

**LOCALIZATION OF INDUSTRY IN CHILE, 1895-1967: MINING CYCLES
AND STATE POLICY**

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Mining cycles have had an enormous impact in the evolution of the localization of economic activity, in particular of industry, in Chile. The nitrate cycle was characterized by a labour-intensive extraction process and activity which was geographically very concentrated. The copper cycle was geographically more dispersed and its activity more capital-intensive. We stress the role played by the State in the latter de-concentration due to the impact of regional development policies and assess the importance of factor endowments and agglomeration economies, in the localization of the manufacture.

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INTRODUCTION

The aim of this article is to study the impact of mining on the distribution of economic activity, and particularly industrial activity, in the Chilean economy. We study the two mining cycles that started in 1880: the first was characterized by nitrate exportations and ended with the First World War and the second, from the First World War until the 1970s, featured copper exportations. The nitrate cycle boosted economic activity in the northern provinces of Chile, ushering in about a period of relative dispersion of economic activity, in particular industrial development.

At the end of the nineteenth century and the beginning of the twentieth century, the provinces of Tarapacá and Antofagasta attracted industrial investments to the region (mainly non-durable consumer goods, with a significant proportion in the textile and food, beverage and tobacco industries). This period saw maximum territorial dispersion of industrial activities. The rise of nitrate prices on international markets, the fall in transport costs and the integration of the international economy favoured this trend.¹ After the First World War falling mineral prices and a decline in the economic activity

¹ Williamson, Real wages, and Bértola and Williamson, Globalization in Latin America, stress the importance of falling transport costs during the First Globalization on the expansion of the economic frontier in countries such as Argentina or Chile, and also the increased incomes of the ‘new settlers’.

of the mining region affected industrial activity, shrinking its wealth and diversity.² The delocalization of the textile industry and the lack of alternative industrial investment left the north of Chile reliant on food and beverage production, which took advantage of proximity to consumers. Fortunately for the Chilean economy, the nitrate crisis was relieved by the ‘new copper economy’ boom during the First World War.³ In 1915, work began at the Chuquicamata mine in the province of Antofagasta (previously a nitrate region), and mining began at the El Teniente mine, in the central zone, near Santiago.

The 1920s were years of transition. The nitrate cycle came to an end with demand turning to other substitute products and, in turn, copper production expanding in response to international demand. The Great Depression was the turning point, with economic recovery during the 1930s made on the basis of a new growth model.⁴ Unlike the nitrate cycle, which was labour-intensive, the copper cycle was capital-intensive. Copper, being territorially more dispersed and with less of the population dependent on its activities, was not a strong pull factor for primary commodity industries, though it did attract technology-intensive mining-related activities. During this period, which was dominated by policies of industrialization by import substitution, Santiago became the hub of industrial activity.

Only at the end of the period studied do we notice a change in the trend of concentration of industrial activity. The industrial census of 1967 shows a timid process

² Badia-Miró and Ducoing, *The long run development of Chile*, analysed the relationship between natural resources and manufacturing expansion during both mining cycles.

³ To understand the changes in mining at the end of the nineteenth century see Ffrench-Davis and Ernesto Tironi, *El Cobre*; and Vergara, *Conflicto y modernización*.

⁴ Bulmer-Thomas, *Economic History*.

of dispersal, but this time it is not the mining industry that explains why. State policy of industrial promotion generated a trend towards territorial dispersion. Free Trade Zones in the far northern and southern provinces of Chile opened up the map of industrialization to the territories furthest from the capital city and the largest concentration of consumers. The localization of industrial activity is important due to the role of the sector as a driver of economic modernization and structural change. The long-run impact of the spatial location combined two main forces. On the one hand, concentration near the market favoured agglomeration economies and industrial growth. On the other hand, excessive concentration entailed an increase in congestion costs, such as rents, labour costs and transport congestion.

This article is an effort to contribute to the knowledge of Chilean economic history from the perspective of the geographical analysis of the economy. While the rich historiography of Chile has stressed social, technical or institutional issues,⁵ this article analyses the impact of mining by interrelating mining activity and the localization of the manufacturing industry. With this study we hope to contribute to the understanding of the industrial structure in the mining regions, its evolution in the long run, its linkages to the mining activity, as well as to understand one of the important causes of the concentration of industrial activity, until now not explored in historiography.

The article is organized as follows. The first part gives a brief description of the evolution of mining prices and their impact on the location of mining activity. Here we aim to describe the main structural changes in the Chilean mining economy during our period of analysis: the transition from nitrate mining to copper mining, from labour-intensive mining to capital-intensive mining and from a geographically concentrated

⁵ See ENAMI, *Chile Minero*.

mining to a more dispersed one. The second part describes the localization of industrial activity during the whole period, focusing our analysis on the evolution of the industry in the mining provinces. We test our previous results considering the model proposed by Midelfart-Knarvik et al to add robustness.⁶ The third part draws links between the evolution of the mining cycles and industrial location and proposes some hypotheses to explain this. The end of the article presents the main results and some conclusions.

THE EVOLUTION OF MINING PRICES AND THE LOCALIZATION OF MINING ACTIVITY

Chile's identity as a mining economy was consolidated at the end of the nineteenth century. First, the great nitrate cycle and then the copper cycle turned Chile into a country that specialized in mining activity. During colonial times, the small territory occupied by the Spanish between the Copiapó and Bio-Bio rivers never produced precious metals (gold and silver) to the extent of the Viceregal centres of Mexico and Peru. Colonial Chile excelled in agricultural exportations to Upper Peru.⁷ Chilean cereals covered part of the food demands of the zones of Cusco and Potosí, which established Chile's marginal position within the Spanish colonial system. The copper and silver export cycles of the early decades of the Republic began to incline the Chilean economy towards mining, but agricultural production retained its dominant position until the mid-nineteenth century.⁸ Until 1881 agricultural production exceeded

⁶ Midelfart-Knarvik et al, Comparative advantage.

⁷ Carmagnani, *Los Mecanismos*.

