Resources Policy 49 (2016) 405–414

Contents lists available at ScienceDirect

Resources Policy

journal homepage: www.elsevier.com/locate/resourpol

When "one thing (almost) leads to another": A micro-level exploration of learning linkages in Brazil's mining industry

Paulo N. Figueiredo*, Janaina Piana

Brazilian School of Public and Business Administration (EBAPE), Getulio Vargas Foundation (FGV), Praia de Botafogo,190, 22253-900 Rio de Janeiro, RJ, Brazil

ARTICLE INFO

Article history:
Received 5 March 2016
Received in revised form
20 July 2016
Accepted 20 July 2016

Keywords:
Learning linkages
Innovation
Supply chain
Natural resources
Mining industry
Brazil

ABSTRACT

This paper explores the nature of learning linkages through a qualitative and empirically grounded study of three sets of interactions in Brazil's mining industry and finds that: (1) these linkages vary along a spectrum of progressive levels of knowledge intensity, provide a basis for cumulative innovative activities within the mining industry, and are likely to influence innovation in other industries; (2) however, there is local failure for either the government or large corporations to implement proactive policies to support these linkages; (3) nevertheless, an intrinsic motivation among industry stakeholders (including universities) to develop these linkages through relational embeddedness exists, as they react to creative knowledge needs and pressures for cost-reduction or seek to grab opportunities; as such, relational embeddedness appears to offset the absence of policies. However, proactive policies are needed for the expansion and long-term sustainability of these linkages. Policymaking should include government and large mining firms, as well as local suppliers and universities, and build on intrinsic motives and small achievements incrementally. This paper contributes to extending our understanding of the intricacies of learning linkages development in the mining industry. Understanding and illustrating this process is key to strategize policies oriented to industrial development, particularly in resource-rich developing countries.

1. Introduction

The commodities super cycle of the early 2000s fueled a revival of the debate on natural-resource-related industries' level of contribution to industrial development in resource-rich developing economies. The numerous studies associated with this debate are predominantly based on macro-level approaches, methodologically varied, and far from consensual (for reviews, see Andersen et al., 2015; Ross, 2015). For example, a large part of this debate is drawn from negative views on natural resource-related industries, such as the "deterioration of terms of trade" (Prebisch, 1950) and the "resource curse" (Auty, 2001). Another stream of this debate argues that natural resource-related industries have a low potential for creating innovation-related linkages with the rest of the local economy, thus leading to "enclaves" (Humphreys et al., 2007), and offer few opportunities for learning and innovation (Castaldi et al., 2009).

However, balanced perspectives on how resource-rich countries may take advantage of their resource endowments and overcome the constraints of resource dependence to growth (Ross, 2015), such as human capital formation (Lederman and Maloney, 2007), technology-intensive supplier development (Torres-Fuchslocher, 2010), backward linkages development (Morris et al., 2012), innovation capability building (Andersen et al., 2015; Perez, 2015), tailored policies and institutions (Frankel, 2012), emerged. Certain studies have also demonstrated the opportunities made available by natural resource-related industries for diversification (Hausmann and Rodrik, 2003; Lorentzen, 2008), which might contribute to a commodity-based industrialization pattern for resource-rich developing economies (Morris and Fessehaie, 2014).

The mining industry occupies a central place within the resource-based industrialization debate because of its economic relevance for several resource-rich developing countries (Morris et al., 2012; Fessehaie and Morris, 2013; Ramdoo, 2015). Since the 1990s, the global mining industry has deverticalized its activities, thus increasing outsourcing of various activities, from operational maintenance to engineering and specialized services, and research and development (R&D), involving different types of partnerships (Africa Mining Vision, 2011; Morris et al., 2012; Urzúa, 2013; Scott-Kemmis, 2013).

This reorganization of the mining industry has contributed to the emergence of specialized knowledge-intensive mining services (KIMS), such as the specialized equipment suppliers in South

* Corresponding author.
E-mail addresses: paulo.figueiredo@fgv.br (P.N. Figueiredo), janaina.piana@fgv.br (J. Piana).

http://dx.doi.org/10.1016/j.resourpol.2016.07.008
0301-4207/

Africa, which reflect local innovative capability development and dissemination of backward and horizontal linkages (Kaplan, 2012), and Chile's world-class suppliers program, which reflects efforts to develop local innovative KIMS for the global mining industry (Barnett and Bell, 2011; Urzúa, 2013). Nevertheless, different (and conflicting) perspectives on linkages and innovative activities exist in the mining industry.

On one hand, studies suggest that because of the existence of weak linkages (or even their absence) between multinational mining firms and local businesses, mining enclaves predominate in countries such as Chile. For example, by drawing on a structural equation model survey with data from 351 small and medium enterprises (SMEs) mining suppliers in the Antofagasta region (Chile), Atienza et al. (2012) find that collaboration with clients does not significantly affect investment in innovation, and has no impact on SMEs' performance, regardless of the firms' positions in the supply chain. Arias et al. (2014) corroborate these findings by drawing on quantitative analysis and secondary evidence of 597 local SMEs in the same region. They find that SME mining suppliers have weak horizontal cooperative relationships with other suppliers, other firms, and universities.

