009)	(0.010)	(0.010)	(0.010)	(0.010)	(0.012)	(0.012)	(0.012)
Local economic conditions:								
- % of High-Skill Workers		0.422***	0.461**	0.480*	0.474*	0.555**	0.570**	0.574**
		(0.116)	(0.186)	(0.242)	(0.242)	(0.219)	(0.211)	(0.227)
- Krugman Specialization Index			0.049	0.034	0.026	-0.061	-0.100	-0.197
			(0.113)	(0.140)	(0.138)	(0.155)	(0.168)	(0.141)
- Mining Royalty				0.001	0.001	0.010*	0.010*	0.007
				(0.005)	(0.005)	(0.005)	(0.005)	(0.005)
- Fiscal Dependency					0.001	-0.006	0.001	-0.001
					(0.005)	(0.011)	(0.014)	(0.015)
- Fiscal Windfalls (per capita)						-0.012*	-0.007	-0.004
						(0.006)	(0.008)	(0.018)
Local amenities:								
- Crime							-0.017	-0.021
							(0.015)	(0.017)
- No of Sports Clubs								0.001
								(0.018)
Constant	-0.199	-0.196	-0.219	-0.271	-0.278	-0.172	-0.163	-0.200
	(0.149)	(0.156)	(0.159)	(0.163)	(0.173)	(0.171)	(0.167)	(0.205)
Adjusted R^2	0.893	0.895	0.895	0.894	0.894	0.916	0.916	0.916
F-stat	5.553	7.988	6.103	5.339	5.006	15.053	14.105	18.590
Observations	365	365	365	300	300	236	236	221

Notes: $^{*}p < .10$, $^{**}p < .05$, $^{***}p < .01$. Standard errors in parenthesis and 95%. Standard errors are clustered at the regional level.

Table B13: Effects on Rents – Multinationals – (extended results)

	Log Rent (city-level aggregate residual)							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS
Log exposure to mining	0.024	0.018	0.018	0.014	0.014	0.024	0.026*	0.030*
	(0.014)	(0.014)	(0.014)	(0.013)	(0.014)	(0.014)	(0.014)	(0.016)
Local economic conditions:								
- % of High-Skill Workers		0.434***	0.454**	0.475*	0.469*	0.542**	0.556**	0.559**
		(0.116)	(0.189)	(0.240)	(0.239)	(0.218)	(0.211)	(0.229)
- Krugman Specialization Index			0.025	0.016	0.009	-0.088	-0.127	-0.232
			(0.121)	(0.143)	(0.142)	(0.157)	(0.172)	(0.145)
- Mining Royalty				0.005	0.005	0.014**	0.014**	0.011*
				(0.006)	(0.006)	(0.005)	(0.005)	(0.005)
- Fiscal Dependency					0.001	-0.007	0.000	-0.002
					(0.005)	(0.011)	(0.013)	(0.015)
- Fiscal Windfalls (per capita)						-0.012*	-0.008	-0.004
						(0.007)	(0.009)	(0.020)
Local amenities:								
- Crime							-0.017	-0.021
							(0.016)	(0.017)
- No of Sports Clubs								0.001
								(0.019)
Constant	-0.184	-0.157	-0.168	-0.147	-0.151	-0.072	-0.075	-0.128
	(0.198)	(0.200)	(0.201)	(0.199)	(0.207)	(0.164)	(0.171)	(0.193)
Adjusted R^2	0.892	0.894	0.894	0.893	0.893	0.915	0.915	0.915
F-stat	2.857	7.127	6.400	4.450	4.171	12.130	10.730	15.707
Observations	365	365	365	300	300	236	236	221

Notes: $^{*}p < .10$, $^{**}p < .05$, $^{***}p < .01$. Standard errors in parenthesis and 95%. Standard errors are clustered at the regional level.

Table B14: Effects on Rents – Domestic – (extended results)

	Log Rent (city-level aggregate residual)							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS
Log exposure to mining	0.004	0.001	0.001	-0.006	-0.006	0.000	0.002	0.007
	(0.010)	(0.010)	(0.010)	(0.008)	(0.008)	(0.011)	(0.010)	(0.012)
Local economic conditions:								
- % of High-Skill Workers		0.456***	0.463**	0.489*	0.482*	0.533**	0.544**	0.546**
		(0.118)	(0.184)	(0.237)	(0.236)	(0.205)	(0.199)	(0.213)
- Krugman Specialization Index			0.009	0.020	0.012	-0.088	-0.119	-0.225
			(0.121)	(0.139)	(0.138)	(0.155)	(0.172)	(0.147)
- Mining Royalty				0.009	0.009	0.018**	0.017**	0.015**
				(0.006)	(0.006)	(0.006)	(0.006)	(0.006)
- Fiscal Dependency					0.001	-0.006	-0.001	-0.003
					(0.004)	(0.011)	(0.013)	(0.014)
- Fiscal Windfalls (per capita)						-0.010	-0.006	-0.001
						(0.007)	(0.008)	(0.019)
Local amenities:								
- Crime							-0.013	-0.018
							(0.015)	(0.016)
- No of Sports Clubs								-0.001
								(0.021)
Constant	0.102	0.080	0.077	0.086	0.085	0.181*	0.175*	0.110
	(0.123)	(0.125)	(0.121)	(0.123)	(0.128)	(0.100)	(0.097)	(0.145)
Adjusted R^2	0.891	0.894	0.893	0.893	0.893	0.914	0.914	0.914
F-stat	0.157	7.524	6.102	4.227	3.852	16.465	12.961	20.423
Observations	365	365	365	300	300	236	236	221