⁸ Méndez Beltrán, *La Exportación Minera*; Robles Ortíz, *Expansión y transformación*.

mining production; agricultural exports represented more than 30 per cent of total Chilean exportations in the 1870s, reaching 48 per cent in 1874.⁹

Mining hegemony in Chile began in the 1880s, with the nitrate boom following the War of the Pacific (1879-1881). The 50-year nitrate cycle gave Chile a monopoly position in world markets of natural mineral fertilizers.¹⁰ The rise nitrate production from 1879 to 1882 was possible because of the annexation of the previously Peruvian and Bolivian provinces into Chilean sovereignty. From 1880, mining exports represented more than 80 per cent total Chilean exportations, with a peak of 93 per cent in 1906. The annexed provinces became a centre of activity ranging from mining to transportation, services and industrial activity, simultaneously boosting demand in other regions of the country.¹¹ Mining production exceeded agricultural production, reaching the 20 per cent mark in 1888 and 30 per cent in 1917. At the height of the First World War, mining was the economic heartbeat of Chile.

Before the beginning of the decline of the nitrate cycle at the end of the 1920s, copper had entered a new expansive cycle. Chile had been producing copper since the colonial period, but until the end of the nineteenth century rudimentary techniques were used for exploitation and international demand remained at moderate levels.¹² From 1915, foreign investment (from the United States in particular) resulted in a definitive

⁹ Braun et al., *Economía Chilena*.

¹⁰ Cariola Sutter and Sunkel, *Un Siglo*.

¹¹ Pinto and Ortega, *Expansión Minera*.

¹² Valenzuela Enriquez, *Tres Estudios*. Copper was said to be used basically to cover the hulls of wooden ships, in the era of the great sailing ships, just before steam technology became dominant in navigation. The success of electricity and the electrical components industry of the early 20th century revalorized copper in world markets and revolutionized copper extraction and melting techniques.

boom in ‘new copper mining’. Copper replaced nitrates as the main source of mining production and exports, widening the geography of mining from the north to the central zone of the country.¹³

The mining map of Chile is completed with the production of fossil fuels. Exploitation of coal in Concepción and Arauco, to the south, began in 1844 and continued steadily until the 1970s.¹⁴ Chilean coal was almost entirely destined for the local market (which had to be complemented with importations from Britain), and fuelled steam engines in the railways, foundries and industrial activities. In the 1960s, coal production was complemented by petroleum production in the southern region of Magallanes. Unlike Chile’s other mining activities, petroleum extraction had no historical precedents. The industry was a totally new phenomenon, with very particular geographic localization and production that barely covered the minimum of local needs. Although fuels were important for the economic development of the country, they never marked an era in the economic history of Chile in the way that exports of nitrate and copper did.¹⁵

The relationship between the mining cycles of the Chilean economy, particularly those of nitrate and copper, and the evolution of international prices of both raw materials differs according to the period studied. Rising prices stimulated increased nitrate and copper production. This was particularly marked in the case of nitrate between 1900 and 1917 and for copper from 1947 onwards. During the downward trend of nitrate prices from 1880 to 1899, production and exportation did not stop growing,

¹³ Sutulov, *El Cobre Chileno*.

¹⁴ Ortega, *La industria*.

¹⁵ For a detailed analysis of coal and oil consumption in Chile, and in Latin America generally, see Rubio et al., *Energy*.

except for the serious dip during the Great Depression in the early thirties. However, when nitrate prices fell from 1922 the industry had no way of recovering and fell into a long decline, from which it never recovered.

The Chilean mining economy was determined by natural resource endowment and had limited options for dealing with cycles of falling prices, and had to redouble its productive efforts in order to maintain revenues. During the first two decades of the nitrate cycle, when prices were on the upswing, the sector responded by increasing the workforce involved in extraction and increasing investment in activities of transformation and commercialization. This led to greater consumption of coal for the production of nitrates and for the railways, which were used to transport the mineral to the ports of Iquique and Pisagua. Both trends were accentuated during the great cycle of expansive prices at the beginning of the twentieth century. The increase in international demand for nitrogenous fertilizer in the golden years of the first globalization occurred when the Chilean nitrate economy was sufficiently capitalized to be able to respond to the opportunities of the cycle of climbing prices. The nitrate-rich regions in the north of Chile experienced their period of greatest abundance. The population grew with the arrival of workers from the central region of the country; the port towns of Iquique, first, and Antofagasta, later, became hubs of industrial activity and services; and the State accentuated its presence in the provinces annexed after the War of the Pacific.

The end of the nitrate cycle, during the First World War, coincided with falling international prices caused by the appearance of a chemical substitute for natural fertilizers. The Chilean monopoly of nitrate minerals then entered a cycle of decline that lasted several decades. Efforts to regain competitiveness through low salaries and technical innovations did not prevent the final crisis, although they did delay the definitive collapse by a few decades. The turning point for nitrates occurred

simultaneously with the boom in copper mining. In industrialized countries, chemical fertilizers were substituted for natural nitrates, while the demand for copper for the electrical industry increased. The First World War and the rise in transport costs due to the collapse of global trade accelerated both processes.

Chile was able to respond to the stimulus of international demand at the end of the nineteenth century due to its generous natural resource endowment. The so-called 'commodity lottery' acted as a determinant in the localization of Chilean economic activity. Between 1894, the year of historical minimum prices, and 1917 when the price was at a maximum not seen again until 1954, Chilean copper was still extracted in a traditional manner: labour-intensive in extraction and capital-intensive in melting. The new copper mining cycle, which began in 1915 with the opening of the El Teniente mine in the Andes region, was to have its very own identifying features. Foreign investment from the United States was predominant and there were technical innovations in mineral extraction as well as in melting. The 'new copper mining' was born at a juncture when prices were unfavourable, which made foreign investment in technical advances indispensable. Chilean copper production grew between 1917 and 1945 in the context of very low international prices, and the industry overcame the historically low prices of the 1930s in a relatively short time.