On the other hand, studies explore positive local economic development implications of the interaction along the mining supply chain. For example, by applying Lorentzen's (2008) lateral migration framework to a study on Peru's mining industry, Kuramoto and Sagasti (2006) emphasize the need for policies to strengthen the mining innovation system, deepen technological capabilities, and expand them to other industries. Bloch and Owusu (2012) challenge the enclave thesis by showing that, after a period of strong investment and growth, the gold mining industry in Ghana is significantly linked to the economy through a set of under-researched but promising linkages, notably backward linkages. A similar perspective is found in South Africa (Walker and Minnitt, 2006; Lydall, 2009) and Chile (Lagos and Blanco, 2010), while Fessehaie and Morris (2013) explore dual linkage development strategies of a Chinese lead mining firm in Zambia.

However, existing studies have paid insufficient attention to the knowledge intensity of those linkages. This issue is particularly relevant in a context of deverticalization in the mining industry and local demand by industry's partners, especially leading commodity firms, for creative knowledge to undertake innovative activities with increasing mineralogical complexity and cost reduction, and environmental pressures. Specifically, there is a paucity of micro-level qualitative empirical studies that explore the nature of knowledge-intensive or learning linkages and their implications for innovative activities in the mining industry in a resource-rich developing economy.

This paper explores this research gap. Brazil offers a rich empirical context to study this issue as one of the world's largest mining producers and exporters. Furthermore, most studies on linkages of the mining industry focus mainly on multinational enterprises (MNEs) from advanced economies that operate in developing economies. However, the bulk of the mining industry in Brazil is dominated by local firms, particularly Vale, a leading Brazilian and global mining firm, with strong international operations. Despite the importance of the mining industry on Brazil's economy, there is a surprising dearth of empirical studies on linkages related to learning and innovation in the industry. Therefore, in this paper we aim to address the following research question: What is the nature of learning linkages developed around Brazil's lead mining firm and their potential implications for innovation within and beyond the local mining industry? To address this research question, we draw on a qualitative and empirically grounded study based on micro-level fieldwork evidence from three sets of interactions related to the lead mining firm and some of its local partners in Brazil's mining industry.

Consequently, we extend our understanding of learning linkages underlying innovative activities in the mining industry and add empirical insights to the resource-based industrialization debate. We also provide a basis to deepen the analysis of learning linkages and their implications for industrial development in developing resource-rich countries. The remainder of this paper is organized as follows: Section 2 provides an overview of Brazil's mining industry; Section 3 discusses the theoretical background; Section 4 describes the methods used; and Section 5 presents our findings, subsequently discussed in Section 6.

2. Brazil's mining industry: a brief overview

Large-scale mining started in Brazil in the early 1940s, following the creation of the Vale do Rio Doce Company (now Vale).[1] The contribution of the mining industry to Brazil's GDP evolved from 1.0% in 1980 to 4.1% in 2013. In value terms, Brazil's mineral production increased from USD 5 billion in 2001, to USD 44 billion in 2013, or by an annual average of 19.8%. In 2013, mining exports represented 23.5% of Brazil's exports by value, and Brazil's mining industry employed approximately 2.2 million people and generated USD 1.03 billion in royalties (National Department of Mineral Production – DNPM, 2014).

Brazil has a diversified mineral basis, which involves the production of 72 minerals, of which 23 are metallic, 45 non-metallic, and four energetic, and is one of the world's largest mineral producers, especially of iron ore, niobium, manganese, nickel, tin, kaolin, chrome, magnesite, graphite, and tantalite. Its iron ore and bauxite production represent 13.8% and 13.2% of world production, respectively. In 2011, Brazil's mining industry comprised 8870 firms. However, the industry is highly concentrated, most of its output being generated by less than ten large firms, most of them local (DNPM, 2014; IBRAM, 2014). Vale is Brazil's leading mining firm, accounting for 52.3% of the total domestic mineral production. Moreover, Vale is the world's largest iron ore, pellets, and nickel producer, operating in 13 Brazilian states and 37 countries worldwide, with approximately 195,000 employees. Such an empirical setting offers a fertile ground for an empirical scrutiny of learning linkages and innovative activities.

3. One thing leads to another: learning linkages and innovative activities

Albert Hirschman's linkage approach identifies interactions between stakeholders within and across industries as one of the pillars for development (Hirschman, 1981). His notion of production linkages involves forward linkages (processing natural resources—e.g., iron ore to steel) and backward linkages (the production of inputs for natural resource exploration—e.g., the development of new equipment for mining—but with significant potential for wide applications in other industries). Consequently, these backward and forward linkages related to commodities industries may generate industrial transformation and alternative development paths in resource-rich developing countries (Hirschman, 1981:75):

> "[…] The linkages capture much of the development story […]; development is essentially the record of how *one thing leads to another* [emphasis added] […] They focus on certain characteristics inherent in the productive activities … [that] invite some operators to take up new activities."

[1] In 2007, the Companhia Vale do Rio Doce was renamed Vale.