

(Un)linking industrial path development and development outcomes through asset mobilization: The decline of the territorial embeddedness of labor in mining regions

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**(Un)linking industrial path development and development outcomes
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The decline of the territorial embeddedness of labor in mining regions**

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Abstract

New industrial paths do not necessarily translate into regional economic development. This study focuses on how asset mobilization for new industrial paths contributes to economic development. We analyze the mining service supplier industry in Antofagasta (Chile) from 1974 to 2021 and how changing human capital mobilization affected regional development opportunities. The declining territorial embeddedness of mining-related workers through long-distance commuting has weakened the mechanisms that translate path development into regional economic development. The study highlights the value of a multi-scalar focus on asset mobilization processes to improve our understanding of what kind of regional development is generated by new paths.

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1 Introduction

Great advancements have been made in understanding how new industries emerge in regions in the last two decades (Boschma 2017; Hassink et al. 2019). Surprisingly, little attention has linked these insights to how the emergence of regional industrial paths translates into regional economic development – which is the ultimate objective to these spatial economic dynamics at least from a policy perspective (Breul et al. 2021; Kogler 2017). To improve our understanding on this relationship and explain why regional industrial path can initiate very distinct developmental dynamics, this article investigates how the nature of asset mobilization for path development can affect the way new industries are able to translate into developmental outcomes.

We focus on the crucial asset human capital that represents an important hinge for converting path development into regional economic development - directly in terms of employment, wages, and value capture and indirectly in terms of embodied capabilities and community development as a base for knowledge externalities and future diversification (Coe and Hess, 2013). Analysis on regional industrial path development (RIPD) has assumed human capital as a local deeply embedded asset and one of the driving forces for the reinvention of cities and regions (Boschma & Frenken 2011). Technological and institutional changes (third wave of globalization (Baldwin, 2019) make this assumption increasingly bold not only at a global level, but within countries and in certain activities. In this regard, Jones (2023) refers to the increasing placelessness of some workers in opposition to their territorial embeddedness. This argument is particularly relevant in the case of path branching processes related to the mining industry where externalization of services and long-distance commuting (LDC) are increasingly used as a way of organizing labor (Atienza et al. 2021; Martinus 2018). In this context, even when a new path of mining service suppliers (MSS) emerges in a region, its consequences for long-term regional economic development can be severely reduced not only because a significant part of the income earned by LDC workers flies-over to other regions, but also, because the lack of these workers' territorial embeddedness reduces the capacity of human capital to become a local driving force of productive and social changes (Ellem, 2016; Breul & Atienza 2022).

The objective of this article is to analyze how human capital mobilization in the emergence and development of a MSS industry in Antofagasta between 1974 to 2021 has affected the development opportunities in this mining region. Antofagasta is the main mining region in Chile with 55% of national mining output (COCHILCO, 2022) and the capital city, Antofagasta, with 388,545 inhabitants, is the largest municipality of Chile out of the Metropolitan Region of Santiago. While the region has been able to develop a MSS industry path in the past three decades, more than 50% of MSS workers live in other regions (Encuesta Nacional de Empleo, 2022).

Based on a historical analysis using public records, reports, and secondary sources from official national and regional databases, we reveal how human capital mobilization has changed throughout the evolution of the MSS industry in Antofagasta and how institutional, technological, and organizational changes have territorially disembedded the workers related to the MSS path.

This multi-scalar process has limited the potential contribution of the new industrial path to regional economic development. The results show the value of a historical and multi-scalar focus on the nature of asset mobilization for studying what kind of regional development is generated by RIPD.

The reminder is organized in four parts: first, we discuss the need of research on RIPD to incorporate the analysis of how new industry paths translate into regional development and study how the mobilization of assets - here particularly the crucial asset human capital - within these paths affects regional economic development. Second, we present the methodology. In the results section, we analyze the evolution of the MSS industry in Antofagasta and how the process of declining territorial embeddedness of workers has limited the extent to which the new path contributes to regional development. Finally, we present the main conclusions and discuss their implications.

2 Linking regional industrial path development to development translation mechanisms: the role of asset mobilization processes and their territorial embeddedness.

2.1 The missing link between regional industrial path development and regional economic development

Since the 2000s economic geographers have substantially advanced our knowledge on regional industrial dynamics and the emergence of new economic activities. Especially Evolutionary Economic Geography studies have deepened our understanding of the importance of regional capacities for developing new related economic activities in a region, following a path branching process (Boschma & Frenken 2011; Boschma 2017; Neffke et al. 2011). These conceptualizations have been increasingly complemented by a constructive critical strand of work that introduced insights and components from other approaches, such as regional innovation systems, transition studies or global production networks (Binz et al. 2016; Grillitsch et al. 2018; MacKinnon et al. 2019; for an overview see Hassink et al. 2019). These advancements point among other things to the role of agency, different types of key assets and extra-regional influences to grasp RIPD.

With all these conceptual advancements, we are increasingly capable of investigating and explaining how new industries emerge in regions. Yet, there is one crucial aspect missing in the equation. The creation of new regional industrial paths is generally not an end in itself. It shall compensate for losses in declining mature paths, rejuvenate existing regional industrial structures, and adapt economies to grand challenges such as climate change (Trippel et al. 2020). In other words, the promotion of new industrial paths is largely associated with regional economic development concerns. However, as recent studies indicate, the creation of new industrial paths does not automatically translate into regional economic development but can also result in 'dark sides' (Breul et al. 2021; MacKinnon et al. 2019).

Since positive developmental impacts induced by new RIPD cannot be taken for granted, it is surprising that little attention has been paid to the mechanisms that translate new industrial paths into regional economic development (Kogler 2017; Breul et al. 2021). It points to an urgent need

to link the question of how new regional industrial paths emerge with a developmental perspective that can grasp under which conditions RIPD contributes to what kind of regional development and for whom, to advance the debate and provide policy-relevant knowledge (Breul et al. 2021; Chlebna et al. 2022; Eadson & van Veelen 2023). While a recent conceptual framework by Breul et al. (2021) contributes to this endeavor by allowing to study positive and negative externalities induced by new paths on other parts of the regional economy, we miss an approach that sheds light on the development translation mechanisms immediately inherent to a new regional industrial path. In the following, we conceptualize asset mobilization for new RIPD as a crucial process for regional economic development. We conceptualize this process as multi-scalar and dependent on varying imprints of extra-regional dynamics and go into detail for one crucial asset for RIPD – that is human capital.

2.2 A focus on development translation mechanisms: the role of asset mobilization processes and its territorial embeddedness

The development of regional industrial paths relies on various assets. These can be distinguished into “natural assets (covering resources); infrastructural and material assets; industrial assets (covering technology and firm competencies); human assets in the shape of labor skills, costs, and knowledge; and institutional endowments of rules, routines, and norms” (MacKinnon et al. 2019, 122). These assets need to be identified, modified, imported, or newly created to promote RIPD (Trippel et al. 2020; MacKinnon et al. 2019). Recent studies have contributed to shift the attention to this mobilization process of assets, understood as an alignment process where the interplay of purposeful actions by different actors and institutions shapes how industrial paths emerge and develop (Binz et al. 2016; Trippel et al. 2020; Breul et al. 2021).