In moving between the two mining cycles, the Chilean economy adapted to three structural changes. It shifted from nitrate to copper mining, from labour-intensive to capital-intensive mining, and from geographically concentrated mining to more dispersed localities. Figure 1 shows an index of concentration of mining activity from data on regional mining GDP. While the nitrate cycle showed elevated concentration indices, with the extraction of the mineral located exclusively in the provinces of the Norte Grande (first in Tarapacá and then in Antofagasta), the copper cycle boom was

marked by a progressive de-concentration, which was heightened by the appearance of petroleum production in the southern zone. Copper mines of greater or lesser significance were found in Atacama, Coquimbo, Aconcagua, Santiago, Valparaíso, Antofagasta and O'Higgins (the mines located in the latter two provinces were of particular relevance).¹⁶

[Insert Figure 1]

THE IMPACT OF THE LOCALIZATION OF MINING ACTIVITY ON INDUSTRY

The localization of the industry in the long run

Chile underwent its first experience of industrial development around the 1850s.¹⁷ This was limited in intensity and duration, and coincided with export booms for agricultural products (wheat to the Australian and Californian goldfield markets) and mining products (silver and copper).¹⁸ Chile's advantageous location on the Pacific and its generous natural resources endowment, including coalmines, facilitated the construction of its first railways, the milling of wheat and the melting of metals using modern, industrial, coal-intensive methods.

¹⁶ Coal production, although spatially concentrated, did not affect the evolution of the localization of mining because its production remained at similar levels throughout the period of analysis. In this sense, the orientation of a sizeable proportion of its production towards the domestic market meant that coal production was not so affected by the evolution of prices on international markets.

¹⁷ Ortega, *Chile en Ruta*.

¹⁸ Reeves, Frost and Fahey, Integrating the historiography; Frost, "Metallic nerves".

However, when new competitors entered international markets, Chile had difficulties retaining its markets.¹⁹ The legacy of this early industrial experience consists of having, for the first time, forged a nexus between exportations and industrialization, while at the same time spreading modern production techniques across the territory. Though these modern production techniques were limited in number, they marked the destiny of the Chilean economy. These pioneering experiences were scattered throughout the territory, which resulted in a relatively low geographic concentration of modern activities. Wheat production was to be found in the valleys of the central zone, south of Santiago, and this is where milling activity was located. Silver and copper mining were characteristic of the so-called 'Norte Chico', a region undergoing desertification to the north of Santiago. In the coal-producing region of Concepción, 700 kilometres south of Santiago, highly specialized industries sprang up, such as those fabricating refractory bricks for the furnaces of metal foundries.

It was with this legacy, which was limited and somewhat diminished by the crisis of the 1870s, that Chile experienced its boom as a nitrate (saltpetre) exporter. The country had experienced industrialization without actually becoming industrialized. However, it had gained experience that would prove useful during the mining export boom that began in the 1880s. Although nitrate production was far more labour-intensive than technologically-intensive (the mineral was exported with very little added value), the increase in mining production in the provinces of the Norte Grande led to the creation of a focal point of economic growth which impacted on industry in the country. The provinces of Tarapacá and Antofagasta became focal points that attracted a workforce from the central regions of Chile. In the mines, known in the zone as

¹⁹ The impact of the economic crisis in the late 1870s in Chile has been extensively studied by Ortega, *Chile en Ruta*.

‘offices’, there was employment for tens of thousands of workers, who had to be imported from distant zones due to the low density of the existing population.

The lack of local labour power and the need to import labourers kept salaries rising, which had the effect of increasing the demand for manufactured goods in the region.²⁰

High levels of GDP per capita in Tarapacá and Antofagasta until 1930 reflect the market potential of these provinces (see Table 1). The wages of industrial workers are consistent with the GDP figures (see Table 2). Industrial wages in Tarapacá, the nitrate province in the north of the country, were at their highest during the nitrate era and fell later. In the copper mining provinces of Antofagasta and O’Higgins, industrial wages were similar to the rest of the country.

[INSERT TABLE 1]

[INSERT TABLE 2]

In response to the increased purchasing power of the northern population, low-quality manufactured goods were imported from elsewhere in Chile, which drove the integration of the national market.²¹ Industrial activities also developed, with the advantage of production taking place close to input suppliers and final consumers.

²⁰ Salaries were relatively high in certain mining-related activities, such as the railways, which connected the mining zones with the export ports, in related urban services such as foreign trade in Iquique and Antofagasta, and in more specialized functions in the nitrate industry where skilled labour was required. See Pinto Vallejos, *Trabajos y Rebeldías*.

²¹ Mining regions bought from inputs for mining, such as coal which arrived after long sea voyages from Arauco (more than 2,500 kilometres down the coast) and sacks for packing the mineral which came from the central zone; to construction materials (mainly timber), and consumer goods such as flour and wine for consumption and leather and textiles for the miners’ clothes.

Iquique, the number-one mining city in the north, was situated more than 1,500 kilometres from Valparaíso, then the main manufacturing centre in Chile. Apart from the production of consumer goods for the mine-labourers, there was also the need to handle and commercialize the nitrate, which gave rise to secondary activities linked to mining and transport. The mechanization of mills and packaging systems, as well as the spreading of the railways as a means of transport, lent a more upbeat pace to industrial activities in the mining zone.

Some manufactured goods came from abroad, which reduced the backward-linkages of mining on domestic industry. While Europe (and particularly the United Kingdom) was the main export destination, imported products benefited from cheap freight costs.²² The First World War marked a change in this respect. Trade data show, for the first time, a divergent development between imports of manufactured goods and mining exports and the end to the restriction that foreign trade imposed on domestic industrial development.²³ The increase in coastal shipping trade was a response on the part of the domestic market to this expansion of demand due to increased prices for exported goods and of the reduction of imports because of restrictions in world trade. Manufacturing production expanded with a focus on the domestic market. By the 1920s,

²² The ships, which usually arrived at Pisagua, Iquique or Antofagasta to export the mineral, arrived loaded with ballast (generally wood) to fill up their cargo capacity, since the volume of importations was significantly less than that of exportations. Consequently, transport costs of importations were relatively low.