Notes: $^{*}p < .10$, $^{**}p < .05$, $^{***}p < .01$. Standard errors in parenthesis and 95%. Standard errors are clustered at the regional level.

Table B15: Productivity Spillovers – Overall – (extended results)

	Log TFP (plant-level OLS residual)							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	OLS	OLS	OLS	OLS	OLS	OLS	OLS	IV
Log Exposure	0.100**	0.070*	0.066	0.066	0.063	0.064	0.066	0.088
	(0.041)	(0.039)	(0.037)	(0.037)	(0.039)	(0.039)	(0.039)	(0.061)
Firm-level controls:								
- % of domestic ownership shares			0.003***	0.003***	0.002**	0.008***	0.008***	0.008***
			(0.001)	(0.001)	(0.001)	(0.002)	(0.002)	(0.002)
- Total Value of Exported Goods				-0.000	0.000	0.000	0.000	0.000
				(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Dummies for size					✓	✓	✓	✓
Dummies for type of property						✓	✓	✓
Dummies for type of firm							✓	✓
Plant FE		✓	✓	✓	✓	✓	✓	✓
Industry (CIIU-3) FE		✓	✓	✓	✓	✓	✓	✓
Constant	-1.005*	-0.658	-0.872*	-0.871*	0.309	-0.248	-0.305	
	(0.493)	(0.465)	(0.482)	(0.486)	(0.920)	(0.933)	(0.923)	
Adjusted R^2	0.004	0.021	0.025	0.025	0.045	0.045	0.044	-0.013
Observations	2,497	2,492	2,492	2,492	2,492	2,492	2,492	2,492
Kleibergen-Paap rk Wald F statistic								23.514
	Log TFP (plant-level Olley-Pakes residual)							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	OLS	OLS	OLS	OLS	OLS	OLS	OLS	IV
Log Exposure	0.087*	0.064	0.060	0.060	0.056	0.058	0.060	0.076
	(0.041)	(0.039)	(0.037)	(0.037)	(0.038)	(0.038)	(0.038)	(0.059)
Firm-level controls:								
- % of domestic ownership shares			0.003***	0.003***	0.003**	0.007***	0.008***	0.008***
			(0.001)	(0.001)	(0.001)	(0.002)	(0.002)	(0.002)
- Total Value of Exported Goods				-0.000	0.000	0.000	0.000	0.000
				(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Dummies for size					✓	✓	✓	✓
Dummies for type of property						✓	✓	✓
Dummies for type of firm							✓	✓
Industry (CIIU-3) FE		✓	✓	✓	✓	✓	✓	✓
Constant	-0.853	-0.582	-0.805	-0.801	0.305	-0.190	-0.259	
	(0.496)	(0.463)	(0.479)	(0.483)	(0.937)	(0.959)	(0.948)	
Adjusted R^2	0.003	0.021	0.027	0.026	0.038	0.039	0.038	-0.021
Observations	2,497	2,492	2,492	2,492	2,492	2,492	2,492	2,492
Kleibergen-Paap rk Wald F statistic								23.514

Notes: Standard errors are clustered at the regional level.

* $p < .10$, ** $p < .05$, *** $p < .01$

Table B16: Productivity Spillovers – Multinationals – (extended results)

	Log TFP (plant-level OLS residual)							
	(1) OLS	(2) OLS	(3) OLS	(4) OLS	(5) OLS	(6) OLS	(7) OLS	(8) IV
Log Exposure	0.148***	0.098***	0.098***	0.098***	0.074**	0.078**	0.082**	0.070*
	(0.032)	(0.029)	(0.029)	(0.027)	(0.031)	(0.031)	(0.030)	(0.033)
Firm-level controls:								
- % of domestic ownership shares			0.002	0.001	0.001	0.004	0.004	0.004
			(0.001)	(0.001)	(0.002)	(0.003)	(0.002)	(0.002)
- Total Value of Exported Goods				-0.000	-0.000	-0.000	-0.000	-0.000
				(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Dummies for size					✓	✓	✓	✓
Dummies for type of property						✓	✓	✓
Dummies for type of firm							✓	✓
Plant FE		✓	✓	✓	✓	✓	✓	✓
Industry (CIIU-3) FE		✓	✓	✓	✓	✓	✓	✓
Constant	-1.442***	-0.885**	-1.026***	-0.996***	0.470	0.095	0.028	
	(0.364)	(0.326)	(0.304)	(0.309)	(0.699)	(0.863)	(0.844)	
Adjusted R^2	0.004	0.014	0.015	0.016	0.036	0.037	0.037	
Observations	2,222	2,215	2,215	2,215	2,215	2,215	2,215	2,215
Kleibergen-Paap rk Wald F statistic								88.108