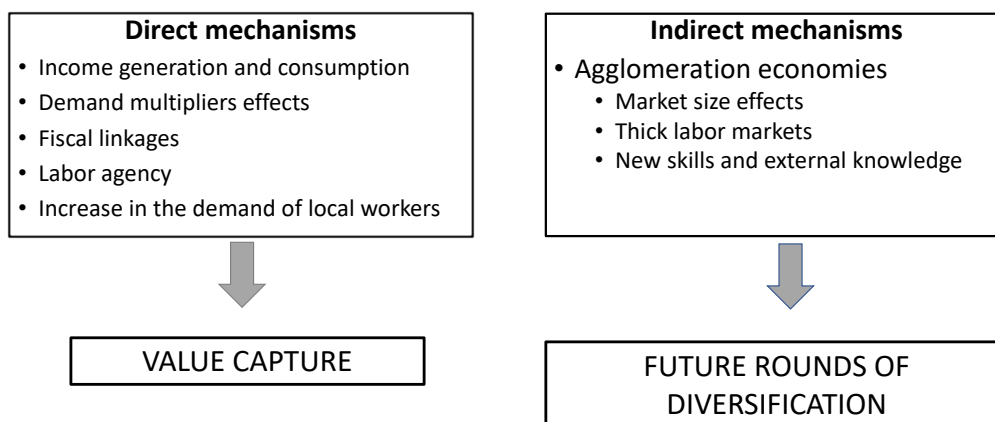
Asset mobilization processes are not only at the heart of RIPD but also of its contribution to regional economic development. The way key assets are mobilized for RIPD leaves different types of developmental imprints in the region. Traditionally, the mobilization of endogenous assets has been considered the main basis for new path creation. However, an increasing number of RIPD studies shows how assets from outside the region like inflows of knowledge, foreign investment, and the immigration of skilled workers, facilitated RIPD by complementing the existing regional asset base (Binz et al. 2016; Breul & Pruß 2022; MacKinnon et al. 2019; Isaksen & Trippel 2017). While this beneficial influence of imported assets for RIPD has been widely acknowledged, the extent to which these new industrial paths based on extra-regional assets translates into regional economic development can be quite limited as empirical insights from GPN-studies or the branch plant literature reveal (Phelps et al. 2018; MacKinnon 2012; Breul & Revilla Diez 2019). These literature strands clearly underline that the prospects for translating RIPD into regional economic development strongly depends on the degree assets such as knowledge, capital, workers, and firms are territorially embedded (Coe & Yeung, 2015; Chu & Hassink, 2023; Kogler et al., 2023) or, in other words, “anchored” in a particular place (Hess, 2004), namely the region where the new path emerges.

A high reliance on extra-regional dynamics can result in path capture (Morales & Atienza 2022) and be the source for what MacKinnon et al. (2019) call a dark side of path creation. Surprisingly, in research on RIPD, “the effects of [...] outflows of firms and highly skilled people on path development have hardly been investigated and remain poorly understood“(Hassink et al. 2019, 1639). This paper applies a multi-scalar lens to the asset mobilization process of RIPD to better account for the “directionality of asset flows” (Hassink et al. 2019) and for the fact that assets are not necessarily territorially embedded (Breul & Atienza 2022; Binz et al. 2016). In the following section, we elaborate this perspective for the mobilization process of one particular asset– that is human capital – and outline the mechanisms through which human capital mobilization can contribute to regional economic development.

2.3 The mode of human capital mobilization and its implications for regional economic development.

The mobilization of human assets through employment is crucial for new paths to become a driver of regional economic development and further diversification (Isaksen & Trippl, 2017). The translation mechanisms that explain how human capital mobilization in RIPD affects regional economic development are both direct and indirect (see diagram 1). Direct mechanisms are related to: (i) wages, and income generation; (ii) demand multiplier effects through local consumption that further increase local income and employment (Aroca and Atienza, 2008, 2011); (iii) fiscal linkages of local tax revenues paid by locally embedded workers (Paredes and Fleming-Muñoz, 2021); (iv) increases in the demand of local human capital by a new industrial path that can positively affect regional employment and wages (Carriel et al., 2023); and (v) stronger local agency of territorially embedded workers’ organizations, such as unions, to articulate local demands for a higher quality of life and to mediate in global networks (Coe and Hess, 2013; Coe and Yeung, 2015; Ellem, 2016; Atienza 2021). All these direct translation mechanisms affect the amount of local value capture which depend on the degree of territorial embeddedness of the human capital.

Diagram 1. Development translation mechanisms of human capital mobilization in RIPD.



Source: Authors

Indirect translation mechanisms are related to the fact that the attraction of workers increases the size of the local market and is crucial for the existence of agglomeration economies. It is widely acknowledged since Marshall (1890) that increases in the market size led to diversification into complementary activities, strengthen backward and forward production linkages and create thick labor markets. This implies a reduction in the costs of workers finding a job they are suitable for, and in the costs of firms finding the type of workers they need. The thickness of local labor markets, therefore, increases the productivity of firms, attracts competitive companies and workers, and subsequently produces further developmental outcomes such as higher employment rates, wages, and regional GDP per capita. Moreover, the skills of workers in a new path can serve as basis for future diversification (Boschma & Frenken, 2011) and potential migrant workers attracted by the new industrial path to a region can become carriers of external knowledge and agents of structural change (Morrison, 2023). These indirect translation mechanisms increase the possibility of creating new rounds of diversification, an aspect that is particularly relevant in resource dependent regions (Breul & Atienza, 2021)

All these arguments assume, from different perspectives, that human capital in RIPD is a territorially embedded asset. Currently, however, this assumption is at least controversial particularly in the case of peripheral regions that are not able to attract and retain skilled workers. The degree of territorial embeddedness of human capital is particularly relevant to understand how the emergence of a new path translates into regional economic development. If the labor mobilization related to a new path is not contributing to territorially embed the labor to the local economy, the above listed development translation mechanisms are arguably weakened or even lost.

Two trends of the last decades highlight the need to apply a multi-scalar approach to the mobilization of human capital for RIPD to fully grasp its potential contribution to regional economic development. First, how human capital can translate RIPD into developmental outcomes has to be considered in the context of the historical trend of the spatial fragmentation of production that is strongly connected to technological and institutional changes that took place during the 20th century and still continues. Massey (1984) put labor on the frontline when she proposed the existence of a process of spatial divisions of labor to explain regional inequality in Britain. From this perspective, differences in economic development opportunities not only depend on what regions produce but on what regions (and particularly workers) do, on what functions they play in the production process. The idea of spatial fragmentation was further developed from an international perspective by global value chain and global production network (GPN) frameworks (Coe and Yeung, 2015) but more focused on firms than on labor. In this technological regime of fragmented production, a new path can emerge within a region but just based on workers that perform low value added, routine and ancillary tasks. In any case, this approach to regional economic development still considers human capital a territorially embedded asset.

The second trend is related to technological and institutional changes that have contributed to decrease the need of people to live where they work. According to Baldwin (2019), this is the main trait of the recent third wave of globalization. This process, however, started before, with the introduction of long-distance commuting (LDC) through fly-in fly-out (FIFO) practices to the

offshore oil platforms of the Mexican Gulf in the 1950's, and it has become a dominant feature in the labor markets of resource abundant regions (Storey, 2001). This form of organization of labor, favored by the development of air transport, also required new institutional arrangements such as shift-work systems that established a fixed number of days on the job, followed by a fixed number of days at home (Houghton, 1993). The separation of the production and social reproduction places is particularly widespread in peripheral regions that are not able to attract workers and will increasingly permeate other industries beyond primary activities due to the more recent expansion of remote work (Baldwin, 2019). In this new technological regime, a region can create a new industrial path without hosting a significant share of its required human capital as a local asset reducing its contribution to regional development.

This trend of declining territorial embeddedness of workers is particularly relevant in the mining industry and has direct consequences on the extent mining related new industrial paths can translate into regional economic development (Coe & Hess, 2013; Phelps, Atienza & Arias-Loyola, 2015). On the one hand, it creates a fly-over effect (Storey, 2001) because the wages paid to long-distance commuters are not spent in the production site. This loss of income has also demand multiplier effects and reduce fiscal linkages, a process that reinforces the reduction in local income, employment, and potential diversification in more sophisticated goods (Aroca and Atienza, 2008, 2011). Furthermore, LDC increases human capital supply (no more local but national) reduce local employment and wages in mining regions (Carriel et al., 2023). Furthermore, social organizations like labor unions become increasingly disconnected from local economic and social conditions, thereby reducing the role of human capital agency to mediate and arbitrate regional value capture (Ellem, 2016; Manky, 2017)). On the other hand, when the human capital of a new path is weakly embedded to the region where it is situated, it only contributes to smaller degrees to the creation of regional assets for future rounds of diversification, through agglomeration economies³ such as market size effects, thickness of labor markets and increases in human capital skills. This reduction in the potential opportunities for diversification is one of the main challenges for regional economic development of mining regions in the long term (Breul & Atienza, 2022).