²³ Palma, *Growth and structure*, shows how the initial big divergences between the evolution of exportations and industrial production are observed in the 1920s, given that production is not tied to foreign inputs as a fundamental part of the production process. Nevertheless, it seems that regional trade patterns did not change. See Carreras-Marín *et al.*, *Intraregional trade*.

60 per cent of domestic consumption of manufactured non-durable consumer goods was satisfied by domestic production.²⁴

During the period of economic growth based on nitrate exports, Chilean industrial activity was spatially dispersed (see Figure 1).²⁵ This reflected the dynamism of the nitrate provinces, which had added new territories to Chilean industrial activity in the north and the renewed strength in the zones of Concepción and Valdivia in the south.²⁶ Valdivia alone accounted for 12 per cent of Chile's total industrial employment in 1911, which compensated for stagnation in manufacturing in Valparaíso.²⁷

The nitrate-mining crisis changed this trend. The loss of the leading role of nitrate exports in the northern provinces of the north from the First World War negatively affected mining itself as well as those activities that depended on it, including industry. From 1920 onwards, there was a strong increase in the concentration of industrial activity that lasted until the end of the Second World War (see Figure 2).²⁸

[INSERT FIGURE 2]

²⁴ Palma, Chile. Another indicator of the importance of industry in this period was the increase in importations of raw materials and fuels. Muñoz Gomá, *Crecimiento*. These figures were revised and undervalued by Badia-Miró and Ducoing, *The long run development of Chile*.

²⁵ Ducoing and Badia-Miró, *El PIB industrial*.

²⁶ The data from the industrial census prior to 1937 underestimate the presence of industry in the rural zones, and thus the levels of entropy of industrial activity would be even greater. Palma, Chile.

²⁷ The decline in the importance of Valparaíso with relation to the country as a whole can be explained by the stagnation of industrial employment. In the census of 1894/5 there were 12,000 people employed in industry; this figure had not increased in 1911.

²⁸ Muñoz Gomá, *Estado e industrialización*.

A change in economic policies, with a move from a relative liberalism to determined State intervention, coincided with the copper mining cycle.²⁹ Copper mining was not capable of generating new geographic focal points of industrial activity, as nitrate mining had done before. Copper mining was far more capital-intensive than labour-intensive and founded on more advanced technological bases. It neither generated new population nuclei to attract industrial activities for consumption by the workforce, nor did it stimulate the appearance of industrial activities associated with mining activity, apart from metal foundries. Consequently, the geographic dynamic of industrialization was a product of the political economy of the time. State-directed industrialization favoured the concentration of industrial activity in the capital city, Santiago.³⁰

During the interwar period, in a context of intense industrial growth in the country as a whole, industrial employment grew faster in Santiago than in the rest of the provinces. Santiago's share of total industrial employment in Chile jumped from 33 per cent in 1911 to 56 per cent in 1945. Not only did Santiago grow, but some of the northern provinces, such as Tarapacá, where diminished by the end of the richest mining deposits. Antofagasta and Atacama took over as key mining export regions, with some impact on industry. In contrast to the previous period, the provinces surrounding Valdivia grow much more slowly, causing their relative weight to diminish to less than 10 per cent. The growth of industrial employment in other population centres was

²⁹ The period from 1840 to 1950 saw the expansion of industry and rising growth of GDP. The economy was reoriented towards the domestic market, with State-directed industrialization (SDI) encouraging the import substitution. Ortega et al., *Corporación*.

³⁰ SDI politics favoured protectionist policies (and increased transport costs for foreign countries), with market power acting as a driver in industry concentration dynamics.

modest. Between 1911 and 1928, Concepción grew at 1.3 per cent per annum and Valparaíso at 1.8 per cent per annum; the more dynamic zones of Antofagasta and Santiago had hitherto grown at more than 3 per cent per annum. In the 1930s, Concepción joined the group of high-growth provinces. Between 1937 and 1945, the concentration of industry in Santiago increased due to falling industrial employment in the mining provinces of the north and stagnation in Concepción. By 1957, Santiago accounted for 60 per cent of the nation's industrial employment.

A new change in trend can be observed at the end of the period studied. By 1967, a light dispersion of economic activity in the context of the expansion of industrial employment was evident. This de-concentration occurred despite the continued population growth of Santiago, at annual rates close to 5 per cent. The northern zones, especially Tarapacá, grew quickly after the creation of the Free Trade Zone of Arica in 1958, and the growth of the Concepción steel industry, which had strong public backing.³¹

Natural resource endowment or agglomeration economies?

In this section, we test the importance of the home market effect and agglomeration economies (New Economic Geography) versus the natural resources endowment (Heckscher – Ohlin) in the location of Chilean economic activity. We consider the same approach as that of Midelfart-Knarvik, Overman and Venables for Europe and the later approach of Crafts and Mulatu for the Industrial Revolution in England.³² These studies

³¹ Haindl Rondanelli, *Chile y su Desarrollo*, details some of the fiscal advantages which the Free Trade Zone of Arica benefited from in 1960. See Behrman, *Foreign Trade Regimes*.

³² Midelfart-Knarvik, Overman and Venables, *Comparative advantage*; Crafts and Mulatu, *What explains*.

are based on the research by Baldwin and Leamer on the impact of the comparative advantage of some locations due to better resources endowments, called ‘first nature effects’.³³ In addition, Krugman introduced ‘second nature effects’, linked with the dynamics of agglomeration economies and the dimension of the home market effect.³⁴ Crafts and Mulatu found the role played by resource endowment to be decisive, with agglomeration economies less important due to the existence of relatively high transport costs. Midelfart-Knarvik, Overman and Venables draw a similar conclusion, stressing the importance of factor endowments (human capital formation and the existence of intermediate-goods, which favored horizontal and vertical linkages) in the European Union at the end of the twentieth century. Progressive economic integration within the European Union reduced transport costs, which could explain why, at the end of the period, agglomeration economies appear as explanatory, to a certain degree.³⁵

Other works show that in the long run, the impact of regional integration on the localization of the industry caused dispersion due to the higher growth in the industry of the leading regions and then, after a peak, a re-concentration around the main market, when the modern industry spreads to the whole country.³⁶ Amiti complements this description by considering the impact of agglomeration economies in those industries with strong vertical linkages, in the context of different factor intensity use.³⁷ Ellison and Glaeser and Davis and Weinstein combine the impact of the market dimension with the impact of comparative advantage in countries as Japan, some European countries

³³ Baldwin, Determinants; Leamer, *Sources*.

