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## Innovation in mining value chains: New evidence from Latin America<sup>☆</sup>

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### ABSTRACT

The paper investigates new opportunities for innovation and linkages associated to mining activities in Brazil, Chile and Peru. Three types of opportunities were researched: demand side, supply side and local specificities. The last source of opportunities is key for natural resource related activities. The evidence shows that an increasing demand is introducing important incentives for innovation and local suppliers. Nevertheless, a hierarchical value chain, dominated by few large firms, and poor linkages is blocking the diffusion of innovations and hindering suppliers' development. The emergence of a group of highly innovative suppliers, which were identified in the three countries, is explained mostly by new technological and knowledge opportunities, which are not exploited by large incumbents and open spaces for new entrants. Local specificities are also key in the explanation of local suppliers. It remains a challenge however, how these, most of which were created to satisfy local needs, will move from local to global.

### 1. Introduction

Economic activities based on Natural Resource (NR) have expanded significantly over the past decades both in developed and developing countries. At the same time, the heavy dependence on NR has not fallen in many developing countries, raising concerns regarding the effects that these industries can have on economic development. This is not new, and has been a traditional question in development economics: are natural resource endowments a curse or a blessing for a developing economy (Sachs and Warner, 2001)?

This study focuses on the mining industry. Traditional development and innovation literatures have often offered a pessimistic picture about the development impact of NRs in general, and mining in particular (Hirschman, 1958; Prebisch, 1950; Singer, 1975). Such an opinion has been based on various explanations, for example arguing that mining is often an “enclave”: “...unlike other sources of wealth, natural resource wealth does not need to be produced. It simply needs to be extracted. .... it is in a number of ways, enclaved... without major linkages to other industrial sectors” (Humphreys et al., 2007: 4).

An additional argument to support the thesis of a natural resource curse comes from the industrial organization prevailing in these sectors.

Typically, large mining operations tend to be controlled by Multinational Corporations (MNCs), which perform little local innovation, govern hierarchically their value chains, set the rules of the game unilaterally and rely mostly on foreign suppliers for key, knowledge intensive, sensitive solutions (UNECA, 2013). This is an impediment, it is argued, for diversification, local innovation and the involvement of local suppliers in the more promising stages of the value chain. In a recent survey on “Using Natural Resources for Development”, Venables (2016) confirms these views but, like most of the literature, looking mainly at traditional macroeconomic arguments, such as the impact on the balance of payments, “Dutch disease” and rent seeking, and neglecting the potential offered by linkages and spillovers.

In contrast however, several recent studies within the innovation literature have questioned these pessimistic views. A new context is emerging, it is argued, which is opening new opportunities for innovation and fruitful linkages between lead firms and their suppliers, which did not exist before (Pérez, 2010; Andersen, 2012; Marin et al., 2015). These new opportunities are associated to a larger and more diversified demand for NRs, new knowledge and technology advances applicable to these sectors, and an increasing pressure to innovate to reduce environmental impact, among others (Dantas, 2011; Iizuka and

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Katz, 2015; Morris et al., 2012; Ovadia, 2014). Moreover, in the mining industry a tendency towards higher degrees of vertical disintegration of large producer companies, which focus more on their core capabilities and outsource other activities, has emerged in the last decades (Urzúa, 2011; Korinek, 2013; Stubrin, forthcoming). This tendency has encouraged in some cases local innovation in host countries.

However, historical evidence confirms that such opportunities do not last forever and necessarily evolve over time. The expansion of the US mining industry, during the iron and electrical power revolution, encouraged the emergence of a supplier industry of mining equipment in this country. Similarly, the Finnish mining industry spurred a metallurgical industry of suppliers, and more recently Australia has developed a huge wave of suppliers of advanced knowledge-intensive services, often based on information and communication technologies (ICT) and other scientific and technological developments (Frances, 2015; Meller and Gana, 2015; Urzúa, 2011). The mining suppliers that took advantage of technological paradigms and market opportunities prevailing at their time, now occupy important stages of the value chain. This suggests that there are windows of opportunity that open and close, and that need to be exploited timely.

This paper contributes to a better understanding of the new opportunities for innovation and linkages in the mining industry, based on original empirical evidence from three Latin American countries: Brazil, Chile and Peru.<sup>1</sup> More specifically, we explore: (i) the nature and extent of the new opportunities for local innovation and local suppliers in mining in developing countries; (ii) the mediating role played by the organization of industry in the mining value chain (MGVC), and the extent to which it is conducive to learning and innovation in local suppliers; (iii) the nature of the firms (i.e. new startups vs. incumbents) taking advantage of these opportunities and how.