Against the background of these developments in the potential mobilization of human capital for path creation, it is surprising that this “directionality of asset flows” (Hassink et al. 2019: 4) has not been studied in the research strand on RIPD so far. In the following empirical analysis, we show that it requires a multi-scalar lens that grasps this directionality of asset flows for the case of human capital to understand the relationship between new paths and regional economic development.

³ It is important to note that the attraction of workers can also create negative agglomeration economies, particularly in the form of higher housing prices (see Prada-Trigo et al., 2021 and Rehner & Rodriguez, 2021 for the case of Chile). However, in the long term, this negative effect is expected to be larger in large urban agglomerations than in small and medium agglomerations as this is the case for mining cities.

3. Methodology

We analyze the creation and evolution of the MSS path in Antofagasta, a region that represented more than 50% of the Chilean mining output and 13% of world copper production in 2021 (COCHILCO, 2022). The period of analysis spans from the mid-1970s, when this industry path was in its emergence conditions, to 2021. This period witnesses a rapid and profound transformation in the organization of the mining industry, from a vertically integrated industry (where all the stages of production were controlled by the mining company) to a global production network (where an increasing number of tasks and services were globally subcontracted) and in the organization of labor with an increasing mobilization of human capital via LDC. It thereby offers an illustrative case to explain how the nature of asset mobilization (in this case human capital) for path development can affect regional economic development.

Our analysis considers three subperiods defined according to different technological regimes, and political and institutional changes that create in some cases a transition and in others a rupture in the evolution of the MSS path and related human capital mobilization (table 1). These subperiods show how socio-economic processes operate at different speeds and at different spatial scales. Therefore, while we will focus on the Antofagasta Region, our analysis will consider those periods from a multi-scalar perspective considering how changes at a global and national scale affected MSS path development in Antofagasta.

Table 1: Subperiods of analysis

Emergence conditions.	1974-1991: From the beginning of the privatization of Chilean copper to the starting of Escondida operations.
Emergence of the new path.	1992-2002: Arrival of mining multinationals and the transformation of the mining industry towards a GPN.
Consolidation of the path.	2002-2021: Mining prices super cycle and the reorganization after the super cycle.

Source: Authors.

We use a historical analysis that considers how global, national, and regional technological and institutional changes dynamically interact to create the conditions for the emergence of the new path in the Antofagasta region and determine its further evolution. This analysis is based on documentary information from public records and reports and secondary sources from official national and regional data bases. It is important to highlight the limitations related to the availability of long-term information at a regional level in Chile. In this regard, our study faces the following information problems: 1) Long-term regional time series in Chile are very incomplete. 2) This problem is even bigger in the case of activities that do not belong to the standard classification of industries, such as mining services suppliers. 3) Detailed data series on employment regarding mining contracted and subcontracted workers and particularly long-distance commuters are only available since 2009 and information about workers' characteristics are very limited.

These limitations imply the use of incomplete time series and indirect approaches to evaluate some of the main variables of our analysis. This analysis is based on public and private information from the following sources: National Censuses, National Employment Survey (NES), Central Bank,

National Copper Commission (COCHILCO), National Service of Geology and Mining (SERNAGEOMIN) and the Chilean Direction of Civil Aeronautics, as well as information from local guilds related to the evolution of the MSS industry. Since the MSS industry is not part of the standard industry classifications and includes different kinds of services such as energy supply, construction, exploration, maintenance, industrial and environmental services, engineering, transport, lodging, and catering, we approximate its size and evolution using different sources and considering those workers and firms that are subcontracted by mining companies. Information regarding long-distance commuters is only available in the National Census 2002 and in the NES from 2009 to 2021. A comprehensive description of the data used in the analysis is presented in Appendix 1.

4 Results

This section analyzes the emergence and consolidation of the MSS path in Antofagasta, its process of declining territorial embeddedness of labor, and how this process undermines the translation mechanisms of this new industrial path into regional economic development.

4.1 The development of a mining service supplier industry path in Antofagasta

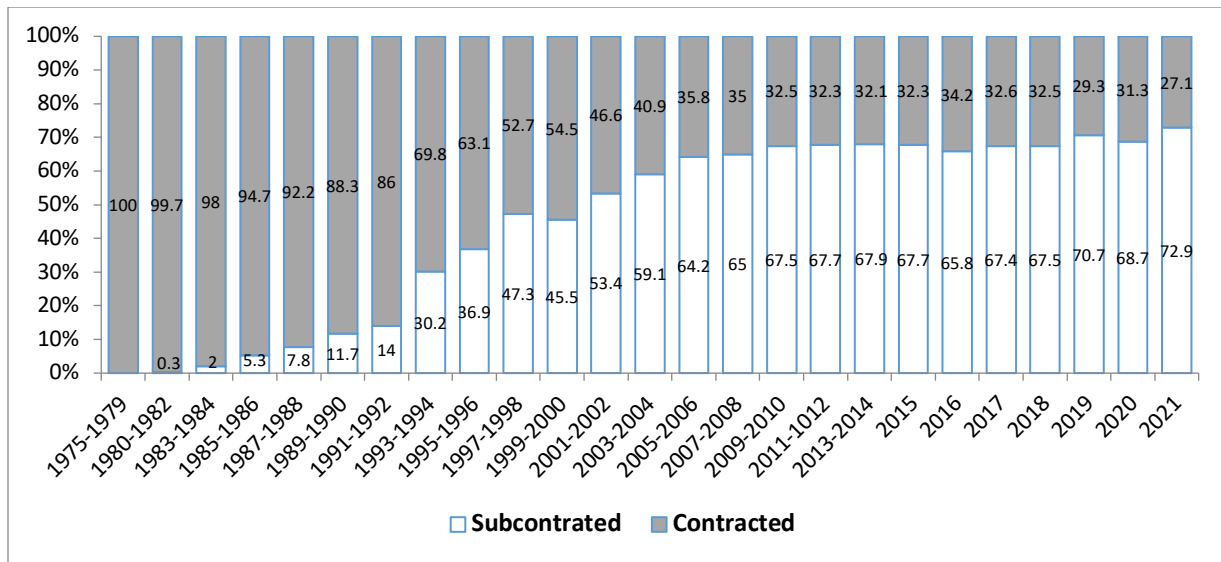
Emergence conditions of the mining service supplier industry path: 1974-1991

The last quarter of the XX century was characterized by the low prices of minerals (Appendix 2). The mining industry adapted to this situation through a process of cost reduction and restructuring (Humphreys, 2015). A crucial change during this period was the increasing outsourcing as a way of accommodating investment, labor, and production to the boom-and-bust cycles (Bridge & Le Billon, 2013). As a result of these processes of rationalization, mining transformed itself from an almost vertically integrated activity to a GPN, reorganizing its service suppliers and labor at multiple scales (Bridge, 2008). These changes created the opportunity for the development of a MSS industry (Morris, Kaplinsky & Kaplan, 2012).

In this global context, between 1974 and 1990, Chile was experiencing a major political and institutional transformation. After a period of resource nationalism in the 1950s, 1960s and the nationalization of mining deposits at the beginning of the 1970s, the Pinochet dictatorship, that started in 1973, implied a series of reforms oriented to the liberalization of the economy and the attraction of foreign direct investment (FDI). Despite those institutional reforms, the attraction of mining FDI between 1974 and 1987 was not as large as expected due to the economic crises suffered by the country in 1973 and 1982, its political isolation and the lack of trust of international investors (Moguillansky, 1999; Fernando et al., 2009). Therefore, during this period the mining industry in Antofagasta was dominated by the public company CODELCO (Moguillansky, 1999), which represented on average more than 80% of national copper output during the 1970s and 1980s and remained almost fully vertically integrated. The number of hours worked by mining subcontracted labor force until the end of the 1980s was below 10% (Figure 1) and, consequently, the opportunity for the emergence of a MSS industry in Antofagasta was – in contrast to the global

dynamics of the industry - meager. The situation started to change from 1987 onwards, when the 1982 recession was overcome, and the Chilean neoliberal economic regime was completely implemented. Since the beginning of the 1990s when the country returned to democracy, Chile experienced a massive arrival of mining FDI mega-projects from mining multinational companies (Moguillansky, 1999; Fernandois et al., 2009).