³⁴ Krugman, Increasing returns; Krugman, Urban concentration.

³⁵ For an analysis of the Spanish case, see Martínez-Galarraga, The determinants. For the US, see Klein and Crafts, Making sense.

³⁶ Brülhart and Tortensson, Regional integration; Brülhart, Economic geography.

³⁷ Amiti, Location.

and the US.³⁸ Their results reinforce the importance of factor endowments of the regions in the location of industrial activity. Explanations combining agglomeration economies and specific allocation of factors have been offered for the US.³⁹ Badia-Miró observes patterns of localization for the US to be consistent with both theories, but not with Marshallian-type external economies.⁴⁰

The model proposed by Midelfart-Knarvik, Overman and Venables combines factor endowments with agglomeration economies, a set of specific variables of the industrial sectors under analysis, a set of regional characteristics and also their interactions. Industry in Chile exhibited varying characteristics due to differences in the intensity of use of raw materials, skilled labor or agglomeration economies. At the same time, the Chilean provinces had huge differences in resources endowments. In a general equilibrium framework, we expect that the location of industries is determined by the interaction of regional differences and industrial characteristics. Hence, our interest relies mainly on the analysis of this. The variables considered are set out in Table 3. As a proxy for factor endowment, we use the percentage of agricultural area cultivated (this is confined to wheat due to data limitations) and mining production over the whole country, to obtain the impact of mining activities of one region on their neighbor industry (in our work, this variable is important to detect the existence of linkages, specifically during the copper cycle).⁴¹ For the impact of the human capital endowment, we consider the percentage of the entire population that is currently in school. For the sector characteristics, we use the raw materials used as a percentage of total production

³⁸ Ellison and Glaeser, Geographic concentration.

³⁹ Kim, Regions.

⁴⁰ Badia-Miró. La Localización.

⁴¹ Badia-Miró. La Localización.

and the percentage of skilled labor over non-skilled in the sector. For the NEG variables we have considered market potential for the regional characteristic and the average dimension of the firm, as a proxy for scale economies, for the sectorial one.

[INSERT TABLE 3]

We have built the market potential for each region following the procedure used by Harris:⁴²

$$MP_i = \sum_j \frac{GDP_j}{dist_{ij}} \quad (1)$$

Where MP_i is the market potential for region i , GDP_j is the GDP for region j , and $dist_{ij}$ is the distance between region i and region j . Higher MP implies a higher dimension of their own market and better access to the neighbor markets. We have not considered the impact of foreign market access due to the remoteness of this country from their main trade partners. In stressing the importance of interaction variables, the objective of Midelfart-Knarvik Overman and Venables is to combine the effect that the abundance or scarcity of one factor could have on a specific industrial sector with the impact of the use-intensity of one factor on its production. To do this, we could consider four interaction variables: two related with the factor endowments:

- We consider intensive use in industry and in the region: percentage of agricultural area cultivated over the whole country * Raw materials used as a percentage of total production.

⁴² Harris, The market.

- Intensity in the use of raw materials and importance of mining sector to detect the existence of linkages between the industry and mining: Mining production over the whole country * Raw materials used as a percentage of total production
- We consider effects related with the human capital endowment and their impact on industries needing skilled workers: Percentage of schooling for the population of the whole country * Percentage of skilled labor over non-skilled in the sector
- We also consider NGE variables which consider the pattern followed by industry towards a concentration near the big markets to take advantage of the scale economies: Market potential * Average dimension of companies.⁴³

The resulting equation to be tested is:

$$\ln(s_i^k) = \alpha \cdot \ln(pop_i) + \beta \cdot \ln(man_i) + \sum_j \beta[j] (y[j]_i - \gamma[j]) (z[j]^k - \kappa[j]) \quad (2)$$

Where s_i^k is the percentage of industrial employment in the sector k over the total of the province i , pop_i is the percentage of the population in province i , man_i is the percentage of industrial employment in province i , $y[j]_i$ is the regional characteristic for region i , $z[j]^k$ is the value of the characteristic of the industry k paired with the region j and $\gamma[j]$ and $\kappa[j]$ are constants. We simplify equation (1) and obtain:

$$\ln(s_i^k) = \alpha \cdot \ln(pop_i) + \beta \cdot \ln(man_i) + \sum_j (\beta[j] y[j]_i z[j]^k - \beta[j] \gamma[j] z[j]^k - \beta[j] \kappa[j] y[j]_i) \quad (3)$$

⁴³ Krugman, Increasing returns.

Some results

The next step is running the OLS regressions, correcting possible problems of heteroskedasticity, for equation (3). For data on schooling and the urban population we consider the population census and extrapolate the figure from the year of the industrial census. Data for 1894 are not available and we do not run the regression for this year. Data for agriculture come from the statistical abstracts, modified for these years with different regional aggregations.⁴⁴ We considered the 24 provinces existing in 1937. The 1957 data was considered as groups of provinces. We have no data for intensity in the use of raw materials for 1967 and we have used the same data as 1957, assuming no technological changes in the industry and no changes in its structure. The price of fuel is not available for 1957 and this is why we have considered the installed horse power over the aggregated value. The results can be observed in Table 4.

[INSERT TABLE 4]

The significance of the coefficients allows us to split the entire sample into two different periods: before and after the Great Depression or the Nitrate cycle, and the Copper cycle. During the first period, factor endowment variables were significant.⁴⁵ From the 1930s to the end of the period, agglomeration economies appeared as a significant driver of industrial location, as State-led industrialization and industry protectionism began. The strong concentration of the industry started during the 1920s.