	Log TFP (plant-level Olley-Pakes residual)							
	(1) OLS	(2) OLS	(3) OLS	(4) OLS	(5) OLS	(6) OLS	(7) OLS	(8) IV
Log Exposure	0.131***	0.087**	0.087**	0.086***	0.065*	0.069**	0.075**	0.067*
	(0.026)	(0.029)	(0.029)	(0.028)	(0.031)	(0.030)	(0.029)	(0.035)
Firm-level controls:								
- % of domestic ownership shares			0.002	0.001	0.001	0.004	0.004	0.004
			(0.001)	(0.001)	(0.002)	(0.003)	(0.003)	(0.003)
- Total Value of Exported Goods				-0.000	-0.000	-0.000	-0.000	-0.000
				(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Dummies for size					✓	✓	✓	✓
Dummies for type of property						✓	✓	✓
Dummies for type of firm							✓	✓
Industry (CIIU-3) FE		✓	✓	✓	✓	✓	✓	✓
Constant	-1.251***	-0.760**	-0.907***	-0.876**	0.532	0.185	0.091	
	(0.295)	(0.330)	(0.296)	(0.297)	(0.731)	(0.929)	(0.912)	
Adjusted R^2	0.004	0.015	0.016	0.017	0.029	0.030	0.031	
Observations	2,222	2,215	2,215	2,215	2,215	2,215	2,215	2,215
Kleibergen-Paap rk Wald F statistic								88.108

Notes: Standard errors are clustered at the regional level.

* $p < .10$, ** $p < .05$, *** $p < .01$

Table B17: Productivity Spillovers – Domestic – (extended results)

	Log TFP (plant-level OLS residual)							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	OLS	OLS	OLS	OLS	OLS	OLS	OLS	IV
Log Exposure	0.080***	0.042	0.040	0.040	0.038	0.042*	0.042*	0.039*
	(0.021)	(0.023)	(0.023)	(0.023)	(0.024)	(0.023)	(0.022)	(0.022)
Firm-level controls:								
- % of domestic ownership shares			0.002	0.001	0.001	0.004	0.004	0.004
			(0.001)	(0.001)	(0.002)	(0.003)	(0.003)	(0.003)
- Total Value of Exported Goods				-0.000	-0.000	-0.000	-0.000	-0.000
				(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Dummies for size					✓	✓	✓	✓
Dummies for type of property						✓	✓	✓
Dummies for type of firm							✓	✓
Plant FE		✓	✓	✓	✓	✓	✓	✓
Industry (CIIU-3) FE		✓	✓	✓	✓	✓	✓	✓
Constant	-0.586**	-0.201	-0.333	-0.305	1.016*	0.639	0.625	
	(0.214)	(0.240)	(0.243)	(0.259)	(0.564)	(0.769)	(0.762)	
Adjusted R^2	0.003	0.013	0.014	0.015	0.036	0.037	0.037	
Observations	2,222	2,215	2,215	2,215	2,215	2,215	2,215	2,215
Kleibergen-Paap rk Wald F statistic								111.774

	Log TFP (plant-level Olley-Pakes residual)							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	OLS	OLS	OLS	OLS	OLS	OLS	OLS	IV
Log Exposure	0.058**	0.025	0.023	0.023	0.022	0.025	0.026	0.018
	(0.019)	(0.022)	(0.022)	(0.021)	(0.022)	(0.021)	(0.020)	(0.021)
Firm-level controls:								
- % of domestic ownership shares			0.002	0.001	0.001	0.004	0.004	0.004
			(0.001)	(0.001)	(0.002)	(0.003)	(0.003)	(0.003)
- Total Value of Exported Goods				-0.000	-0.000	-0.000	-0.000	-0.000
				(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Dummies for size					✓	✓	✓	✓
Dummies for type of property						✓	✓	✓
Dummies for type of firm							✓	✓
Industry (CIIU-3) FE		✓	✓	✓	✓	✓	✓	✓
Constant	-0.369*	-0.031	-0.170	-0.140	1.131*	0.789	0.758	
	(0.199)	(0.225)	(0.225)	(0.242)	(0.545)	(0.765)	(0.758)	
Adjusted R^2	0.002	0.013	0.015	0.016	0.028	0.029	0.030	
Observations	2,222	2,215	2,215	2,215	2,215	2,215	2,215	2,215
Kleibergen-Paap rk Wald F statistic								111.774

Notes: Standard errors are clustered at the regional level.

* $p < .10$, ** $p < .05$, *** $p < .01$