Figure 1: Percentage of the number of hours worked by contracted and subcontracted mining labor in Chile, 1975-2021



Source: Authors based on SERNAGEOMIN annual reports

Emergence of the mining service supplier path: 1991-2002

The massive arrival of mining FDI mega-projects to Chile during the 1990s not only implied a significant rise in the Chilean production capacity, that almost tripled during this period (Appendix 3), but also the incorporation of new production and organization practices, progressively imitated by the public company CODELCO. The flexible organization of production through outsourcing is particularly relevant in this respect. During this period, the number of hours worked by subcontracted labor in the mining industry increased from 11.7% in 1990 to 53.4% in 2002 (Figure 1).

Between 1991 and 2002, Antofagasta Region was the second destination of FDI flows in the country only after the Metropolitan Region of Santiago and received close to 10% of the total FDI of the country⁴ mostly concentrated in the mining industry. During this period, many private medium and large mines were developed and started their operations in Antofagasta: Escondida in 1991; Michilla in 1994; Zaldivar in 1995; El Abra in 1996; Lomas Bayas in 1998; and Centinela in 2001. Their increasing demand of MSS, fueled by the significant increase in subcontracting, led to the emergence of a new industrial path. The traditional small family business specialized in

⁴ Calculation based on Chilean Central Bank.

minor and generic services increased but, at the same time, a group of medium size and more specialized MSS started to grow in the region. According to SICEP⁵, in 2002, there were at least 46 firms of this type in Antofagasta⁶.

This branching process of the MSS industry in Antofagasta was accompanied by place-based leadership. Since mid-1990s, local organizations led by the Industrial Association of Antofagasta (AIA) and the Regional Association of Municipalities, started a discussion about how the region could benefit from the arrival of large private mining companies. Focus was placed on the promotion of mining backward production linkages with local MSS to create a “Mining, Manufacturing and Services Productive Complex”. The Regional Development Strategy 2000–2006 established the objective of promoting a mining cluster to “improve the strength and quality of the linkages of local services suppliers with mining companies” (Gobierno Regional de Antofagasta, 1999).

Growth and consolidation of the mining service supplier path: 2003-2021

At the beginning of the new millennium, an increasing demand of commodities initiated what has been called the mining prices super cycle (Humphreys, 2015). Copper pound price rose from US\$1.1 in 2002 to US\$4.2 in 2011 (Appendix 2) and the process of increasing externalization continued. In Chile, the number of hours worked by mining subcontracted labor rose from 53.4% in 2002 to 67.7% of total hours in 2011 (Figure 1). The super cycle contributed to consolidate the MSS path in Antofagasta. According to SICEP, the number of firms rose from 83 suppliers in 2003 to 504 in 2011 (Figure 2)⁷, representing more than 25% of total suppliers in the country.

The decline in mineral prices from 2011 to 2016 (Appendix 2) – calling the commodity super cycle to an end – forced the reorganization of global mining industry to reduce costs and increase productivity. This included, among other things, the digital transformation in the mining industry to gain efficiency and reduce labor costs through robotics, automation, remote operations, and an increase in the length of labor shifts to reduce the turnover of workers, creating a more flexible and geographically fragmented organization of labor (Atienza, 2021). In Chile, these changes also fueled the continuous rise in outsourcing services. Hours subcontracted by the mining industry accounted for more than 70% in 2021 (Figure 1). According to SICEP, despite of the end of the super cycle, MSS in Antofagasta almost doubled its number of firms from 504 in 2011 to 980 in 2020, representing 28% of total MSS in the country. This significant growth took place between

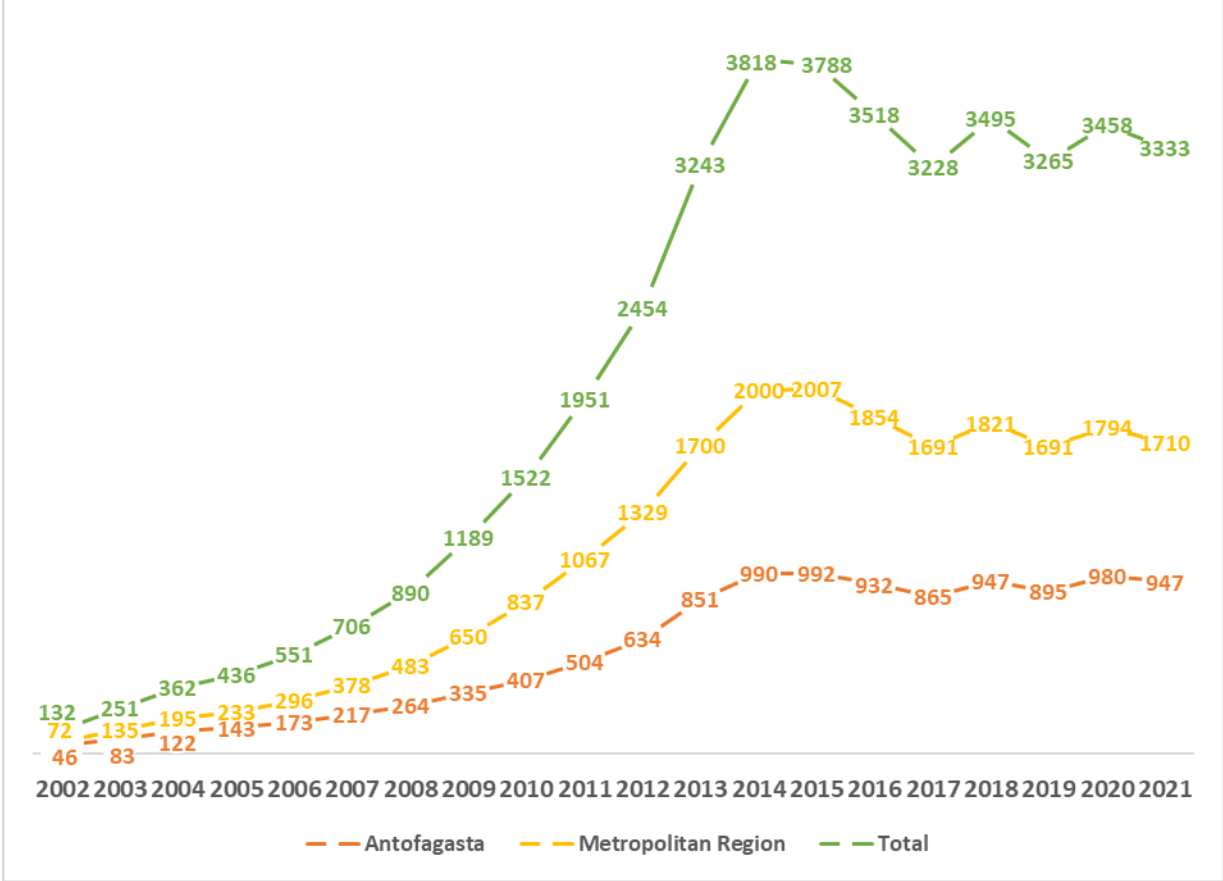
⁵ Acronym for “Sistema de Calificación de Empresas Proveedoras” in Spanish (Qualification System of Supplier Firms). SICEP was created in 2001 and is largest national mining suppliers’ platform and belongs to the Antofagasta Industrial Association (AIA) (www.aia.cl).

⁶ The firms that belong to SICEP during the first years were already medium to large size and had the skills and technological capabilities to offer more specialized services. Therefore, information from SICEP underestimate the number of MSS in the region, particularly small firms specialized in more basic and generic services. Unfortunately, there is no official record of this group of firms.

⁷ It is important to stress that the growth of MSS in Antofagasta during the first decade of the 21st century is probably overstated because at the beginning of this decade, only a limited number of existent MSS were able to fulfill the conditions to belong to SICEP, since most of them were small firms that offered very generic services.