⁴⁴ For 1928 we have merged Aconcagua and Valparaíso, O'Higgins and Colchagua, Maule and Linares, Concepción and Arauco, Malleco and Cautín, and Valdivia and Llanquihue.

⁴⁵ Kim, Regions; Crafts and Mulatu, What explains.

This implies that factor endowment was important at the beginning of this process but the effects of agglomeration economies reinforce the pattern.

The signs of the interaction of factor endowments variables were not significant in most of the cases. Positive coefficients imply that industries were located in those places with high prevalence of factor endowments and with industrial sectors that use those resources intensively. In 1911, although none of the interaction variables were significant, all coefficients were negative. Moreover, among the non-significant interaction variables, those related to the existence of higher levels of agricultural area available combined with the highly intensive use of raw materials were listed as the more important. This would indicate that in this period, there was a slight concentration of commodity-intensive sectors in those provinces with greater availability of agricultural land. Similar results were recorded in 1928. None of the interaction variables were significant, although the signs differ.

While the provision of agricultural land and the intensive use of raw materials were negative, the variables that combine higher mining GDP levels, intensive use of raw materials and high levels of human capital endowment with the use of intensive skilled labor have a positive sign (not significant at a 10 per cent level, but very close). This result allows us to state that human-capital-intensive sectors tend to be concentrated in provinces with higher school enrollments. Something similar happened in 1967 although in this case, the interaction variable of human capital is already significant in the model estimation. In 1937, two of the three interaction variables were significant. Unlike what occurred in previous years, the variables of human capital appeared to be significant and negative (in this case the combination of these variables did not favor the location of economic activity). Something similar occurred with the interactions that combine mineral resource endowment and high-intensity in the use of

raw materials, although in this case it is not significant. By contrast, interaction of this variable with the agricultural endowment was significant and positive. In this case, the impact of this variable on the location of the industry is positive.

The results of the 1950 and 1957 benchmarks show only the interaction variable of the allocation of agricultural land and the intensive uses of raw materials to be significant. In 1950 we obtained the same sign as in 1937 and interpret this as an indicator of the positive impact of high availability of agricultural resources and the presence of highly intensive use of raw materials on industrial location. The sign was negative in 1957. Finally, in 1967, the variables related to agricultural area and levels of mining intensity combined with the use of raw materials do not appear as significant. Nevertheless, this result must be taken with caution because this variable is no longer significant when we consider the results of the control estimation (see Table 5).

In examining the impact of variables relating to agglomeration economies, a positive coefficient sign will indicate that provinces where industry is concentrated will be those with large market potential and industrial sectors that intensively exploit scale economies. In most cases, the sign was negative and only during the years of the State-led industry was the sign positive, although this was significant only in 1937 and 1967. During most of the period of import-substitution policies, the main drivers of the concentration of industry were, as the NEG literature suggests, market access and increasing returns to scale.⁴⁶ In 1950 and 1957 the combination of scale economies and better access to markets promoted the concentration of industry (although the coefficients are not significant). However, in 1937 and 1967, when the push of state-led industrialization was exhausted, industry tended not to locate in the provinces with

⁴⁶ Krugman and Elizondo, Trade policy.

better access to markets and in the sectors with high levels of scale economies. Part of the concentration of industry in 1937 is explained by the performance of traditional sectors and their recovery from the Great Depression. Something similar happened in 1967, although this was related to high levels of state intervention, in particular the promotion of Free Trade harbors and regional industrial development. This in turn must be combined with the existence of scattered mining activity across the country, which could not establish linkages with the rest of industry. In this context, the existence of a larger market appeared as a key player in the location of industry.

Following Crafts and Mulatu, Table 6 considers the estimation of equation 3 using time and sector dummies, which allows us to analyze the magnitude of the impact of each interaction. This is possible because we compare the effect of natural resource endowments and production factors to that of NEG variables. For England in the late nineteenth century, the higher impact was for the interaction related to human capital and the use of highly-intensive skilled labor. This result was surprising, considering that the natural resource endowments and market size are conventionally seen as the main drivers of industrial location. The Chilean case, as observed in Table 4, produces different conclusions. The interaction of NEG forces was slightly more important than other variables. To obtain the data in Table 6 we consider the difference between the value of the prediction and the real figure of equation 2 (for the exogenous variables we used mean values). In this case we choose a value found in a percentile above 75 per cent for the variables that we are trying to analyze, considering the average for the other cases and for each year. The results confirm the important role played by NEG variables in the location of industry and the difficulties experienced by copper mining in generating backward and forward linkages to the industry of those provinces. This

explains much of the intense industrial concentration observed prior to the Great Depression.

The nitrate cycle in the Norte Grande boosted industry in these provinces through an increase in consumer goods spending from recently arrived, well-paid workers.⁴⁷ This process was reinforced by problems associated with the collapse of foreign trade outbreak during the First World War. The high labor-intensity of nitrate mining and its limited processing requirements limited the impact of this cycle on industry. Maintenance of the existing rail infrastructure and the establishment of small processing plants were main industrial impacts. During the nitrate cycle the location of industry was determined by the natural resource endowment, which resulted in the dispersal of the industry, at least until the Great Depression. This explains why the demand linkages of the mining activity generated a positive impact on the mining provinces themselves, with the appearance of a significant number of companies producing non-durable consumer goods and disseminating these to the rest of the country. The collapse of foreign trade during the Great Depression affected the entire Chilean economy, but recovery was fast and coincided with a strong pattern of spatial concentration of industry. Agglomeration economies did not impact until the 1950s, as a outcome State-led industrialization and import-substitution policies.⁴⁸

CONCLUSION

During the first Chilean mining cycle, dominated by nitrate exports, the mining industry was subject to a decentralizing impulse. The industrial structure in the nitrate provinces maintained a highly diversified pattern. When copper replaced nitrate as the main export

⁴⁷ Cariola and Sunkel, *Un Siglo*; Palma, Growth and structure.