The mining sector is a very important activity for Peru, Chile and Brazil, reaching respectively 11.7%, 9.9% and 1.9% of GDP, and 21%, 60%, and 46% of exports in 2015. The mining sector employed 4.2% of the total in Peru, 2.9% in Chile and 0.52% in Brazil. Peru is one of the most important suppliers of a wide range of metallic minerals in the world and in 2015 it was ranked 2nd largest producer of silver, 3rd of copper and zinc, 4th of tin, lead and molybdenum. Chile's production is much more concentrated on copper, with 29.9% of world output. Brazil's mining production is extremely concentrated in iron, with sizable volumes also in niobium, vermiculite, asbestos, tantalum, and bauxite. The presence of foreign capital in Peru is critical due to its dominance in the production of copper, zinc and calcium carbonates. In Chile, the main player is the state-run company CODELCO (31.3% of copper production), with foreign companies producing 49% of the total. The Brazilian state-run company Vale represented 74% of Brazilian iron ore sales in 2015, and in copper and nickel two foreign and two domestic companies dominate the market.

Our results suggest that some local suppliers carry out important innovative activities. They have developed advanced levels of innovation capabilities, reflected in patents, new product developments, international awards, exports of goods, services and technology, and technologies in use. However, local suppliers' innovative activity has not emerged as a result of rich linkages between the suppliers and the mining companies, as sometimes happens in GVCs (Pietrobelli and Rabelotti, 2011). Large mining companies have not built formal long-term linkages or committed to joint innovation with local suppliers, especially in Chile and Peru (Molina, 2018; Stubrin, 2018). They tend to rely on established suppliers, and when new technological challenges emerge, they either rely on solutions coming from headquarters based abroad, or on their first-tier suppliers. However, sometimes they demand technological solutions from their present or potential suppliers, and supply information about their needs, but only through informal

and unplanned interactions with local suppliers. Some instances of better collaboration within the value chain appear to have emerged in Brazil, with dedicated efforts to help local suppliers to surge (Figueiredo and Piana, 2016, 2018), but evidence is not conclusive. Our evidence also suggests that, in most cases, the costs and risks of seeking new technological solutions and offer new services and intermediate products have been entirely borne by the successful firms, with limited involvement of chain-leaders. One of our conclusions is therefore, that incentives to innovate in our cases have not derived from interactions with large clients, but mostly from new knowledge and technological opportunities (e.g. new IT and biotech advances) and the idiosyncratic nature of NRs, that often requires locally developed solutions.

Our evidence also suggests that if these successful experiences were to expand to large numbers of local suppliers, the capabilities required to go from local to global would go far beyond the scientific, technological and production-related capabilities. The need to commercialize the results, and to enter in fruitful bargaining processes with chain leaders and large mining firms (and their first tier of suppliers) have often been missing in the cases studied and are in strong demand. An additional conclusion of our cases is thus, that potential suppliers need to thoroughly understand the logic of operations of MGVCs, and to strengthen the capabilities complementary to production and innovation to succeed. These include the capacity to develop the non-technological assets required to exploit their scientific and technological capabilities, in a framework where large mining companies are not investing in these linkages and in joint innovation and where systematic policies oriented to support emerging innovators appear to be lacking.

The paper is organised as follows. First, we present the research background. Two main issues are highlighted: first, the importance of new technological and market opportunities for understanding the potential for innovation and upgrading in mining activities; second, the different types of opportunities emerging from the demand and the supply side. In the second section, we discuss key features of the methodology and empirical approach. The evidence is presented in a third section, where we explore the nature and extent of new opportunities for innovation, and we discuss the main barriers to innovation and upgrading faced by the suppliers studied. A final section concludes by analysing research implications and policy insights derived (Ville and Wicken, 2012).

## 2. Theoretical background

Can innovation help reverse the resource curse so often claimed to apply to developing countries (Venables, 2016)? The innovation literature recognizes demand and technology as the two main sources of opportunity for innovation. These change across industries and over time. In NRs, the literature has also identified a third source of opportunities for innovation: local specificities, which are an incentive to innovation at the local level to the extent that solutions developed in one context may not work in another. These different types of opportunities may create a fruitful context for innovation, that firms may exploit provided they have the necessary capacities based on their resources, knowledge and competence. These ideas are discussed in the rest of this section.

### 2.1. Demand opportunities

#### 2.1.1. Demand size

The size and quality of demand may be important for innovation. Schmookler (1966) was the first to emphasize the importance of the size and growth of the market for innovation. He claimed that firms that innovate more are those that induced by a large and increasing demand, make more use of the fixed common pool of existing knowledge by making their own complementary investments in applied R&D. They will do so because the expected benefits associated to the costs of R&D will be larger. More inventive activity would therefore be expected in

<sup>1</sup> Part of this evidence presented and discussed here and in other papers in this special issue was developed for a research project coordinated by two of the authors.

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