2011 and 2014, since then the number of MSS suppliers in Antofagasta remained relatively constant slightly below 1,000 firms (Figure 2). However, around 92% of the local MSS were micro and SME strongly dependent on just one customer, with high entry and exit rates and severe difficulties to attract qualified human capital, innovate and export, while large MSS were concentrated in the Metropolitan Region (Atienza, 2011). There are various indications that the region was not successfully advancing towards the consolidation of a mining cluster: (1) backward mining production linkages decreased during the super cycle (Castaño et al. 2019); (2) knowledge transfer from mining companies to local suppliers was very limited (Arias et al. 2014; Phelps et al., 2015); (3) most MSS firms provided generic and basic services to mining companies, while more specialized and strategic suppliers were located in the Metropolitan Region or abroad (Atienza et al. 2021). Apart from this, the emergence and growth of MSS implied beneficial developmental outcomes for Antofagasta. New firms were established, and employment opportunities were created. However, at the same time, this branching process was characterized by a progressive decline in the territorial embeddedness of human capital as we will show in the next section.

Figure 2. Number of mining service suppliers in Antofagasta Region, 2002-2021



Source: Authors based on SICEP

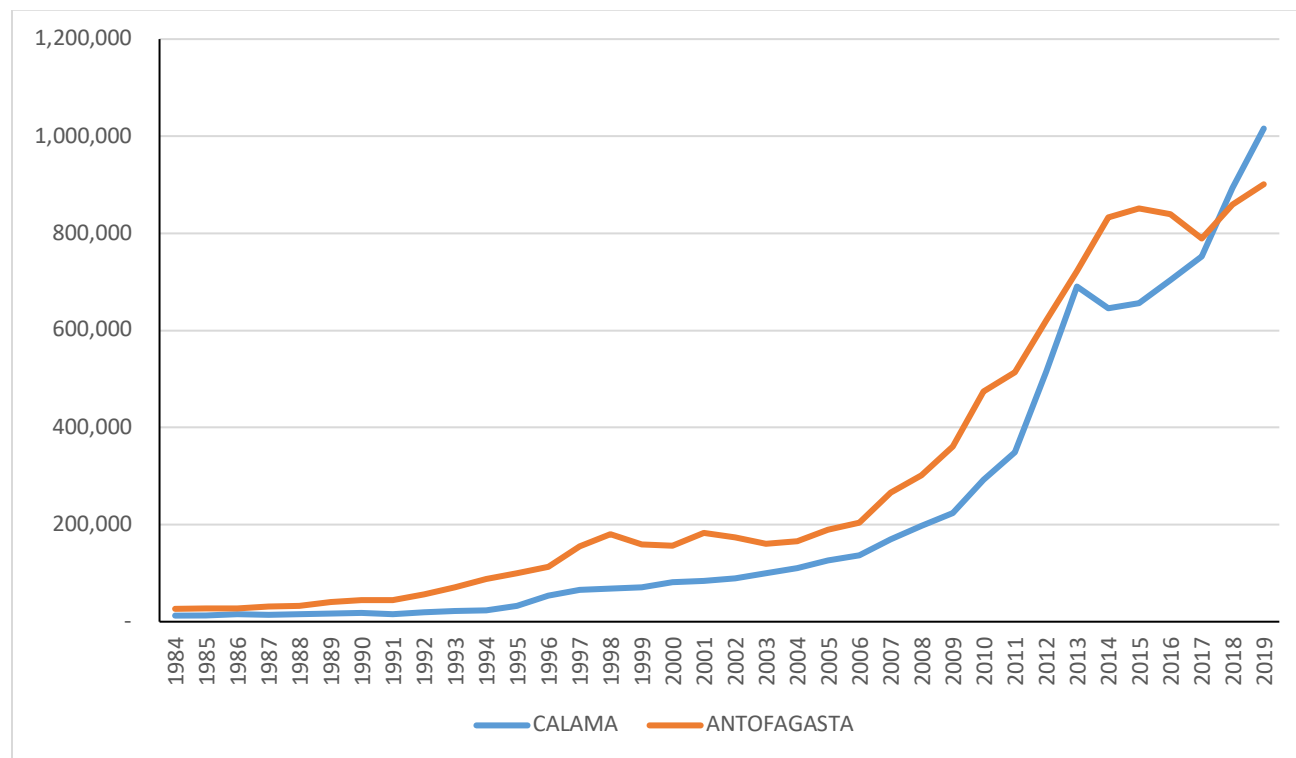
4.2 Changing human capital mobilization processes in the mining service supplier path in Antofagasta.

Traditionally the geography of labor in the Chilean mining industry was characterized by a company town regime, self-contained human settlements located close to the mineral deposits where all housing, urban infrastructure, amenities, and services were designed, built, and owned by the mining firms (Phelps et al., 2015). According to the National Census, in 1982 around two thirds of the mining workers in Antofagasta region lived in the municipalities of Calama and María Elena which were organized as company towns in geographical proximity to the mines (INE, 1982). If we consider the low level of subcontracting (Figure 2) and that other municipalities such as Taltal and Tocopilla were devoted to small mining and represented close to 10% of mining workers, it is plausible to state that between 1974 and 1991 most mining workers were territorially embedded in the region in a company town regime.

Between 1992 and 2002, when the MSS industry emerged, this situation experienced a significant change. In 1992, the population living in Calama and María Elena had diminished but still represented around 55% of mining labor (INE, 1992) and foreign mining multinationals still maintained some of the traits of company town culture. CEOs lived in the region and the foreign companies provided housing to some workers in the main cities of the region. However, these practices and the company town culture had almost faded by 2002, when the largest company town – Chuquicamata in Calama dependent on CODELCO – started its closure and only the company town of María Elena remained open. According to the National Census, in 2002, Antofagasta Region received 16,517 workers who lived in other regions and represented 10% of the regional active workers. These long-distance commuters were concentrated in Mining (25%), Construction (35%) and Professional and Technical services (15%) (INE, 2002). Aroca and Atienza (2011) estimate that around 70% of long-distance commuters to the Antofagasta Region were directly or indirectly related to mining considering the mining production linkages with other activities. A progressive decline in the territorial embeddedness of those workers began in the 1990s, while, at the same time, the company town culture that had contributed to geographically anchor human capital in the region was close to disappear. Two important technological and institutional changes explain those developments: First, the significant rise in the hours worked by subcontracted labor (Figure 1) favored by the flexible regulation of shift-work systems; and second, the development of domestic air transport in Chile and the increase in fly-in fly-out practices in both the mining industry and the MSS firms. Between 1991 and 2002, the number of passengers in domestic flights per thousand kilometers more than tripled in Chile. However, the number of passengers from Santiago to Antofagasta and Calama, the two main cities of the region, multiplied by five (Figure 3)⁸. Despite the relevance that LDC was gaining, the mining cluster strategy did not pay any attention to it.

⁸ It is relevant to mention that in the case of the municipality of Calama part of the rise observed in domestic passengers is not fully related to long-distance commuters but also to tourism. This airport is the only connection to San Pedro de Atacama one of the main tourist spots in Chile.

Figure 3: Number of passengers in domestic flights from Santiago to Antofagasta and Calama, 1984-2019⁹



Source: Authors based on Dirección de Aeronáutica Civil

Since the beginning of the super cycle, when the MSS path experienced a significant increase in size, the reduction in the territorial embeddedness of mining and mining-related workers, increased. At the end of the super cycle, in 2011, long-distance commuters represented 15.3% of total employed labor, but more than two thirds of them were directly or indirectly related to the mining industry¹⁰. LDC was particularly widespread among subcontracted workers of MSS firms. In 2011, 42.1% of Antofagasta's mining subcontracted workers lived in other regions of the country and were, so to say, detached from the development trajectory of the mining region (Figure 4). Three circumstances affected the rise in the number of mining and mining related workers living outside Antofagasta during the rise of mineral prices: First, the progressive implementation of the shift-work 7x7 (seven days working in the mine and seven days off) instead of the usual 4x3, allowed workers to spend more time in their home regions and reduced incentives to migrate to the mining regions. Second, the widespread perception that the quality of life in Antofagasta was low while prices were too high because of the boom of mineral prices (Rodrigo and Atienza, 2014). Third, the cease of an almost monopolist situation in the Chilean domestic flight market in 2005 led to a reduction in air travel prices (Villena, 2009) and a noteworthy increase in the number

⁹ This figure does not cover the complete period of analysis due to problems of data availability before 1984 and after 2019.