⁴⁸ Krugman and Elizondo, Trade policy; Hanson, Increasing returns.

product, the capacity for attracting industrial activities producing non-durable consumer goods disappeared, and was replaced by an industry that was oriented towards intermediate goods and equipment goods which supplied mining activities themselves. Between nitrate and copper, the Chilean economy adapted to at least three important changes in the economy: that which involved the change from nitrate mining to copper mining; that which brought an important change from labour-intensive mining to capital-intensive mining; and lastly, that which transformed geographically-concentrated mining into one that was more dispersed in the territory. The industry of the mining zones adapted to these changes. The nitrate provinces, particularly Tarapacá, suffered the effects of de-industrialization, losing part of their structural diversity. By contrast, copper mining encouraged growth in the chemical, machinery and transport equipment industries. These were more technologically-intensive than labour-intensive, which meant they had a weaker impact on the employment structure of the provinces where they were located.

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Table 1. Index of GDP per capita in Chilean mining provinces, 1880 – 1940

(National average = 100. 1995 Chilean pesos)

	1890	1900	1910	1920	1930	1940
Tarapacá	652	497	238	276	209	112
Antofagasta	239	271	426	352	358	302
Atacama	127	97	69	81	197	253
Valparaíso	127	118	122	117	109	115
Santiago	127	111	108	117	108	120
O'Higgins	136	100	74	147	159	190
Concepción	115	118	117	108	123	127
Magallanes	305	164	126	144	118	117
National	100	100	100	100	100	100
average						

Table 2. Index of industrial wage data of the main mining provinces, 1890 – 1945

(Chile = 100)

	1890	1911	1928	1937	1945
Tarapacá	-	146	146	124	59
Antofagasta	-	119	106	119	91
Atacama	-	96	79	84	74
Valparaíso	124	120	120	106	30
Santiago	110	105	103	106	40
O'Higgins	-	72	116	60	60
Concepción	74	122	85	96	76
Magallanes	-	135	167	167	69
National average	100	100	100	100	100

Source: Anuario de la Sofofa (1896) and Censo Industrial de Chile.

Table 3. Regional and Sectorial characteristics

	Regional characteristics	Sectorial characteristics
Factor Endowments	Percentage of agricultural area cultivated over the whole country	Raw materials used as a percentage of total production
	Mining production over the whole country	
	Percentage of the nation's population currently in school	Percentage of skilled labor over non-skilled in the sector
Agglomeration economies	Market potential	Average dimension of companies

Table 4. Estimation of equation 3 by OLS heteroskedasticity corrected for various years

	1911	1928	1937	1950	1957	1967
Constant	-3.65 (5.28)	0.10 (7.07)	12.03** (3.72)	4.11 (9.33)	-0.61 (27.54)	-21.52** (6.59)
Population	0.05 (0.29)	0.25 (0.17)	-0.03 (0.20)	0.55 (0.40)	-1.13 (2.65)	0.06 (0.31)
Industrial employment	0.92** (0.16)	-0.05 (0.12)	-0.16 (0.13)	0.27 (0.19)	1.01** (0.15)	1.23** (0.17)
Province characteristics						
Agric. Endow	-0.11 (0.10)	-0.04 (0.08)	0.29** (0.08)	0.68** (0.18)	-0.14 (0.53)	0.03 (0.21)
Mining GDP	-0.19 (0.15)	4.78E-003 (0.09)	-0.03 (-0.09)	-0.07 (0.14)	-0.06 (0.18)	0.07 (0.15)
Education	-0.32 (0.29)	-0.05 (0.45)	-0.27 (0.24)	0.31 (0.47)	1.29 (1.48)	0.66** (0.31)
Market potential	0.17 (0.43)	0.35 (0.53)	0.72** (0.28)	-0.19 (0.68)	0.13 (1.93)	1.32** (0.48)
Industry characteristics						

Raw materials use	-0.52 (0.58)	-0.47 (0.35)	2.68** (0.41)	2.99** (0.81)	-0.77 (0.62)	-2.66** (0.86)
Human Capital	-0.23 (0.23)	1.06 (0.67)	-0.73** (0.28)	-1.05 (0.81)	0.91 (1.01)	-0.02 (0.54)
Average size	0.77 (1.33)	-0.42 (2.31)	4.28** (1.16)	-0.26 (1.56)	-1.68 (5.66)	8.09** (1.58)
Interactions						
INT11	-0.10 (0.12)	-0.08 (0.06)	0.23** (0.07)	0.82** (0.19)	-0.34* (0.19)	0.17 (0.25)
INT12	-0.25 (0.19)	0.07 (0.08)	-0.09 (0.09)	3.79E- 004 (0.15)	-2.76E- 004 (0.15)	0.05 (0.20)
INT2	-0.10 (0.07)	0.22 (0.19)	-0.13* (0.07)	0.08 (0.21)	0.24 (0.47)	0.26* (0.15)
INT3	-0.06 (0.11)	-0.15 (0.20)	-0.30** (0.11)	3.94E- 004 (0.13)	0.11 (0.41)	-0.55** (0.12)
N. obs.	207	153	216	192	72	216
R ² – adj	0.658	0.603	0.443	0.457	0.841	0.684

Notes: **indicates significance at the 5 per cent level; *at the 10 per cent level. Standard deviation values in brackets. Years with data problems are highlighted in grey. In 1950 the source for the industry data is the Statistical

abstract, not the census. In 1957 we have different spatial divisions (only eight divisions).

Table 5. Estimation of equation 3 by OLS heteroskedasticity, corrected for various years.

	1911	1928	1937	1950	1957	1967
Constant	8.64 (8.00)	-15.59** (6.30)	14.17* (8.07)	-0.10 (5.45)	-10.18 (6.63)	26.73** (5.75)
Pop	1.04 (1.70)	-0.39 (2.46)	4.80 (6.34)	1.85 (2.52)	-0.79 (0.69)	1.34* (0.77)
Indus.	0.51 (0.64)	0.57 (1.20)	-2.78 (3.67)	0.60 (1.30)	0.97** (0.13)	1.94** (0.90)
Interactions						
INT11	-0.14* (0.08)	-0.08 (0.06)	0.21** (0.05)	0.11 (0.17)	-0.16 (0.15)	-0.11 (0.19)
INT12	-0.14 (0.12)	-0.04 (0.05)	-0.06 (0.06)	-0.02 (0.13)	0.04 (0.06)	-0.08 (0.12)
INT2	-0.08 (0.07)	0.47** (0.21)	0.20** (0.05)	0.27 (0.18)	-0.16 (0.18)	0.15 (0.14)
INT3	-0.05 (0.10)	0.24 (0.19)	-0.27** (0.09)	0.17 (0.11)	0.20 (0.13)	-0.54** (0.12)
N. obs.	207	153	216	192	72	216
R ² – adj	0.655	0.899	0.856	0.716	0.851	0.840

Notes: We have considered dummies for each sector and for each year.

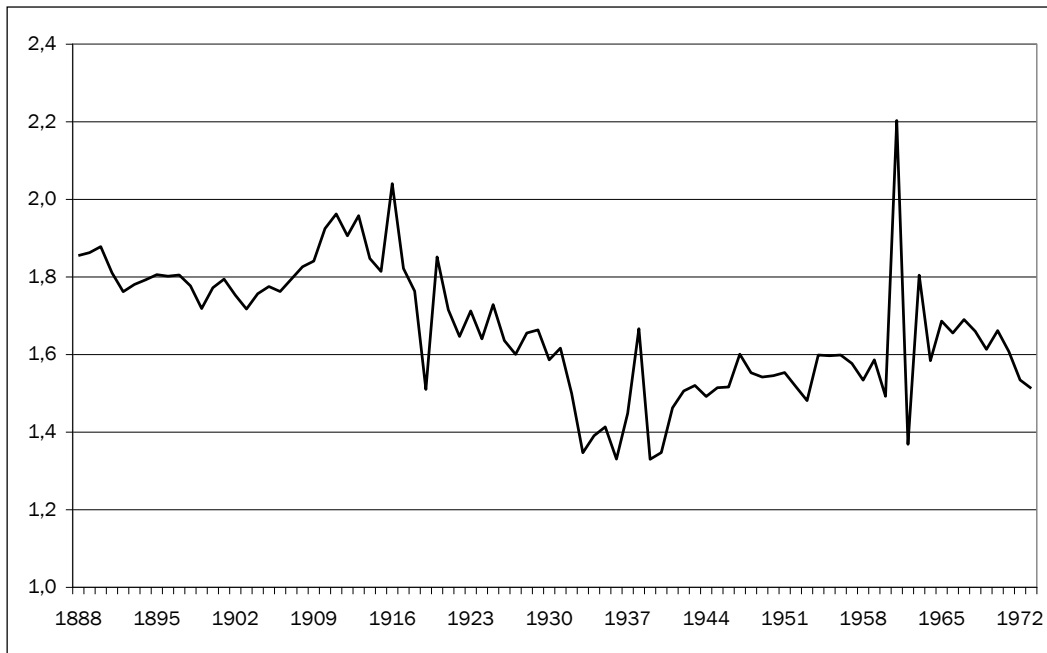
**indicates significance at the 5 per cent level; *at the 10 per cent level.

Standard deviation values in brackets. Years with data problems are highlighted in grey. In 1950 the source for the industry data is the Statistical abstract, not the census. In 1957 we have different spatial divisions (only eight divisions).

Table 6 – Interactions impact considering the values of the 75% percentile

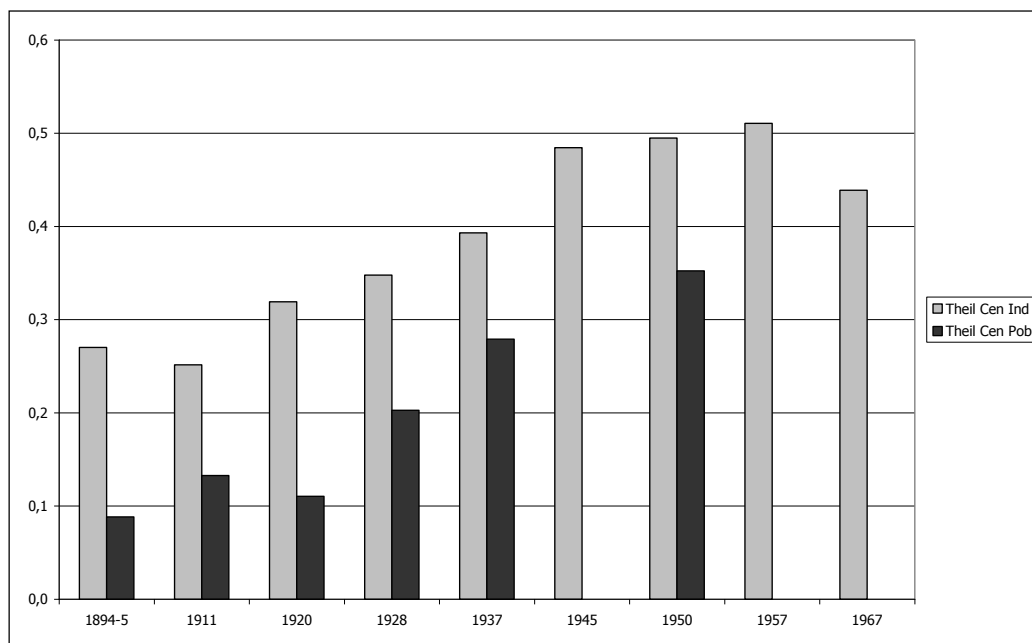
	Int 11	Int 12	Int 2	Int 3
Average	0.98	1.02	1.03	1.16

Figure 1. Theil Index regional mining GDP, 1890-1967



Source: Authors' own calculations. Mining concentration derived from the Theil indexes of regional mining GDP. See Badia-Miró, *La localización*. Low values show dispersion and high values, concentration.

Figure 2. Concentration of Industrial Employment, 1895 – 1967



Source: Authors' own calculations.