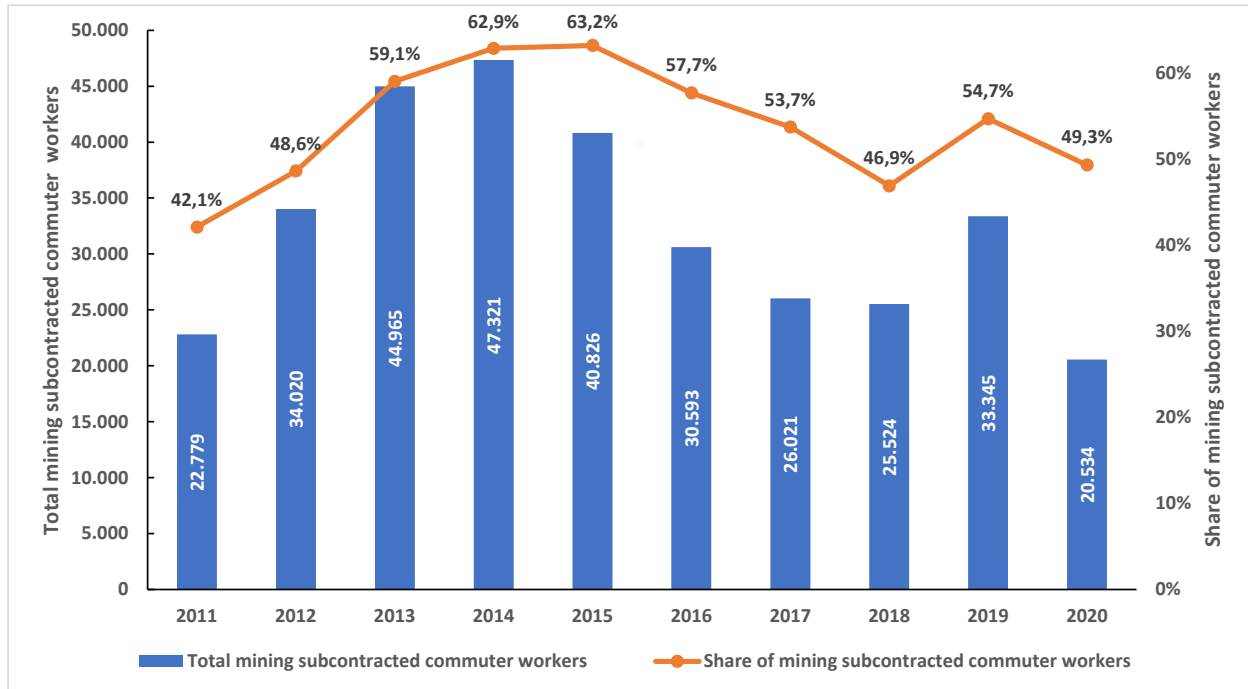
¹⁰ Calculations made using the NES.

of passengers from Santiago to Antofagasta (five times from 2002 to 2011) and Calama (twelve times), many of them long-distance commuters (Figure 3).

Between 2011 and 2019, the growth of domestic flights from Santiago to the cities of Calama and Antofagasta continued (Figure 3) because of the reduction in flights fares, the generalization of the shift work 7x7 as the most common in the mining industry and an increase in the number of subcontracted workers, among other factors. According to the National Employment Survey (ENE), between 2011 and 2020, on average, 51% of total long-distance commuters to Antofagasta were mining subcontracted workers who represented 72% of total commuters directly or indirectly related to mining. LDC is more common in mining subcontracted workers than in those directly contracted by mining companies. On average, long-distance commuters represented 54% of the workers in the first group and 30% in the second group of workers. The predominance of commuting among subcontracted workers of MSS firms is due, among other factors, to the short-term nature of many of their contracts used by mining companies to adapt their labor force needs to the changes in mineral price cycles. Figure 4 shows that between 2011 and 2015 the number of commuters subcontracted workers increased from almost 23,000 to more than 40,000, representing in some years more than 60% of these workers.

Since 2015, there has been a reduction in the share of long-distance commuters in both contracted and subcontracted workers – still around 50% in the case of the latter group in 2020 (figure 4) – that are partly related to the rise in copper prices but can also be explained by an increase in the regional demands for local content policies. While LDC had not been considered a regional problem in the previous periods and was not part of the mining cluster policy, the end of the super cycle and the improvement of local statistics made evident that both mining industry and MSS workers were increasingly disembedded from the region. Mining companies, such as CODELCO, BHP Billiton and Antofagasta Minerals, reacted to local demands and started different programs to increase the incorporation of local workers. It is only during the second half of the 2010's when local content policies related to employment started to be considered as a crucial additional component of the cluster policy. However, this policy has been mainly applied by mining companies but scarcely by MSS and it is doubtful that this type of local content policies by themselves would be able to reduce a trend that started in the 1990s and has deeper technological, institutional, political, and local roots.

Figure 4: Number and share of mining subcontracted long-distance commuters in Antofagasta Region, 2011-2020



Source: Authors based on NES

To sum up, across the different periods, new global and national institutional arrangements were created, technological changes occurred, and global market dynamics caused a reorganization of the mining industry. These various influences on different geographical scales have affected how human capital is mobilized for the MSS path in Antofagasta during its evolution. The empirical insights indicate a progressive reduction in the territorial embeddedness of mining-related workers since the emergence of the path, in some years with more than half of the workers commuting from outside the region. While the emergence of MSS path has contributed to the development of the Antofagasta region in terms of production and employment, the spatial fragmentation of labor has not translated it into the expected economic development of a path branching process and has weakened the consolidation of a mining cluster based on MSS as proposed by regional development strategies since the beginning of 21st century.

In the next section, we analyze how the changing human capital mobilization process of the MSS path has limited its contribution to regional economic development.

4.3. Developmental implications of changing labor mobilization

As outlined in section 2, human capital mobilization activates translation mechanism for transferring RIPD into regional economic development. In this section, we analyze how the configuration of human capital mobilization in the MSS path in Antofagasta region has limited its potential contribution to regional economic development. We focus first on the direct translation mechanisms and afterwards on the indirect ones (see section 2.3).

The most evident loss suffered by the region due to the decline in the territorial embeddedness of human capital is the fly-over of a significant share of the wages paid by the MSS industry. Table 2 summarizes the fly-over of mining and mining-related long-distance commuters' wages in 2013 and 2021 based on information from the NES. Wages of long-distance commuters represented 19.1.% of the total wages paid in the region¹¹ in 2013 and 16.8% in 2021 (Table 2). The most relevant share of this fly-over is due to subcontracted mining workers that represented 13.1% of total regional wages in 2013 and 10.5% in 2021. In this sense, subcontracted mining worker fly-over accounts for US\$ 641,008,668 and US\$ 367,466,760 that did not remain in the region in those years respectively. This amount represents almost six times the National Fund for Regional Development (FNDR), the main government fund to reduce regional disparities, available for Antofagasta in 2013 and more than three times in 2021.

Another mechanism that limits the potential contribution of the MSS path to regional economic development is a reduction in the demand multiplier effects because those wages are not expended in the region. According to Aroca and Atienza (2011), the indirect demand multiplier effects of total mining wages were 2.3 times the direct effect in 2002, when LDC only represented 10% of total labor¹². This would more than double the direct fly-over of wages. At that time, this indirect multiplier effect also implied a loss of more than 7,000 jobs (around 5% of regional labor force). Another effect of the decline in human capital territorial embeddedness is the fly-over of fiscal linkages. Local workers are a relevant source for local tax revenues (Paredes and Fleming-Muñoz, 2021.) While the potential loss of housing and other local taxes is difficult to estimate and relatively small considering the Chilean tax system, it is particularly relevant for mining regions, since it diminishes the budgets of local governments and their capacity to improve the quality of life in mining regions which is also further strengthening the rationale for LDC.

¹¹ Total wages can be considered as a proxy of regional income.

¹² Unfortunately, this calculation cannot be replicated for recent years due to the lack of a regionalized input-output matrix of the Chilean economy.

Table 2: Monthly fly-over of Antofagasta mining wages, 2013 and 2021

	Monthly Total Wages (US\$)	
	2013	2021
Total Mining Wages of long-distance commuters	77,872,578	49,237,397
Total mining wages LDC direct workers	24,455,189	18,615,167
Total mining wages LDC subcontracted workers	53,417,389	30,622,230
Total Regional mining Wages	188,020,339	113,180,224
% of LDC mining wages in total mining wages	41.4%	43.5%
% of LDC mining wages in total mining wages direct workers	13.0%	16.4%
% of LDC mining wages in total mining wages subcontracted workers	28.4%	27.1%
Total Wages Antofagasta Region ¹³	407,255,322	293,319,028
% of LDC mining wages in total regional wages	19.1%	16.8%
% of LDC mining wages in total regional wages direct workers	6.0%	6.3%
% of LDC mining wages in total regional wages subcontracted workers	13.1%	10.5%

Source: Authors based on NES, 2013, 2021

The potential increase in the demand of local workers expected from the development MSS path is limited not only because workers do not live in the region due to LDC, but also because long-distance commuters substitute existing local workers. In this regard, Pérez-Trujillo et al. (2020) and Carriel et al. (2023) find that LDC negatively affects employment and wages in the host regions depending on the degree of substitution between local and commuter workers. According to the NES, between 2010 and 2021, Antofagasta had the highest percentages of residents that share the same characteristics as long-distance commuters in Chile: close to 20% of total workers and around a third of unemployed people (Carriel et al., 2023). From this perspective, LDC increase the size of human capital supply for mining and mining related firms and, subsequently, reduce local employment opportunities and wages. In this regard, Carriel et al., (2023) find a negative and statistically significant effect of the percentage of long-distance commuters that are like local workers on local wages of approximately 1.7% on the hourly wage for every 1% increase in the share of residents who are similar to commuters.

The decline in the territorial embeddedness of mining and mining-related workers has also direct effects on the role of labor as a local agent that promotes further regional development. Workers and labor unions generally contribute to mobilizing civil society and articulating local demands to improve the quality of life and articulate strategies for strategic coupling and local value capture in GPNs. While the need of a higher quality of life in Antofagasta has become probably one of the main reasons for the rise of LDC, commuters are completely detached from that need (Rodrigo & Atienza, 2014). Labor protests of mining and mining-related unions in Chile very rarely include

¹³ The apparent sharp decline in the wages between 2013 and 2021 is due to the impact of the devaluation of the Chilean peso regarding to the US dollar and to internal inflation.

demands connected to public services, urban infrastructure, and other improvements in the quality of life of the spaces of social reproduction in mining areas (Irrarrazaval, 2022). This has been different in the past before the extension of LDC (Velasquez Orellana, 2020) and particularly during the company town era that gave rise to unionism in Chile (Salazar & Pinto, 1999).

The decline in the territorial embeddedness of mining and mining-related workers also has indirect effects on the developmental prospects of RIPD. The increase of LDC has limited the growth of the size of the regional economy and its political influence in Chile, that is strongly related to the share of population. In fact, the demographic growth in Antofagasta between 2002 and 2017 was basically due to the attraction of international migrants. Despite the super cycle, the population growth of Antofagasta was below the national average, in contrast to the period between 1982 and 2002 when LDC was less widespread, and Antofagasta was among the regions with the highest demographic growth in the country.

Moreover, the significant rise in LDC limits the capacity of Antofagasta region to achieve larger agglomeration economies through increasing returns to scale despite the growth in the number of MSS. Phelps et al. (2015), Castaño et al. (2019) and Atienza et al., (2021) reveal a decline in backward mining production linkages, particularly during the prices super cycle. Furthermore, LDC has a direct impact on the thickness of Antofagasta's labor market, since workers are sourced by MSS suppliers from across the country and not locally (Phelps et al., 2015). In fact, Carriel et al. (2023) find that around a third of Antofagasta's workers have similar characteristics as long-distance commuters and are not able to find a job. This is a clear signal of the thinness of the local labor market that particularly affects the unemployment rates of the region. This is also related to the pattern of spatial divisions of labor that characterizes the organization of the MSS industry. Larger and more technology and skills-intensive service suppliers are located in the Metropolitan Region of Santiago (Atienza et al., 2021) and these are the MSS firms that have the largest share of long-distance commuters. According to AIA (2023), in 2021, 85% of large MSS were from the Metropolitan Region. In contrast, Antofagasta represented only 5% of national large MSS and almost 60% of local MSS were small firms (AIA, 2023). Furthermore, large MSS have the highest percentage of long-distance commuters. Only 23% of the large MSS whose headquarters are out of Antofagasta contract more than 60% of local workers (AIA, 2023). These patterns affect the skills available in the region. The limited focus of local MSS on generic and ancillary services clearly limits the possibility of local labor enhancement and the accumulation of skills for future diversification rounds.

5. Conclusions

This study addresses a largely neglected question in research on RIPD – how the development of regional industrial paths translates into regional economic development. To this aim, the paper focuses on how the nature of asset mobilization for path development (here particularly human capital) can affect its developmental outcomes.

The case study highlights that new path creation does not necessarily translate into the expected regional economic development. While the emergence of the MSS path in Antofagasta has

contributed to the development of the region in terms of production and firm creation, the crucial mechanisms that translate the new path into regional development in Antofagasta are severely restricted due to the progressive decline in the territorial embeddedness of MSS workers in the region. Developmental implications of this changing nature of human capital mobilization are fly-over effects, reduced demand multiplier effects in income and employment, loss of fiscal linkages, lower employment and wages, scarce engagement of workers in the local agency to improve the quality of life, and a limited contribution to agglomeration economies - from production linkages and the generation of skills to knowledge transfer - as regional assets for future diversification.

Despite data limitations the empirical basis allows to draw the important conclusion that workers cannot per se be understood as regional assets that contribute automatically to a regionalized development translation mechanism of new industrial paths, since modern technological and organizational developments allow new forms of organizing workers across different regions. These results are not necessarily specific to the experience of extractive industries where LDC is more common. It is a process that can be also extended to the emergence of other new industries such as new energies and others that require workers with very specific skills, particularly in peripheral regions due to their difficulty to attract and retain labor. In fact, this trend of territorial disembeddedness of workers can be reinforced if travel costs increasingly diminish, and institutional setups allow more flexibility in labor regimes and remote work, as accelerated by COVID-19, expands (Ellem, 2016; Paredes and Fleming-Muñoz, 2021). These developments in terms of human capital mobilization have implications for a central argument in evolutionary economic geography, that local capabilities (the focus lies especially on skills) are a key driver of regional diversification dynamics (Boschma & Frenken 2011; Boschma 2017) and require further consideration in future studies on regional industrial dynamics and their developmental implications.

On a conceptual level, the article provides an approach with its focus on asset mobilization that can generate insights into the conditions under which new industrial path development can initiate very distinct developmental dynamics. The results demonstrate the value of a multi-scalar focus on the nature of asset mobilization for studying what kind of regional development is generated by RIPD. Through its application the “directionality of asset flows” (Hassink et al. 2019, 4) – here human capital – could be revealed, thereby highlighting the geographical discrepancy between value creation and value capture for the case of the MSS path in Antofagasta. In this sense, further research, both conceptual and empirical, is needed to understand, first, how the decline in workers’ territorial embeddedness affects labor agency and the role of workers as drivers of regional development through their demands and collective action as means for strategic coupling as proposed by labor geographers (Ellem, 2016). Second, future work could analyze to what extent LDC practices reduce the role of migrants as agents of innovation, structural change, and further diversification (Morrison, 2023)

Moreover, while extra-regional assets have experienced increasing attention in recent research on RIPD, the empirical focus largely remains on their facilitating role for diversification (especially in peripheral regions and for unrelated path development) (Binz et al. 2016; Breul & Pruss 2022; Isaksen & Trippl 2017). Particularly, to answer questions regarding developmental outcomes the

consideration of the territorial embeddedness of these extra-regional assets becomes crucial as the example of LDC practices illustratively demonstrates in this study. In this regard, further lines of research can also analyze how the decline of workers' territorial embeddedness manifests in other activities and types of regions, as well as the directionality of other asset flows in path creation and their consequences for regional development.

From a policy perspective, it is also relevant to evaluate to what extent the increasing application of local content policies that ask mining companies to incorporate local workers and local supplier firms in their supply chains can become an effective instrument to territorially embed extra-regional assets and increase the contribution of MSS to regional development in mining areas.

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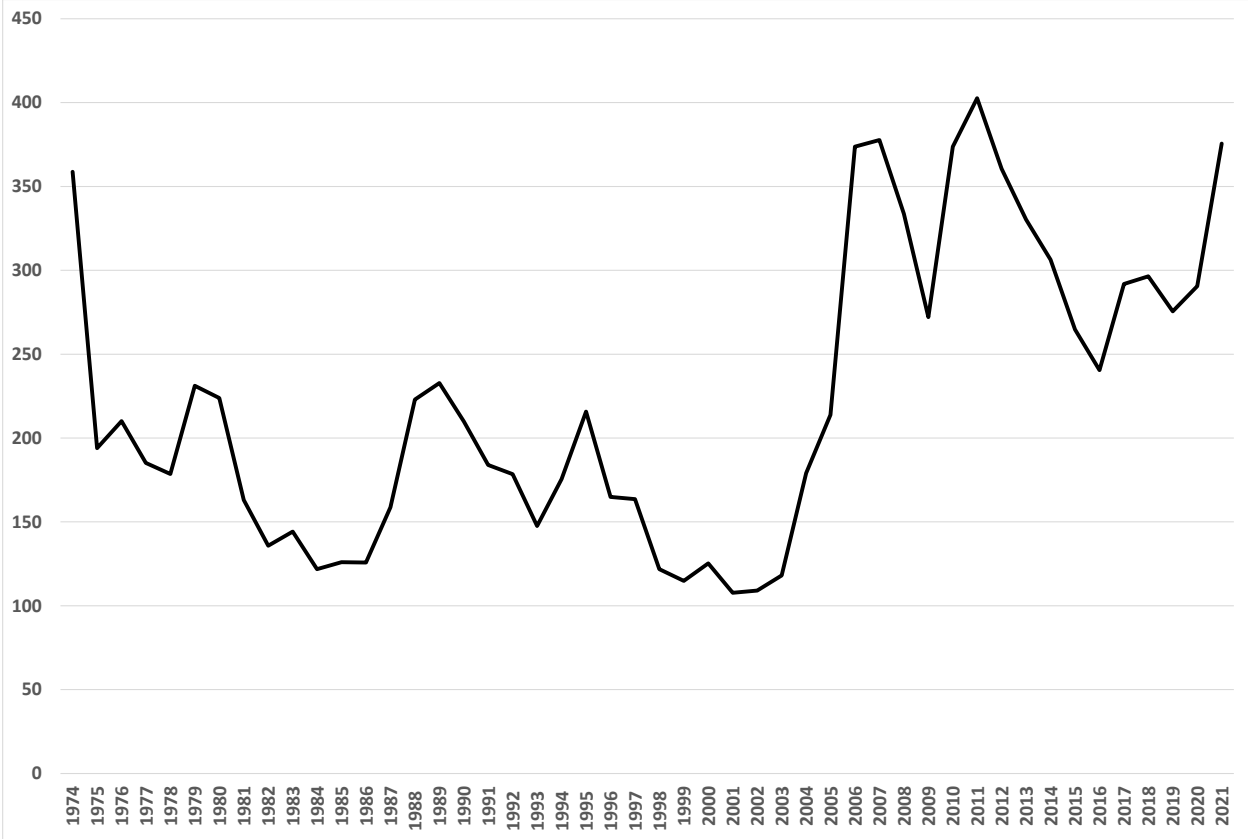
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Appendix 1: Data sources

Variable	Period	Source
Copper prices	1970-2021	COCHILCO
Copper output	1970-2021	COCHILCO
Share of mining subcontracted worker	1975-2021	SERNAGEOMIN
Mining subcontracted workers and wages	2009-2021	National Employment Survey (NES)
Mining services suppliers	2002-2021	SICEP
Domestic flights	1984-2021	Dirección General de Aeronáutica Civil
Long-distance commuters (Contracted and subcontracted)	2002 2009-2021	National Census National Employment Survey (NES)
Wages	2009-2021	National Employment Survey (NES)

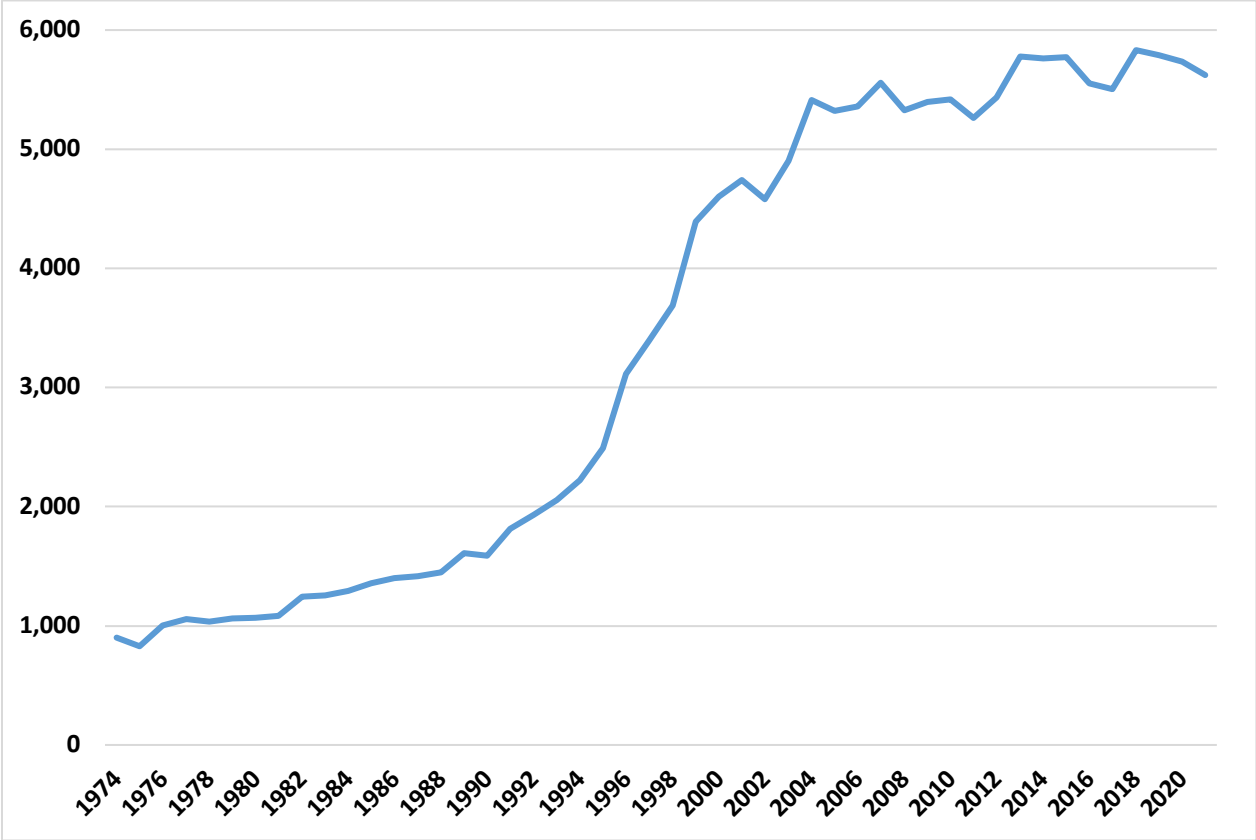
Source: Authors.

Appendix 2: Constant refined copper prices (constant USD 2012 cents/lb.), 1974-2021



Source: Authors based on COCHILCO

Appendix 3: Copper mine total production (thousand tones), 1974-2021



Source: Authors based on COCHILCO